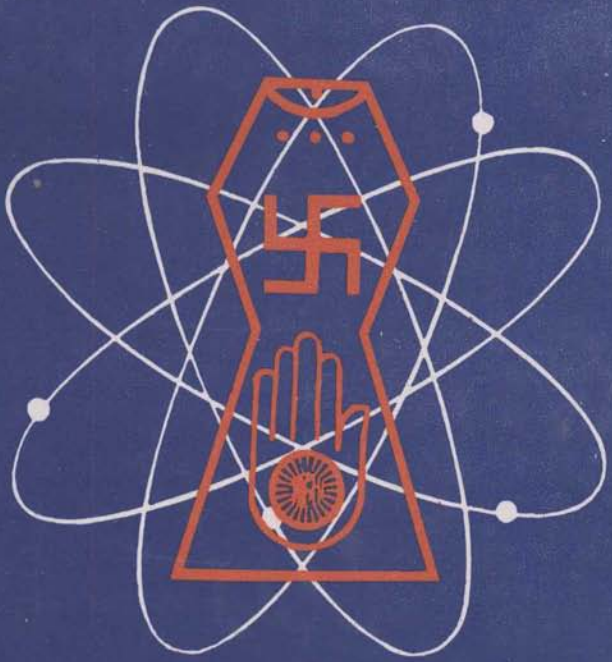
MICROCOSMOLOGY

ATOM IN JAIN PHILOSOPHY

&

MODERN SCIENCE



LATE J. S. ZAVERI

MUNI MAHENDRA KUMAR

About the Book

The subject of microcosmology has been dealt with by ancient sages as well as modern physicists. The book succintly presents a comparative and critical study of the theory of atom as expounded by Jain Philosophy and Modern Science. The author, being a versatile scholar of both the disciplines, has elucidated the intricate points in a lucid manner. The topics discussed include : Development of Structure of Atom; Paradoxical Nature of Matter; Characteristics of Pudgal/Paramanu.

An important feature of the book is the new interpretation of the concepts like massless particle, super-luminal speeds, basic unity of physics and philosophy, etc.. The striking similarities in the concepts of :

(i) Black Holes and Kṛṣṇaŕaji, (ii) Quantum Jump and Aphusmáṇa gati, (iii) Uncertainty Principle and Motion of Paramanu, etc. in Modern Science and Jain Philosophy lead to future possibilities of fruitful interaction of each other. Both scientists and philosophers would be interested to pay attention to them.

A reader interested either in the modern scientific theories of sub-atomic world or in the ancient Indian philosophical thoughts/intuitive comprehensions of the nature of physical reality in general and paramanu (the ultimate atom) in particular, would be equally benefitted by this book.

We, the publishers, as a "University", aiming at a happy blending of science and philosophy/spirituality hope that this book will prove to be an important landmark in the field of comparative studies in the science and philosophy.

MICROCOSMOLOGY : ATOM
IN
THE JAIN PHILOSOPHY
AND
MODERN SCIENCE

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Introduction

Where did the universe come from and where is it going? Did it have a beginning? How and why did it begin? What happened before that? Will it come to an end, or not? Did anybody create the universe? Is it static and unchanging or dynamic and mutable?

These and many other questions regarding space, time, animate and inanimate orders of existence have been before mankind ever since man became capable of thinking. Theories about the origin of universe and its contents have been put forward by theologists, metaphysicists, philosophers as well as modern scientists. In the orient, such questions were mostly dealt with by philosophers.

The enigma of the physical universe has also been pondered alike by religion (theology), phliosophy and science. The fundamental problems, no doubt, remained the same from one age to another, but the point of view from which they were attacked varied with the viewer as well as the age. It would, therefore, be not surprising if the answers to the problem are found to be radically divergent. Answers given by theology, for instance, are based mostly on dogmatic belief that we have knowledge, where, in fact, we have ignorance. Science, on the other hand, cannot answer many questions of great interest raised by the inquisitive human mind. "Philosophy is intermediate between theology and science" says Sir Bertrand Russell, "and it is the business of philosophy to study such problems in order that we do not become insensitive to many things of great value."[1]

India's philosophical culture is characterised by a sincerity of purpose and seriousness of outlook as well as freedom of thought which was unknown in the western countries. State persecution and censorship of thought was conspicuous by its absence because Indians did not seek to make political capital out of their religious persuasion.

1. History of Western Philosophy, p.13

At the same time, unlike in the West, science has never been able to completely subjugate the religious sensitivities. In India, at least, mystery, ambiguity and transcendence remain as important as rationality, logic and sensible perception. Here, man's personality is not entirely denatured by the scientific objectivity nor has mystery and sacredness been taken away by its rationality. In short, science, in spite of its spectacular achievements, did never become a new religion here as it in effect did in the West.

Systematization of Jain philosophy is comparatively a recent event though it has its moorings in the canonical literature i.e. *Āgamas*. According to Jain belief, the doctrines promulgated by Bhagavān Mahāvīra, whose 2500th Nirvāṇa was celebrated 15 years ago, are even more ancient and were preached by a succession of 23 *Tīrthaṅkaras* thousands of years before him. The earliest Jain literature, though not extant, is much more ancient than Bhagavān Mahāvīra. Commentaries on *Āgamas* and independent treatises by great savants between 8th to 12th centuries systematised and connected the divergent elements into logical doctrines remarkable for their originality, acuteness and subtlety.

Jain philosophy does not swear by mysticism, though it culminates in it. But the mysticism is not the result of dogmatic faith. Philosophical speculation is a necessary discipline of the mind for attenuating doubts. But the ultimate truth cannot be realised by philosophical discipline alone. The terminus of philosophy is the beginning of spiritual career. The plenum of knowledge can be attained by the development of a superior power of vision which is not satisfied with the negative findings of reason and seeks infinite perfection. "The Jains are emphatic that omniscience is the condition as well as the result of perfection and however much we may advance in our philosophical enquiry and scientific pursuit, which are not antagonistic in their aim in spite of their difference in method and lines of approach, it cannot by itself unlock the mystery of ultimate reality and bring about the final consummation."[1]

1. From Preface to *Jain Philosophy of Non-absolutism* by Prof. Dr. Satkari Mookerjee.

Eastern mystics in general and Jains in particular emphasize the systematic unity of Reality which does not mean that all things are identical, but they are aware that all differences and contrasts are relative (and not absolute) within an all-embracing unity. It is difficult to accept the paradoxical unity of opposites in our normal state of consciousness and even some philosophies either bypass or conceal the problem. Jain philosophers, on the other hand, by their remarkable insight, reveal the relativity and polar relationship of all opposites which not only include unity and multiplicity, motion and rest, but also the fundamental attributes of existence and non- existence. The Jain doctrine of non-absolutism (*anekānta vāda*) solves the problem by affirming the possibility of diverse attributes in a unitary entity. A thing exists in some context and does not exist in some other context. In atomic physics, we can never predict the absolute existence or absolute non- existence of a subatomic particle. We can never say that it does not exist, but the particle has tendencies or probabilities to exist in various places and this manifests a strange kind of physical reality between existence and non-existence. In this book, we shall briefly discuss the Jain philosophy of non-absolutism and how it can be applied to properly understand the paradoxical behaviour of subatomic particles. Readers will recognise many parallels between the notions of atomic physics and Jain views.

"Modern science[1] has made tremendous progress during the last hundred years. Few people have been more publicly admired than scientists, engineers and technologists. Together they discovered the secrets of the microcosm and perfected the ways of controlling and tapping colossal stores of nuclear energy, they probed the vast spaces of the universe and pried into the mysteries of the macrocosm, discovered the mechanisms of heredity and compounded the miracle of modern medicine. With utmost daring and immense resourcefulness, they capped their achievements by landing man on the moon to gather first-hand knowledge of the earth's nearest celestial body.

"Ironically this very age of unprecedented scientific progress has also become the dawn of a new age of doubts, regarding the

1 . Time (Weekly Magazine)

future benefits to the human race of bold new scientific ventures, because technological advances seem to accompany environmental ravages. On the philosophical level, there is a new mood of scepticism about the absolute objectivity and utter rationality of the scientific methods. Says Harvard Biologist- Historian E.I. Mendelsohn, 'Science, as we know it, has outlived its usefulness.' There is a new fascination with the mystical and even irrational. In the recent years, there is a loud and insistent chorus for antiscience. Declares Richard H. Bube, a professor of materials science and electrical engineering at Stanford, 'One of the most pernicious falsehoods ever to be almost universally accepted is that the scientific method is the only reliable way to truth.' Insisting that there is also spiritual knowledge and power besides reason, Theodore Roszak pleads for a return of submerged religious sensitivities. 'Here is a range of experience that we are screening out of our experience in the name of what we call knowledge', says Roszak. The late psychologist Abraham Maslow said that we have learned to think of knowledge as verbal, rational, logical and sensible but transcendental experience is equally important.

Recently, however, some eminent physicists like Geoffrey Chew and David Bohm find it necessary to regard consciousness as an essential aspect of universe that will have to be included in a future theory of physical phenomena.

And so, perhaps this is the most appropriate time to make an attempt to compare the findings of philosophical enquiry with the results of scientific pursuit. "In the history of human thinking" says Werner Heisenberg, "new, interesting and the most fruitful developments frequently take place when two different lines of thought – lines having their roots in quite different parts of human culture, in different times, or different religious traditions – meet and mutually interact."[1] Synchronising the presentations of scientific facts with those of philosophical findings is, however, a very difficult task. The writer may "either succeed in being intelligible by offering only superficial aspects of the problem and thus arousing in the reader the deceptive illusion of comprehension or give an account in such a fashion that the reader is unable to

1. Physics and Philosophy, p. 161.

follow the exposition and becomes discouraged from reading any further."[1] I do not know whether I have been successful in making this presentation both readable and intelligible, the reader who honours me by perusing my humble efforts has to decide this for himself. I have derived much assistance from the following publications for compiling this monograph :

(1) *One, Two, Three*...Infinity by George Gamow.

(2) *Jain Padārtha Vijñāna Meṅ Pudgala* by Mohanlal Banthia.

(3) *History of Western Philosophy* by Sir Bertrand Russell.

(4) *Physics and Philosophy* by Werner Heisenberg.

(5) *Vishva Prahelika* by Munishri Mahendra Kumarji.

(6) *Studies in Jain Philosophy* by Dr.N.M. Tatia.

(7) *The Tao of Physics* by Fritjof Capra.

(8) *The Dancing Wu Li Masters* by Gary Zukav.

(9) *The Jain Philosophy of Non-absolutism* by Dr. Satkari Mookerjee.

(10) *A Brief Historoy of Time* by Stephen W. Hawking.

I am extremely grateful to Acharya Shri Tulsi, who has been the main source of inspiration and but for his blessings, the present work would not have been accomplished.

I am also grateful to Munishri Mahendra Kumarji (my son in worldly relation) for his valuable assistance.

17th October, 1991 (Dushera) *J.S.Zaveri*
263, SION (East)
Bombay-400 022

1. Albert Einstein : Foreword to The Universe and Dr. Einstein.

PRONUNCIATION

Vowels

अ a, आ ā, इ i, ई ī, उ u, ऊ ū,
ऋ ṛ, ए e, ऐ ai, ओ o, औ au,
अं (अनुस्वार) ṁ, अः (विसर्ग) ḥ

Consonants

क् k, ख् kh, ग् g, घ् gh, ङ् ṅ,
च् c, छ् ch, ज् j, झ् jh, ञ् ñ,
ट् ṭ, ठ् ṭh, ड् ḍ, ढ् ḍh, ण् ṇ,
त् t, थ् th, द् d, ध् dh, न् n,
प् p, फ् ph, ब् b, भ् bh, म् m,
य् y, र् r, ल् l, व् v,
श् ś, ष् ṣ, स् s, ह् h,
क्ष् kṣ, त्र् tr, ज्ञ् jñ

ABBREVIATIONS

1.	A.& A.E.M.	Alkali and Alkaline Earth Metals
2.	B.&C.Fam/ B.&C.Families	Boron and Carbon Families
3.	*Bhag. Joḍa*	*Bhagavatī Sūtra Joḍa*
4.	*Bhag. Sūt.*	*Bhagavatī Sūtra*
5.	*Br. Dra. Saṁ/* *Bṛh. Dra. Saṁ.*	Bṛhad Dravya Saṁgraha
6.	C I	Copenhagen Interpretation
7.	Gom.	Gommaṭasāra
8.	I.J.T.	Illuminator of Jain Tenets (English Translation of Jain *Siddhānta Dīpikā*)
9.	J.V.B.	Jain Vishva Bharati
10.	N & O Families	Nitrogen and Oxygen Families
11.	*Niy. Sār.*	*Niyamasāra*
12.	*Pañ. Sār./Pañc. Sār.*	*Pañcāstikāyasāra*
13.	*Prav. Sār.*	*Pravacanasāra*
14.	*Ṣaṭ. Khaṇḍā.*	*Ṣaṭkhaṇḍāgama*
15.	*Tat. Rāja.*	*Tattvārtha Rājavārtika*
16.	*Tat. Śloka Vār.*	*Tattvārtha Śloka Vārtika*
17.	*Tat. Sū/* *Tat. Sūt.*	*Tattvārtha Sūtra*
18.	*Tat. Sūt. Bhā*	*Tattvārtha Sūtra Bhāṣya*
19.	Tr. Metals	Transition Metals
20.	Utt./Uttar.	*Uttarādhyayana Sūtra*

CONTENTS

CHAPTER 1

Atom in Modern Science

INTRODUCTORY

The world is composed of a multitude of things—animate and inanimate. But the two orders of existence known in the modern times as physical and psychical, were not clearly distinguished by the early naive and primitive thought in the West. The recognition of the psychical as an order of existence distinct from the physical belongs to a later stage of intellectual development.

The concept of matter has undergone a great number of changes in the history of human thinking. Different interpretations have been given in different philosophical systems. All these different meanings of the word are still present in our time as the word 'matter'.

The problem of atom, the smallest indivisible unit of matter, is one of the earliest as well as one of the most persistent in the whole range of philosophy of nature, as well as experimental sciences. When experimental sciences, which deal directly with material substances and their properties, investigate the problem, it can do so only through a study of the infinite variety and mutability of the forms of matter. Its fundamental task is the discovery of descriptive formulae which assist depiction and calculations of various processes and finding some natural laws. The philosophy of nature, on the other hand, does not deal with the particular facts amassed by experiment but with the hypothesis used by experimental science for the co-ordination of those facts. The goal of experimental science is the description of the facts while the goal of philosophy is their interpretation. The difference of aim is, however, not ultimate.

Physical science draws a marked distinction between objects which are perceived by senses, and consciousness. The following points are generally agreed upon as the distinguishing marks between the two orders :

(A) Physical existence is purely material and is devoid of consciousness, whereas psychical order possesses consciousness.

(B) Physical order is made up of events which conform rigidly to certain universal laws; the elements of which it is composed always behave in the same surroundings in the same uniform way. Whereas, the sequence of events in psychical order is teleological (i.e. determined by reference to an end or purpose), that of the physical order is mechanical (i.e. determined by the principle of causality).

(C) Every element of physical order fills a position in space and time and is, therefore, perceptible whereas consciousness is imperceptible by the senses.

Thus, we may say that the physical order comprises all existence perceivable by the senses, as an aggregate of events in time and space, linked together by the principle of causality and exhibiting conformity with the laws of physics. From this general characteristics of the physical order arise the fundamental problems of cosmology viz., the real structure of material existence and the ultimate significance of the distinction between the two orders.

In this chapter, we propose to review how the exceedingly primitive way of conceiving the nature of material existence developed stage by stage from the first epoch of Greek philosophy to the sub-atomic physics of modern times. Our discussions, however, will necessarily be quite imperfect and elementary for more reasons than one. Firstly, the facts of which some account must be taken are so numerous and complicated that they would require for their mastery something like an encyclopaedic acquaintance with the whole range of experimental sciences viz., physics, chemistry, etc. Secondly, an adequate interpretation on the cosmological side would demand a familiarity with higher mathematics. Thirdly, full discussion of the divergent views held by the different philosophers and scientists would demand very much more space than we are at liberty to grant in this book. We shall deal with the broad outline of the general principles.

SECTION I

ANCIENT DEVELOPMENT

The word 'physics' is derived from the Greek word 'physis' which means the 'essential nature' or 'real constitution of things'. The roots of physics are to be found in the first period of Greek philosophy in the sixth century B.C. At that time, science, physics and religion were not separated, and the earliest Greek philosophers saw no distinction between animate and inanimate, spirit (consciousness) and matter. All forms of existence were supposed to be endowed with life and spirituality. And they did not even have a proper term for what we now call matter.

The early Greek philosophy from Thales (Sixth Century B.C.) to the atomists (420 B.C.) in seeking the unifying principle in the universal mutability of all things, had formed the concept of cosmic matter, a universal substnace, which experiences all these transformations, from which all individual things arise and into which they become again transformed. This matter was partly identified with some specific natural element like water, air or fire.

There is enormous difference between modern science and ancient Greek philosophy. Since the time of Galileo (and Newton), science has been based upon a detailed study of nature and upon the postulate that only such statements should be made. as have been verified or at least can be verified by experiments. This way of basing all theories firmly on experiment is known as the scientific method. The idea that one could single out some events from nature by an experiment, in order to study the details and to find out what is the constant law in the continuous change, did not occur to the Greek philosophers. Therefore, science has from its very beginning stood upon a much more modest, but at the same time firmer, basis than the ancient philosophy. Therefore, the statements of modern physics are, in some way, meant far more seriously than the statements of Greek philosophy. When Plato says, for instance, that the smallest particles of fire are tetrahedrons, it is not quite easy to comprehend what he really means.

ATOM IN GREEK PHILOSOPHY

The idea of the smallest indivisible ultimate building blocks of matter first came up in connection with elaboration of the concepts of Matter, Being and Becoming which characterised the first epoch of Greek philosophy. The fundamental question was 'what is the material cause of all things?' Simultaneously, there was a demand that this question be answered in conformity with reason, without resort to myths, mysticism or superstition.

Greek philosophy and science which were not originally separate were born together at the beginning of the sixth century B.C.,with the first of the Milesian philosopher, Thales. He took his view primarily from meteorological considerations and held that "WATER is the material cause of all things."

Of all things we know, WATER can take the most diverse shapes; it can take the form of ice and snow, it can change itself into vapour and can form clouds. it seems to turn into earth where the rivers form their delta, and it can spring from the earth. And to add to all this, water is the condition – a must – for life to exist. If there was such a fundamental substance at all, it was natural to think it to be of water as out of this all others are formed.

Anaximander, second philosopher of the Milesian school and a pupil of Thales, did not accept water or any other known substance. According to him the primary substance was infinite, eternal and ageless and it encompassed the whole world. This primary substance, according to him, was transformed into various substances with which we are familiar and these were transformable into each other.

Anaximenes, the last of the Milesian triad (500 B.C.) taught that AIR was the primary substance. "The soul is air, fire is rarefied air; when condensed, air becomes first water, then earth and finally stone." Thus he introduced the idea that the process of condensation and rarefication caused the change in the primary substance. The condensation of water vapour into clouds was an obvious example and of course the difference between water vapour and air was not known at that time.

The Milesian school of thought is important not for what it achieved but for what it attempted. The speculations of Thales, Anaximander and Anaximenes are to be regarded as scientific hypothesis. The next stage in Greek philosophy is more religious but less scientific.

Heraclitus (500 B.C.) was a mystic of a peculiar kind. He regarded FIRE as the basic element. Everything like the flame in a fire is born by the death of something. He taught that the world is at once one and many. There is unity in the world but it is not unity forming the combination of opposites. The strife of the opposites is really a kind of harmony and 'the opposite tension' of the opposites constitutes the unity of the one. He believed in perpetual change that all things are in a constant state of flux, this flux being due to an everlasting conversion of matter into energy and energy into matter, everywhere over the vast stretches of the material universe.

At this point, let us pause for a while and compare the findings of the ancients with the modern. Firstly, the problem whether the primary substance can be one of the known substances or must be something essentially different, occurs in a somewhat different form in the most modern part of atomic physics. The physicists today try to find a fundamental law of motion for matter from which all elementary particles and their properties can be derived mathematically. This fundamental equation of motion may refer either to waves of a known type, proton and meson waves or to waves of an essentially different character which have nothing to do with any of the known waves of elementary particles. In the first case, it would mean that all other elementary particles can be reduced in some way to a few sorts of 'Fundamental' elementary particles. In the second case, all different elementary particles could be reduced to some universal substance which we may call energy or matter, but none of the different particles could be preferred to the others as being more fundamental. The later view, of course, corresponds to the doctrine of Anaximander and in modern physics, this view is perhaps the correct one.

Next, Heraclitus holds that the change itself is the fundamental principle and is represented by FIRE as the basic

element which is both matter and a moving force. Modern physics is, in some way, extremely near to the doctrines of Heraclitus. If we replace the word 'fire' by the word 'energy' we can almost repeat his statement word for word from our modern point of view. Each manifestation of energy involves either matter in motion or a change in its physical state, which we designate as physical energy; a change in the chemical constitution of matter, which we know as chemical energy; or a combination of the two. Physical energy can be converted into chemical energy and vice versa. The chemical energy stored in the plant manifests itself by an increase in the plant as weight as compared with that of its original constituents. Similarly, the release of energy manifests itself through a loss in the total weight of the plants as substance. Energy is, in fact, the substance from which all elementary particles, all atoms and therefore all things are made, and energy is that which moves. Energy is a substance since its total amount does not change, and that the elementary particles can actually be made from this substance is seen in many experiments on the creation of elementary particles. Energy can be called the fundamental cause for all change in the world. But comparison of Greek philosophy with the ideas of modern science will be discussed later.

Parmenides (450 B.C.) denied the existence of empty space for logical reasons. Since all change required empty space, as he assumed, he considered change to be impossible, and regarded the changes perceived by us as mere illusions of the senses. Parmenides was in strong opposition to Heraclitus, and where Heraclitus maintained that everything changes, Parmenides retorted that nothing changes. What the subsequent philosophy accepted from Parmenides was not the impossibility of all change but the indestructibility of substance. The concept of an indestructible substance as the substratum of varying properties grew out of this philosophy, and became one of the fundamental concepts of western thought.

Empedocles (440 B.C.), younger contemporary of Parmenides changed for the first time from monism to a kind of pluralism. He assumed four basic elements : Earth, Water, Air and Fire. Each of these were everlasting but they could be mixed

together in different proportions and separated to form the varieties of things and thus produce the changing complex substances that we find in the world. Here for the first time, the idea is expressed that the mixture and separation of a few substances, which are fundamentally different, explains the infinite variety of things and events.

According to these views, the soil, for example, was a combination of earth substance and water substance closely mixed, atom by atom. A plant growing from the soil combined earth and water atoms with the fire atoms coming from the rays of the sun to form composite molecules of wood substance. The burning of dry wood from which the water element was gone, was viewed as decomposition or breaking up of wood molecule into the original fire atoms, which escape in the flame and the earth atoms which remain as the ashes.

Anaxagoras (462 - 422 B.C.), a contemporary of Empedocles, took the next step towards the concept of atom. He assumed infinite variety of infinitely small seeds (not the four elements of Empedocles. but innumerably many different seeds) which were mixed together and separated again to create multiplicity of things. The seeds may change in number and in relative position. All seeds were in everything, only the proportions might change from one thing to another.

THE ATOMISTS

The founders of atomism were two—Leucippus and Democritus. It is difficult to disentangle them because they are generally mentioned together. They drew clear line between spirit and matter, picturing the latter as being made up of "basic building blocks"

Democritus who was a contemporary of Socrates and who flourished about 420 B.C., took the final step towards the concept of atom, the indivisible smallest unit of matter. His atom is eternal and indestructible but it has a finite size. Thus the idea, of the elementary particle as the fundamental building block of the matter, was voiced for the first time in the history of western philosophy twenty-three centuries ago.[1]

1. The Jain Theory of *Paramāṇu* is more ancient. See Chapter II

The atoms of Democritus were purely passive and intrinsically dead particles moving in the void. They were all of the same substance but had different sizes and shapes. Each atom was eternally unchanging and, in fact, a Parmenidean one. Each atom was impenetrable and indivisible, because it contained no void. Between atoms there was empty space or void through which they could move, collide with each other and occupy different positions, and may combine with each other sometimes, according to some natural laws. But they had no other physical properties. They had neither colour, nor smell, nor taste. The properties of matter which we perceive by our senses were supposed to be produced by the movements and positions of the atoms in space.

Democritus is quoted to have said: "A thing merely appears to have colour, it merely appears to be sweet or bitter. Only atoms and empty space have a real existence".

The basic ideas of atomic theory were taken over and modified in part by the later Greek philosophers. Epicurus (342-270 B.C.) followed Democritus in believing that the world consisted of atoms and void, but he did not believe, as Democritus did, that atoms were at all times completely controlled by natural laws.

Plato (428-348 B.C.) who was not an atomist himself combined ideas that were near to atomism with the doctrines of the Pythagorean school and the teachings of Empedocles. Pythagoreans had established the connection between religion and mathematics which ever since has exerted the strongest influence on human thought. There was also much mysticism in the doctrines of the Pythagorean school which for us is difficult to understand. But by making mathematics a part of their religion, they touched upon an essential point in the development of human thinking.

Plato knew of the discovery of the regular solids made by the Pythagoreans and of the possibility of combining them with the elements of Empedocles. He compared the smallest part of the element earth with the cube, of air with the octahedron, of fire with the tetrahedron and of water with the icosehedron and so on. The common characteristics of the regular solids which

represent the four elements and the atoms of Democritus was that both were indestructible. But the smallest parts of matter were not the fundamental Beings, as in the philosophy of Democritus, but were mathematical forms. Here it is quite evident that the form is more important than the substance of which it is the form.

The Democritean atoms were associated with external forces which caused their motion. These were assumed to be of spiritual origin and different from matter. In subsequent centuries, the dualism between mind and matter became an essential element of western thought.

WESTERN SCIENCE : CARTESIAN DIVISION

Further development of Western science came after renaissance, when the influence of the church was greatly diminished. In the late 15th century, experiments were undertaken to test speculative ideas. Later on, with the development of mathematics, proper scientific theories were formed and expressed in mathematical formulae. Galileo was the first to combine empirical knowledge with mathematics and is considered as the father of modern science.

In the 17th century, Rene Descartes' views led to an extreme formulation of the spirit/matter dualism, and is known as 'Cartesian division of matter and mind'. This resulted in viewing the material world as a huge machine and Sir Isaac Newton's 'Laws of Mechanics' formed the foundation of classical physics. The mechanistic Newtonian model of the universe dominated all scientific thought for nearly three centuries. Thus, the Cartesian division and the mechanistic world-view were extremely successful in the development of classical physics and technology.

After this short survey of development of theory of atom, let us compare our modern views on the atom with the ancient development. Historically the word 'atom' in modern physics and chemistry was referred to the wrong object, during the revival of science in the seventeenth century, since the smallest particles belonging to what is called a chemical element are still rather

complicated systems of smaller units. These smaller units are now-a-days called elementary particles and it is obvious that if anything in modern physics should be compared with the atoms of Democritus, it should be the elementary particles like proton, neutron, electron, meson, etc.

Metaphysically, the atom of Democritus is rather an abstract piece of matter, since it is deprived of the qualites of colour, smell, taste, etc. which are explained by the motion and arrangement of atoms. But his atom has the primary quality of "Being" and of extension in space, shape and motion. It would have been difficult to speak about the atom, if latter qualities had also been taken away from it.

Elementary particle of modern science has also no colour, no smell, no taste, and in this respect resembles the atom of the Greek philosophy. Moreover, elementary particles of modern physics are as much abstract as the atom of Greeks. All atoms of Democritus consist of the same substance. The atoms of Democritus are eternal, indestructible units of matter. The elementary particles of modern physics are certainly not eternal and indestructible units of matter, and they can actually be transformed into each other. All particles are made of same substance: energy.

Carrying the comparison from metaphysical point of view to familiar objects, we now know that air is not a simple element as the ancients thought it to be but is a mixture of nitrogen, oxygen, carbon dioxide, water-vapour and other gases. Let us take another example illustrating differences between ancient and modern views on chemical transformations. We know that different metals are obtained by processing corresponding ores in furnaces at high temperatures. The ancient scientists believed that ores were made from the earth substance as other rocks. So, when they obtained strong shining substance from these ores, they explained the transformation by saying that the metal was formed by a union of earth and fire. The different qualities of different metals were accounted by saying that different proportions of earth and fire atoms went into their formation. Thus, gold contained more fire than iron.

Reasoning that if fire atoms were added to iron or copper, it would turn into gold, the alchemists of Middle ages spent much time to make synthetic gold from cheaper metals. The fallacy of their theory and practice lay in their belief that metals were composite rather than elementary substances. The transformation of iron ore into metallic iron in the blast furnace is not due to a union of atoms as ancients believed, but quite the reverse. Most metallic ores are oxides and the process of making metal is the separation of oxygen atoms from the molecules of the oxide, leaving the atoms of pure metal. On the other hand the rust which appears on the surface of iron objects due to moisture is not earth substance left behind after the escape of fire atoms from the iron substance but the formation of iron oxide resulting from the union of iron atoms and oxygen atoms from the water or air.

1. Thus, whereas, an ancient scientist would express the processing of iron ore by the formula:

(a) Earth atom+fire atom=Iron atom
and the rusting of iron by:

(b) Iron=Earth (rust) + Fire

2. The modern chemist would express the same by:

(a) $FeO_2=Fe+O_2$

(b) $Fe+O_2=FeO_2$
(Fe=Ferrum (iron), O=Oxygen).

From the above discussion it is obvious that ancient concepts of the structure of matter and the nature of chemical transformations were basically correct. Their error lay in the misconception of what was composite and what was the elementary substance. In fact, none of the four elements listed by Empedocles is really elementary. Air is a misture of oxygen, nitrogen and other gases; water is a compound of hydrogen and oxygen; earth has a very complex composition and fire atoms do not exist at all.[1]

1. As we have remarked earlier, the word fire can be replaced by energy but the idea of fire atoms itself was also partially revived in Quantum Theory of Light.

There exist in nature 92 different chemical elements i.e. 92 different kinds of atoms. While some of these elements such as oxygen, nitrogen, carbon, etc., are rather abundant, some others such as lanthanum, cerium, etc. are very rare. In addition to 92 natural elements, modern science has succeeded in making several entirely new elements artificially.[1] Combining among themselves in various proportions, the atoms of these basic elements form the unlimited number of various substances, some simple and common such as water; others complex chemical materials such as sugar, starch, cellulose.

1. The following elements have been artificially made by man :

Atomic No.	Name	Symbol
93	NEPTUNIUM	Np
94	PLUTONIUM	Pu
95	AMERICIUM	Am
96	CURIUM	Cm
97	BERKELIUM	Bk
98	CALIFORNIUM	Cf
99	EINSTEINIUM	Ei
100	FERMIUM	Fm
101	MENDELEYIUM	Md
102	NOBELIUM	No
103	LAWRENCIUM	Lw

SECTION II

MODERN SCIENCE

A. MECHANICS AND ELECTRODYNAMICS

CLASSICAL PHYSICS

As we have seen, Philosophy and Science were not separate until the first half of the seventeenth century when Rene Descartes based his view of nature on a fundamental division into two realms – mind and matter. The Cartesian division helped the scientists to study the physical universe as an independent objective reality. And they treated the material world as a huge machine composed of different objects. It was Isaac Newton who constructed his mechanics on its basis and his laws became the foundation of the classical physics. From the second half of the seventeenth to the end of the nineteenth century, scientific thinking was very largely dominated by the Newtonian model of the universe which supported all of science as well as Natural Philosophy for almost three centuries.

Newton was the first person to discover "Laws of nature" which unify many aspects of common experience. Newton's Laws of Motion were, in fact, based upon sound experimental evidence and nothing else. They predict and depict events which are simple to understand and easy to picture, because they pertain to ordinary objects of daily experience. Besides the laws of motion, Newton's great contribution to science was the 'law of gravity'—a remarkable Natural phenomena, though it is generally taken for granted. It is the same force which pulls objects downwards and also keeps the celestial bodies like the moon and the planets rotating in the orbits. The laws of motion not only give us a fore-knowledge of eclipses, seasons etc., but we can also know precisely where the moon will be in relation to the earth, and the earth in relation to the sun at any given moment. Without Newtonian physics, the space-programmes might not have been possible.

The stage of the Newtonian universe was (1) the three dimensional absolute space—"always similar and immovable" and (2) absolute time, a separate dimension—"flowing uniformly without regard to anything external". Material particles (actors) or mass-points—small, solid and undestructible objects, out of which all matter was made—moved in this asbolute space, filled with ether (medium of motion), strictly obeying the laws of motion in respect to the absolute time. It can be seen that this model was not very much different from that of Greek atomists. The important difference between the Democritean and Newtonian atoms is that the former were moved by external forces, which were assumed to be of spiritual origin, and therefore, were fundamentally different from matter while in the case of Newtonian particles, the moving force acting between them is an innate quality of matter, depending upon the mass and the mutual distance of the particle. It is the force of gravity.

Physicists upto the 19th century firmly believed that the universe was indeed a huge machine worknig in accordance with the Newtonian equations of motion which were the basis of classical mechanics. In fact, these laws of motion were accepted as the ultimate theory of natural phenomena. But, alas, a new physical reality viz electromagnetic phenomena which was discovered in less than a hundred years dethroned the supremacy of the Newtonian laws and exposed their limitations, and also established that none of their features had absolute validity.

DISCOVERY OF ELECTROMAGNETIC PHENOMENA

In the nineteenth century, the first persons to go beyond the Newtonian Physics were Michael Faraday and James Clerk Maxwell. This radical change in scientific outlook was brought about by the discovery of a new type of force which the mechanistic model failed to describe. This was the 'electomagnetic phenomena'. In fact, Faraday was the first person to bring science and technology to a turning point by producing an electric current in a coil of copper by moving a magnet near it. The colossal technology of electrical engineering was the result of this fundamental experiment converting mechanical energy into electrical one. At the same time, it formed the foundation of the

theory of electrodynamics. The fundamental difference between the Newtonian laws and Electrodynamics is the concept of "field of force", i.e. an electric charge produces a 'condition' in space around it so that another charge feels a force. This was a much subtler concept than that of Newtonian 'force' and eliminated the existence of ether. It produced a most profound change in the basic concept of physical reality. It was Einstein who clearly recognised this fact 50 years later, when he declared that no ether existed and the electromagnetic fields were physical entities which could travel through empty space and could not be explained mechanically. Ultimately, it resulted in the realization of the electromagnetic nature of light.

ELECTROMAGNETIC RADIATION—LIGHT

Much earlier, there were two theories about light : One which Newton favoured was that it was composed of particles, called corpuscles; the other was that it was made of waves. A proper theory of the propagation of light did not come until 1865, when Maxwell succeeded in unifying the forces of electricity and magnetism. Maxwell's equations predicted that electromagnetic waves travel at a fixed speed. Thus, light is a rapidly alternating electromagnetic field travelling through space in the form of waves at a fixed speed.

In due course, it was established that radio-waves, light, and X- rays are all waves forming the electromagnetic spectrum, a tiny fraction of which—the visible spectrum—is visible in the form of light. This remained the accepted and proven theory of light upto 1905.

Einstein's theory of light was that it is composed of tiny particles called photons. A beam of light is analogous to a stream of bullets. To prove his theory, Einstein referred to a phenomenon called the photo-electric effect, in which when light impinges on a metal surface, it sends electrons flying off. If a photon hits an electron, it knocks it away just as one billiard ball hitting another one knocks it away.

It was also found that the velocity of the rebounding electrons did not depend upon the intensity of the impinging light,

but on its colour. Thus each photon of a given colour, say, green, has a certain amount of energy. Reducing intensity only reduces the number of photons, but each green photon has the same amount of energy. This brings us to the problem of colour.

Newton had discovered that if sunlight passes through a triangular-shaped piece of glass, one of the most beautiful phenomena occurs. From the other side of the glass comes not white light but every colour in the rainbow from red to violet with orange, yellow, green, blue, and indigo in between. This display of colours is called visible spectrum. When white light, which is a mixture of different colours, passes through prism, different colours are bent by different amounts—red the least, violet the most. Each colour has its own specific wave-length and frequency. The wave-length of red is longest while that of violet is shortest.

All the colours of visible light (together with infra-red and ultra-violet radiations) represent only a small portion of a band of radiations from high-energy X-rays to low-energy radio waves. The higher the energy, the shorter is the wave-length. Thus, high frequency light such as violet has a short wave-length and a high energy; low frequency light such as red has a long wave-length and a low energy. Velocity is the product of wave- length and frequency. The velocity of all electromagnetic waves—lights of all colours radio-waves, X-rays, and all the other forms of radiation—is always 1,86,000 miles per second (i.e.3,00,000 kilometers per second). This constant speed of light is usually represented by the letter "c".

In the beginning of the 20th century, thus, there were two successful theories :

(1) Newtonian mechanics, and

(2) Maxwell's electrodynamics; the Newtonian monopoly of being the basis of all physics was destroyed.

B. STRUCTURE OF ATOM

For fully understanding the structure of matter, we have to descend from the macroscopic to the microscopic level. This has to be done in two stages—first, at the atomic level and second, at the subatomic level.

The first real step forward in an understanding of the structure and the various chemical and physical properties of matter was taken when it was accepted that atoms were not simple indivisible particles of various shapes and sizes, but on the contrary rather complex mechanisms with a number of independent parts in motion.

At the turn of the century, inexplicable phenomena connected with the structure of atom were discovered. Discovery of a new radiation – X-ray – gave the first indication that the atom had some structure. Radio activity gave definite proof of the complex nature of atom, when it was discovered that radioactive substances not only emit radiations but also transform themselves into atoms of new substance.

PLANETARY MODEL

In 1904, famous British physicist J.J.Thomson successfully proved that the atoms of various chemical elements consist of positively and negatively charged components. They are held together by the forces of electric attraction. He called the negatively charged particles electrons, a large number of which were floating in the interior of a mass, with a uniformly distributed positive charge. The atom on the whole is electrically neutral because the total charge of all negative particles equals the total positive charge. The electrons were assumed to be bound comparatively loosely to the body of the atom and one or several of them could be removed by the process of ionisation. Thomson was able to estimate the mass of an electron which turned out to be very small indeed. According to his estimate the mass of a whole hydrogen atom is 1840 times the mass of an electron. This indicated that the main portion of atomic mass is contained in its positively charged components. Thomson was, however, very far from the truth concerning the uniform distribution of the positive charge through the body of the atom.

In 1911, another British scientist Ernest Rutherford, called the father of modern atom, realized that so-called alpha particles emanating from radio-active substances can be used as high speed

projectiles to explore the interior of the atom. He bombarded atoms with alpha particles in his now famous experiments called "scattering of the alpha particles in their passage to the matter". He obtained totally unexpected results. It was established that the atoms, far from being solid particles, (they were believed to be since antiquity), consist of extremely small particles and vast empty space. Rutherford also showed that almost the entire mass as well as the positive charge of the atoms is concentrated in a nucleus located in the very centre of the atom. The nucleus is, in fact, thousands of times smaller than the atom itself. Thus the originally widespread positive charge of Thomson's atom shrunk into a tiny one in the centre of the atom, while the electrons rotated outside.

Thus, the model of the atom created by Ernest Rutherford was somewhat akin to our solar system : at the centre of an atom is the nucleus, just as the sun is at the centre of our solar system. Almost all of the mass of the atom is located in the positively charged particles called protons at the centre. Orbiting about the nucleus, as the planets orbit the sun, are electrons, which have almost no mass compared with the nucleus. Each electron has one negative charge. The number of electrons is always the same as the number of protons, so that the positive and negative charges cancel each other and the atom, as a whole, has no charge. The space occupied by the atom is so huge, compared with the size of its particles, that the electrons orbiting the nucleus are 'like a few flies in a cathedral', according to Rutherford.

The magnitude of atoms is so far removed from our macroscopic scale that it is very difficult to visualize the size of this microscopic entity. The diameter of an atom is about one hundred-millionth of a centimeter. If an object of the size of a cricket ball is magnified to the size of earth, its atoms will then have the size of grapes. An atom, therefore, is extremely small compared to macroscopic objects but it is huge compared to its nucleus in the centre. The diameter of the atom is 1,00,000 times greater than the diameter of nucleus, while its volume is 5,00,000 billion times the volume of nucleus. To see the nucleus, the atom will have to be blown up to the size of the biggest dome in the world. In an atom of that size, the nucleus would have the size of a grain of sand!

In the planetary model of the atom, the nucleus contains 99.97 percent[1] of the total atomic mass and the distance between the electrons exceeds their diameter by several thousand times. The electric attraction forces between the nucleus and the electrons obey the mathematical law of inverse square i.e. the forces are inversely proportional to the square of the distance between them and the electrons describe the circular and elliptical trajectories around the nucleus. It can, thus, be seen that most of the matter in the universe is concentrated in the nuclei of the atoms. The density of the matter in the nucleus is such that a paisa would weigh 600 million tons if its atoms were as tightly packed as the particles in the nucleus.

It was found by Rutherford that in the natural sequence of elements arranged in the order of increasing weights, there is a consistent increase of one atomic electron in each element in the sequence. Thus an atom of hydrogen has one electron; an atom of helium 2; lithium 3; berillium 4; and so on upto the heaviest natural element—uranium which has altogether 92 electrons.

The numerical designation of an atom is usually known as its atomic number and coincides with its positional number in the atomic table. Thus, all the physical and chemical properties of any given element can be characterised simply by one figure giving the number of electrons rotating around the central nucleus.

BOHR'S THEORY OF ATOM

It was noticed that some of the properties of the elements begin to repeat themselves after a definite number of steps when arranged in a natural sequence. Since each step along the sequence of elements corresponds to one additional electron, the observed periodicity must be due to the recurrent formation of certain stable configuration of atomic electrons, or "eletronic shells".

1. 97.87 percent of the total mass of the solar system is concentrated in the sun.

In 1913, Neils Bohr, a Danish physicist, won the Nobel prize by showing that electrons do not revolve round the nucleus of an atom at any random distance, but in definite orbits or shells which are at specific distances from the nucleus. A certain number of electrons, but no more, can be accommodated in each of these shells thus :

Shell number	1	2	3	4	5.....
Maximum number of electrons	2	8	18	32	50.....

Thus, an atom with 3 electrons will have 2 in shell no. 1 and 1 in shell no. 2. If the atom has more electrons than the combined capacity of the first two shells, viz. 10, then the third shell begins to fill up and so on.[1]

Bohr also discovered that whenever an atom absorbs energy, its electrons jump to one of the outer shells. They return to the inner shells (ground state) by emitting the energy absorbed earlier and normally stay as close to the nucleus as they can.

We can now, having the picture of an atom, turn our attention to the nature of forces which bind together the atoms of different elements into complex molecules of innumerable chemical compounds The chemical bond between the neighbouring atoms in molecule is due to the interaction of the electronic shells and the forces involved are comparatively small. The distinction between the atomic nuclei and the electronic shells of different elements at once gives a proper explanation of the various physical and chemical properties of the elements and also of the fact that they are the ultimate units of matter. The chemical properties of atom are, however, controlled by the nucleus. If one wants to change the chemical properties of an atom, one has to change the nucleus and this requires energies about a million times greater.

CONSTITUENTS OF ATOM

With the creation of the planetary model of atom by E. Rutherford, 'proton' and 'electron' emerged as the smallest units of matter. The questions asked by the physicists were : Are these

1. See Atomic Table in the appendix.

the "basic building blocks"—the ultimate units of matter? Can we subdivide them still further into smaller and simple particles? Would it be possible to reduce all different atoms to perhaps a few really simple particles?

In the middle of the last century, William Prout, an English chemist put forth a hypothesis that the atoms of all elements are made up of various numbers of hydrogen atoms. This hypothesis was based on the fact that the atomic weight of various elements were in most cases very nearly exact multiples of that of hydrogen. Thus atoms of oxygen which are sixteen times heavier than those of hydrogen, must be composed of 16 hydrogen atoms, somehow stuck together. But the facts found at that time were unfavourable to the acceptance of this bold hypothesis. Isotopes were not discovered and the chemical atomic weight of chlorine for instance, being 35.5 was in direct contradiction to Prout's hypothesis. He died without ever learning how right he actually was.

In 1919, British Physicist F.W. Aston discovered that ordinary chlorine was actually a mixture of two different kinds of chlorine possessing identical chemical properties but having different atomic weights: 35 & 37. Further study revealed the striking fact that a mixture of several components, identical in chemical properties but differing in atomic weights, made up most of the elements. They were called isotopes. Prout's forgotten hypothesis was given a new life and was reformulated by saying that nuclei of various atoms are composed of various number of hydrogen nuclei called protons.

An important step towards a better understanding of nuclear structure of atom was the discovery of neutron as the second constituent of nucleus. It is a particle which has roughly the same mass as proton, but does not carry an electric charge. Actually the nuclei of various elements are composed of protons as well as neutrons. The existence of neutrons was suggested by Rutherford in 1920, but they were found experimentally only in 1932.

Thus, the nucleus of an oxygen atom which is the eighth element in the atomic table and has 16 units of mass and 8 units of charge must be composed of 8 protons and 8 neutrons, whereas the heavy nucleus of uranium, atomic weight 238, atomic number 92, is formed by 92 protons and 146 neutrons. An important fact to keep constantly in mind about protons and neutrons is that the two are interchangeable. A proton, under certain conditions, loses its positive charge by emitting a positive electron (positron) and thus becomes a neutron. Similarly, a neutron, when agitated, emits a negative electron and becomes a proton. As we shall see, the latter process is taken advantage of in the transmutations of nonfissionable uranium into plutonium and of chromium into fissionable uranium 233. The transmutations of all other elements—age-old dream of alchemists—is made possible by the interchangeability of protons into neutrons and vice versa. Protons and neutrons are, thus, two electrical states of the same basic particle called nucleon.

The atoms of the elements have twins, triplets, etc., known as isotopes. The nuclei of these twins etc, all contain the same number of protons and hence all the same chemical properties. They differ, however, in the number of neutrons in their nuclei and hence have different atomic weights. For example, an ordinary hydrogen atom has nucleus of one proton. The isotope of hydrogen—deuterium has one proton plus one neutron in its nucleus. It is, thus, twice as heavy as ordinary hydrogen. We may now say that different combinations of two types of basic particles (called elementary particles), participating in the structure of the material universe, result in the infinite variety of the material world: First of all we have electrons with a negative electric charge and negligible mass. Then, we have nucleons which represent the basic material particles. They are either neutral, called neutrons, or positively charged, called protons.

But, as we shall see presently, many more particles have been discovered, and the number of particles increased from three to six by 1935, then to eighteen by 1955, and today we know over 200 "elementary particles".

SECTION III

NEW PHYSICS

DUAL NATURE OF MATTER

As stated above, the planetary model showed that atoms, instead of being hard, indestructible and indivisible particles, consisted of vast regions of empty space, in which extremely small particles – electrons – moved around the nucleus, bound to it by electromagnetic forces. But, later development in Quantum physics established that even these particles were not solid objects of classical physics. They appear sometimes as particles, and sometimes as waves.

QUANTUM PHYSICS

The Quantum physics forced itself upon the scientific world at the beginning of this century with a discovery made in 1900 by Max Planck. He was trying to solve a specific problem, dealing with energy radiation. He wanted to know why objects glow bright and change colour when the temperature is increased (or decreased). Classical physics failed to give explanation to this simple phenomenon. Planck discovered that energy is not radiated (or absorbed) smoothly and continuously, but in spurts of specific amount or quanta[1] (discrete packets). It was difficult to accept the concepts of the new theory, even after its precise and consistent mathematical formulation, because their implications were practically unbelievable.

In 1905, at the age of 26, Albert Einstein exploded upon the field of science with a force seldom exerted by a single scientist. He constructed the 'Theory of Relativity' in its complete form, entirely by himself. In the same year, he also declared a new way of studying the electromagnetic radiations which was to become the basis of Quantum Physics. It took several years' work by a

1. Planck himself was very unhappy with the implications of his discovery as he had no intention to destroy the foundation of the Newtonian Physics.

whole team of International group of physicists[1] to complete the mathematical formulation of the Quantum Theory.

The dual nature is also exhibited by light which can take the form of a particle (photon) or an electromagnetic wave. Radiation must be in the form of waves, because it produces well-known phenomena–interference associated only with waves. On the other hand, however, light also produces photo-electric effect. It was Einstein's theory of light that a beam of light is composed of tiny particles, like a stream of bullets, each bullet being a photon. The problem is that we are talking about particles (photons) in terms of waves (wave-length and frequencies) and waves in terms of particles, thus producing the wave-particle duality paradox. Thus, while Planck described the processes of energy in terms of 'quanta', Einstein theorized that energy itself is quantized. Photons are particles of special kind. They are massless and also travel with the speed of light.

In the early stages of atomic theory, physicists were puzzled by the dual nature of matter : how can anything be simultaneously particle (i.e. confined to a very small space) and a wave (which is spread out over a large area of space)? This apparent contradiction gave rise to a paradox. Physicists were confronted with two sets of repeatable experiences, each of which seemed to disprove the other. This resulted in the famous 'wave-particle duality' which is fundamental to Quantum theory.

The paradox became more paradoxical when Louis de Broglie (in 1924) dropped a bomb which demolished what was left of classical view. He proposed, "Not only are waves particles, but particles are also waves". It was bewildering enough when electromagnetic waves (light) behaved like particles, but when electrons which are particles, were found to behave like waves[2], the effect was stunning. Subsequent experiments revealed that not only subatomic particles but atoms and molecules also have

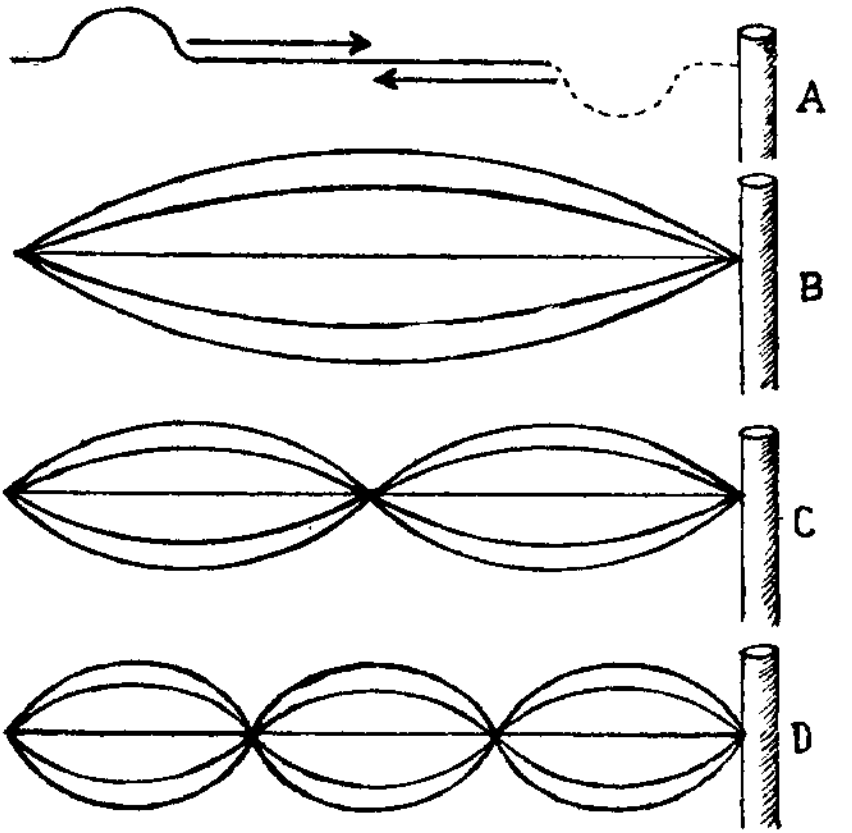
1. The team consisted of (i) Neils Bohr, Denmark, (ii) Louis de Broglile, France (iii) Erwin Schrodinger (iv) Wolfgang Pauli, Austria, (v) Werner Heisenberg, Germany and (vi) Paul Dirac, England.

2. The famous Davisson-Germer-Experiment showed electrons reflecting off a crystal surface in a way that could be explained only if they were waves.

associated matter-waves. Theoretically, everything – tables, cars, men – has a wavelength but their wavelengths are so small that they are not noticeable.

THE NEW ATOMIC MODEL

Let us return to the discussion of the structure of atom. At the atomic level, the planetary model cannot explain some puzzles which arose in connection with the structure of atom. The Quantum theory has shown that the astonishing properties of atom arise



from the wave-nature of the electrons, i.e. the electrons are not spherical objects but patterns of standing waves.[1]

Whenever a particle is confined to a small region of space, it reacts by moving around. Smaller the region of confinement, faster is the speed of the particle. Hence, while the electrons are bound to the nucleus by electric forces (which keep them as near as possible), they respond to their confinement by whirling around. Tighter the bond, higher is their velocity, which is about 1000 km. per second.

Due to dual nature of the electrons, they can no longer be compared to 'planets' in the solar system. Instead they produce what is called 'electron clouds' which are made up of a various standing waves which surround the nucleus.

Just as a fast-rotating fan appears as a disc, the high speeds of the electron-wave make the atom appear as a solid sphere. Thus, they have to settle in orbits in such a way that there is a dynamic balance between attraction of the nucleus and their tendency to escape. This means that they can rotate only in certain atomic orbits, with definite diameters. For example, the single electron of a hydrogen atom can remain in first, second or third orbit, but nowhere in-between. Normally, it will always be in its lowest orbit called 'ground state'. It can jump to a higher orbit, if it is excited by receiving energy. After a while, however, the electron gives off the extra energy by emitting a photon and returns back to its ground state. For all atoms with the same number of electrons, the shapes and mutual distances of their orbits are exactly the same. This is why any two atoms of hydrogen or oxygen will be totally identical. The wave nature of the electrons, thus, clarifies the puzzle of the great mechanical stability and the identity of the atoms. We can now enumerate the unusual features of the atomic level of physical reality which are not found at the macroscopic level :

1. Standing waves can be produced on a rope, tied to a pole. When the rope is pulled tight, there is no wave, but a flick of wrist sharply downwards and then upwards creates a hump which travels down the rope to the pole, where it turns upside down, and returns to our hand. This is a travelling wave. By sending a series of humps down the rope, we can set up different patterns of standing waves. The widest point in the wave and the points at the ends of the waves remain stationary. They are called nodes. Plucking a guitar's string also produces patterns of standing waves on it.

(i) reaction with fast motion to confinement in small space.

(ii) tendencies to exist, instead of definite existence.

(iii) sudden jump from one quantum state to another.

(iv) inter-connectedness of all phenomena.

On the other hand, there is nothing peculiar or special about the basic force of electric attraction between the nucleus (with + ve charge) and electron (with – ve charge), which is responsible for all atomic phenomena. It is the same old familiar force experienced at macroscopic level, between any two opposites. It is the interplay of this familiar electric charge force with the unfamiliar electron waves that is responsible for all chemical reactions and for the formation of a tremendous variety of aggregates of several atoms bound to each other by mutual attraction. Thus, the basis of the entire physical existence and the bodies of the living organisms and their biochemical processes is the interaction between the atomic nuclei and electrons. It must be remembered that inspite of the electrons constituting only a very tiny fraction of the total mass of matter in the universe, their wave-like nature gives a solid aspect to it and also provides the links necessary to build up molecular structures. They are also responsible for and are involved in the chemical reactions. On the other hand, nuclear reactions, as we shall see, generally do not take place because of extremely stable nuclear equilibrium and tremendous energies required for carrying them out.

HEISENBERG'S UNCERTAINTY PRINCIPLE

Newton's Laws of Motion, which, for three centuries, were the basis of physics, do not apply to the subatomic realm[1]. Probability (and not absolute certainty) is a major characteristic of quantum physics because events of individual subatomic particles cannot be determined precisely/accurately. The concepts of position and momentum (mass x velocity) are intimately bound up with our idea of an entity called a moving particle. Werner Heisenberg, a German physicist, proved that even

1. Strictly speaking, Newton's laws remain valid in some experiments involving sub-atomic particles and may be taken as good approximations with description of what is happening.

if we had the best possible measuring devices, time and determination, it is not possible to know both the position and momentum of a subatomic particle (say, an electron) with absolute precision. Both can be known approximately, but the more accurately we know about one, the less accurately we know about the other. For instance, given a beam of electrons, quantum theory can predict the probable distribution of the electrons over a given space at a given time, but cannot predict the course of a solitary electron. The precise mathematical form of the relation between the uncertainties of position and momentum of a particle is known as Heisenberg's Uncertainty Principle. It has undermined the whole idea of a causal universe.

SUBATOMIC LEVEL : THE HEART OF THE ATOM

Let us now descend to the subatomic level for a more detailed study of the nucleus—the heart of every atom. It is not necessary to know more about the nucleus than its charge and its mass to understand the great variety of molecular structures. But to unravel the nature of matter, i.e. to comprehend what matter is ultimately made of, the study of nucleus is essential because it contains almost the entire mass of the atom. Whereas the structure of the outer body of the atom can be, to a certain extent, compared to a miniature solar system, the structure of the nucleus itself presents an entirely different picture. The main task of the post-quantum theory physicists was to study the structure, i.e. the constituents of the nucleus as well as the forces which bind them together as a stable entity.

First of all, it is clear that the nuclear forces which tightly bind the nucleus together cannot be of the familiar electromagnetic origin, since the protons are all positively charged, thus repelling each other.[1]

It must, therefore, be an entirely new force of nature, not encountered anywhere outside the nucleus and must be many

1. The electromagnetic repulsion force in the nucleus varies inversely as the square of the distance separating the positively charged particles. Prof. F. Soddy has figured out that two grams of protons placed at the opposite poles of the earth would repel each other with a force of twenty-six tons.

times stronger than the repelling electromagnetic force. In fact, it is one hundred times stronger than the electromagnetic force and is the strongest force known in nature.[1]

We have already seen that the nucleus is about one hundred thousand times smaller than the atom itself but it contains almost all of the atom's mass. A nucleon has the same quantum nature as an electron and, therefore, reacts, to its being squeezed into a much smaller space, more violently than electron. It races about in the nucleus with an incredible velocity of about 40,000 to 50, 000 miles per second. We have already seen that the nuclear matter is extremely dense[2] compared to matter at macro-level. The high velocity and high density of the nuclear matter is, thus, entirely different from any thing experienced at the macro-level.

The exclusively unique aspect of the strong nuclear force that makes the nucleus an extremely stable unit is that it acts as an attractive force when the constituent nucleons are at a distance of two to three times their diameter. The very same force is strongly repulsive when the distance becomes less so that the constituents cannot get any closer. Thus the equilibrium is dynamic and yet extremely stable.

The comparative instability of the radio-active elements is explained thus. The electromagnetic force of repulsion between the positively charged protons tries to disrupt the nucleus into its constituents. This force is countered by the strong nuclear force which tends to keep it unified. Now if the repulsive force predominates, the nucleus will have a tendency to break up into two or more parts, the process being known as 'fission'. On the contrary, if the strong nuclear force holds the upper hand, not only

1. This strong force can be compared to that encountered in ordinary liquids causing the phenomenon of surface tension. In the atomic nuclei, we have similar force of much greater magnitudes acting as the cosmic cement which prevents the breacking up of the nucleus under the action of electric repulsion between the protons. Thus. if we assume the nuclei of different elements to be droplets of a universal "nuclear fluid", the density of such a fluid will be 24×10^3 times that of the water. Its surface tension forces will be about 10^{18} times larger than those of water.

2. If a mass of about 100 kgs. were to be compressed to nuclear density, it would take less space than an ordinary pin-head.

the nucleus will never break by itself, but will also have a tendency to fuse with other nuclei coming into its contact. It is now established that the electric repulsion forces prevail in all heavier nuclei, while the cohesive forces hold the upper hand in the lighter elements from hydrogen approximately upto silver in atomic table[1] Each proton or neutron in the elements weighs less than it does in the free state, the loss of weight equal to the energy binding the nucleons. This loss becoming progressively greater for the elements in the first half of the atomic table, reaching its maximum in the nucleus of silver. After that the loss gets progressively smaller. Since each loss of mass manifests itself by the release of energy, it can be seen that to obtain energy from the atoms, nucleus requires either the fusion of two elements in the first half of the table or the fission of an element in the second half.

However, because of the state of metastability, neither the fission nor fusion would occur normally unless something was done to start the process[2]. And the process of starting a nuclear reaction is extremely difficult because it needs very high activation energies.

The available energies. when the temperature is not too high, are not high enough, to disturb the nuclear equilibrium, and as we have stated earlier, mostly electrons are responsible for the diverse nature of physical existence on earth.

The multitudes of shapes and molecular architecture can exist only on earth where temperature is not too high.

In the stars, where the thermal energy increases a hundredfold and where most of the matter in universe exists, the state of the matter is radically different from that on earth.

In the centre of stars, where temperatures are very high, the matter exists in large accumulations of nuclear matter and nuclear processes which are rare on earth, predominate there. Of particular importance to us are nuclear reactions in the sun because they supply life-supporting energy on earth. The

1. See appendix.

2. Please see Chapter III for discussion on this point.

discovery that the constant energy-flow from the sun is the result of nuclear reactions is one of the significant achievements of modern science[1].

FORCES KNOWN IN NATURE

The universe, according to physicists, is held together by four fundamental types of glue (force). In other words, all known forces in nature can be grouped into four categories according to their strength. This division is empirical (i.e., man made) for the convenience of explaining partial theories. It is quite possible that all the four types of forces are but different aspects of a single force.

In order of the decreasing strength, they are :

1. Strong nuclear force
2. Electromagnetic force
3. Weak nuclear force
4. Gravity (gravitational force)

1. The strongest force is the 'strong nuclear force' that is the binding force of the nuclei. It not only binds the nucleons, protons and neutrons together in the nucleus of an atom, but binds the constituents (quarks)[2] of these nucleons together. The strong force deserves its name, because it is 100 times stronger than the familiar electromagnetic force. In fact, it is the strongest force known in nature. It has to be strong because it has to keep mutually repulsive protons, not only in close proximity, but also keep them bound together very tightly. It has the shortest range of all the forces known in nature. For example, only if a free proton comes within about one ten-trillionth 10^{-13} of a centimeter of the nucleus, it is suddenly sucked into the nucleus with a force one hundred times more powerful than the repulsive electromagnetic force. One ten-trillionth of a centimeter is about the diameter of the proton itself. At a distance, only slightly greater than its magnitude, the proton is relatively unaffected. Strong force

1. Further description of solar processes is given at the end of this chapter.

2. Quarks are dealt with in a later part of this chapter.

interactions are very very fast i.e., they take about 10^{-22} seconds. (Weak force reactions take about 10^{-10} seconds).

Because the short range, it can never appear as a force at macroscopic level and cannot be experienced in the everyday world.

2. Electromagnetic Force is encountered in everyday world and holds together the atoms and molecules. Every subatomic particle has a positive or a negative charge or it is neutral. Positively and negatively charged particles are attracted to particles with opposite charge and repelled by those with the same charge. It varies inversely as the square of the distance separating the particles. It enables atoms to join together to form molecules and it keeps electrons in orbit around nuclei. At this level, it is the fundamental glue of the universe.

It is much stronger than the gravitational force. For instance, the force between two electrons is 10^{-40} times bigger than the gravitational force.

3. Weak (nuclear) force is the least known of the four forces. Its existence was inferred from the time required by certain subatomic interactions. Whereas strong force interactions happen in about 10^{-23} seconds, weak interactions take a much longer time i.e. about 10^{-10} seconds. In all probabilities, this force and the electromagnetic force are different manifestations of the same force operating at distances between particles.

4. Gravitational force : The weakest of the four is the gravitational force which is universal, i.e., every particle exerts/feels it. It is essentially a long range force, i.e., it acts over large distances. whereas the other three forces are sometimes attractive and sometimes repulsive, this one is always attractive. It holds together the solar systems, galaxies, etc. On the subatomic level, its effect is so negligible that it is ignored altogether.

PARTICLE PHYSICS

The picture of atom which emerged from the study of its nuclei showed that the matter was concentrated in microscopic

drops, separated by huge distances. In the vast ocean of space between the fast moving nuclear drops, moved the electrons which gave matter its solid aspect. Historically, during the course of our descent into the subatomic world a landmark was reached in 1930s when physicists thought that they had finally discovered the "basic building blocks" of matter consisted of atoms and that all atoms consisted of "elementary particles", viz. protons, neutrons and electrons. These were accepted as the ultimate indestructible units of matter. With further refinement of techniques and development of new devices for particle-detection, their number increased from 3 to 6, and then to 18 by 1955. By 1970s, over two hundred elementary particles were known to exist. How can such a large number be called elementary? In fact, a widespread belief among physicists that none of them deserves this title, prevailed.

Theoretical developments which paralleled the discovery of new particles, reinforced the belief. It became increasingly clear that nuclear phenomena demanded the incorporation of relativity theory with the quantum theory, mainly because of the high speed of the subatomic particles, coming close to the speed of light. Relativity established unification of mass and energy which was summed up in the famous equation $E=mc^2$. This unification of mass and energy by the relativity theory forced the physicists to radically modify the concept of a particle. In classical physics, where matter and energy were separate entities, mass was associated with some "stuff" of which all material objects were made. Relativity showed that mass was a form of energy. Now energy being a dynamic entity, the particle can no longer be conceived as a static object but as a dynamic pattern. In 1930, this new view of particles was put forth by Paul Dirac, an English physicist, who imposed the requirement of relativity on quantum physics, and formulated relativistic equations, describing the behaviour of electrons. His theory revealed a fundamental symmetry between matter and anti-matter. It predicted the existence of an 'anti-electron' with the same mass as the electron, but with a positive charge. Two years later, in 1932, Carl Anderson actually discovered this new particle and called it 'positron'. Physicists later discovered that every particle has a counterpart

which is exactly like it but opposite in several major aspects. These counterparts were called antiparticles (equal mass but opposite charge). An anti-particle, despite, its name is a particle. Some particles have other particles as anti-particles. A few particles are their own anti- particles (like the photon).

Whenever a particle meets its anti-particle, they annihilate each other. When an electron meets a positron, for example, both of them disappear and in their place are created two photons which instantly depart from the scene at the speed of light. If there is sufficient energy, a pair of particle and anti-particle can be created conversely, they can be made to turn into pure energy by mutual annihilation. These processes of particle-creation and annihilation, predicted from Dirac's theory have since been observed millions of times by experiments.

HIGH-ENERGY PHYSICS

The most spectacular proof of relevance of relativity theory in particle physics was the creation of material particles from pure energy. Uptil now, the basic question was whether the matter can be divided again and again until one arrived at the smallest indivisible unit. In relativistic particle physics, the only way to further divide subatomic particles is to bang them together. When they collide with high energies, they do break up but the pieces are not smaller than the original particles, but particles of the same kind. We can never obtain smaller pieces because new particles are constantly created out of the energy involved in the process of breaking up. The subatomic particles are thus divisible but at the same time indestructible. Such a paradox is inevitable with the static view of matter composed of basic building blocks. But it disappears when particles are viewed as 'processes', which involve energy appearing as their mass. Because of the high energy collision process, 'particle physics' is also called 'high-energy physics'.

Most of the particles created by collisions have an extremely short life—less than a millionth of a second, after which they disintegrate into one of the three stable particles, viz., protons neutrons and electrons. In spite of this, they can be detected,

photographed and their properties can be measured. They can be produced in the laboratory in the so-called bubble-chambers. The high energy-scattering experiments of the last few decades have firmly established that matter is completely mutable.

All particles can be transmuted into other particles, they can be created from energy and can vanish into energy. In this subatomic universe, classical concepts such as "elementary particles", "basic building blocks", "material stuff" or "isolated object" become meaningless. "A dynamic web of inseparable energy patterns" is a fit description of this world. This means that the properties of a particle can be known only in terms of its interaction with surrounding environment, and therefore, the particle has to be understood as an integrated part of the whole and never as an isolated entity. All particles contradict each other in many ways but all of them reflect the basic unity and intrinsically dynamic character of matter.

Relativity theory has not only affected our conception of particles but also our picture of the forces between these particles. Relativistically the forces between the particles are also **other particles.** This four-dimensional space-time character of the subatomic world is very difficult to visualize nor can our language deal with this concept adequately. And yet it is essential for understanding the subatomic properties where force and matter, which had seemed two entities, are unified. Subatomic particles are both matter **and** force, and this fact is a reason why they can be never subdivided into elementary components. As we shall see later, even protons and neutrons are not elementary but composite objects; but the classical distinction between the force and matter vanishes when the forces are also particles and cannot be decomposed into components.

But old ways die hard and there are physicists who continue the old way of thinking and continue their search for the elementary building blocks of the material universe. The most likely canditate for this title is the 'quark'. It is a type of hypothetical particle theorized by Murray Gell Mann in 1964.

ORDER BENEATH CHAOS

Thus the answer to the fundamental question about a material object "what is it made of" would be a series of similar questions, e.g., what is a chair made of? It is made of wood and what is the wood made of? It is made of fibres. Then fibres are made of cells and cells are made of molecules. Molecules, under high magnification are found to be patterns of atoms and lastly atoms have turned out to be patterns of subatomic particles. Now what are these (particles) made of? Energy! But subatomic particles are not made of energy. They are energy and subatomic interactions are interactions of energy with energy. At this level there is no longer a clear distinction between what is and what becomes, being and becoming become one. Pure energy can perhaps qualify to be called the ultimate stuff of the physical universe. It is energy that assumes the form of a wave or a particle, and what is called a particle is being created, annihilated and created again. High-energy physics is the study of colliding, transmuting, appearing and disappearing particles.

How does this new physics compare with the old classical physics? While the old world-view was the picture of "order beneath chaos", the new one is that of 'chaos beneath order".[1] The rational laws which govern falling objects also govern the motion of planets and there is still, of course, much truth in this as far as the macrocosm is concerned. But in subatomic world-view of relativistic particle physics, there is an unending tumultuous dance of creation, annihilation and transformation.

As Jack Sarfatti wrote : "Particles do not move formally in predetermined paths. Rather it is Marx Brothers' hyperkinetic pandemonium, Charlie Chaplin slapstic, now you see it, now you don't. Infact, it is not even clear what is that has a path Its psychedelic confusion until one sees the subtle order."[2]

Is there absolutely no law ? There, of course, is law of conservation. In fact, the two separate conservation laws of mass and energy of the Classical Physics is replaced by a single

1. The Dancing Wu Li Masters by Gary Zukav, p. 213.

2. Ibid., p. 213.

conservation of mass-energy. For a major revelation by Einstein's theory of relativity is that mass and energy are not separate entities (like space and time) but different forms of the same thing. What, then, is the single law of conservation? It says that the total amount of mass-energy in the universe always has been and always will be the same. Mass may be converted into the energy and vice versa but the total amount of mass-energy does not change.

In spite of what has been said above, the enormous variety of patterns fall into a few distinct categories and reveal a great deal of order. All atoms, and consequently all forms of matter in our environment, are composed of only three particles with mass – the proton, the neutron and the electron and a fourth massless one – the photon which is the unit of electromagnetic radiation. Except the neutron, all are stable particles, i.e. they live for ever unless they are involved in a collision process. The neutron can spontaneously disintegrate into a proton by emitting an electron and a new type of massless particle called neutrino through a basic process of radioactivity called "beta decay". The electrons, which are emitted in this process, become powerful radiations and are used in biology, medicine and industry. The neutrinos, or to be precise, the anti-neutrinos[1] are very difficult to detect as they have neither mass nor electric charge.

Except the above four which are only a fraction of the total number of particles given in the table[2] are unstable, and decay again and again until a combination of stable ones remains. These unstable particles live for less than a millionth of a second. Some of them have different 'charge-states' as can be seen in the table. Again they have different mass – electron has the least mass, muons, pions and kaons are a few hundred times heavier, the others are one to three thousand times heavier. All particles (except photon) fall into two broad groups : 'leptons' and 'hadrons'. The leptons do not participate in strong interactions as the hadrons do. The hadrons are again divided into mesons and baryons which differ in various ways, one of them being that all baryons have

1. Every particle has an anti-particle. Photon is its own anti-particles.

2. See the table in the appendix.

distinct anti-particles, while meson can be its own anti-particle. The leptons are involved in weak interactions which manifest themselves only in certain kinds of 'particle collisions' and in 'beta decay'.

Thus, the universe is made of both particles and antiparticles. Our part of it is, however, made almost entirely of regular molecules which compose regular atoms, to produce regular molecules which make regular matter which is what our physical world is made of. Leptons, mesons, baryons, mass, charge, and anti-particles are some of the man-made concepts that the scientists use to describe the subatomic world.

CHARACTERISTICS OF SUBATOMIC PARTICLES

Fundamental thing to know about the subatomic particles is that every particle of the same species looks exactly alike. Every electron, proton and neutron looks exactly like every other electron, proton and neutron respectively.

Mass : Particles of different types, however, can be recognized by their distinguishing characteristics. Mass is the first distinguishing characteristic. A proton has about 1980 times more mass than an electron[1]. Mass of a particle at rest is called its rest-mass. The mass of a moving particle increases with its velocity and at 99% of the speed of light it is seven times larger than the rest-mass. At velocities above 99% of the speed of light, particle-masses increase dramatically. An electronvolt is a unit of energy but it is also used for measuring a particle's mass (the energy that an electron gains from an electric field of one volt is called an electron-volt). Thus the rest-mass of an electron is 0.51 million electron volts (Mev) while the rest-mass of a proton is 938.2 Mev. It is customary to use the mass of an electron as a unit. This arrangement makes the mass of a proton 1836.12 and the mass of a neutron 1837. By this system it is easy to see how much heavier a particle is than an electron. A photon has zero rest-mass, and is, therefore, called massless[2] particle.

1. This does not mean that a proton is 1800 times larger than electron. A kilogram of iron has the same mass as a kilogram of cotton.

2. "Massless' is actually a clumsy translation from the language of mathematics to English language.

All its energy is the energy of motion at the speed of light. It can neither be slowed down nor made to run faster.

Electric Charge : The second characteristic of a subatomic particle is its charge. Every subatomic particle has either a positive charge or a negative charge or is neutral. Its charge determines how the particle will behave in the presence of other particles. A neutral particle will be utterly indifferent to all other particles. Two positively charged or negatively charged particles will repel each other and will put as much distance between them as possible. On the contrary, a negatively charged particle and a positively charged particle will be irresistibly attracted to each other and will move nearer to it if they can.

A subatomic particle can have zero charge (neutral) or 1 unit, either positive or negative, or in certain instances 2 units of charge, but nothing in between. No particle can have 1.25,1.5 or 1.7 units of charge. In other words, electric charge is also quantized like energy, and all the charge quanta are of the same size. A particle with mass and charge emerges as a particle- personality.

Spin : The third characteristic of a subatomic particle is its 'spin.' A particle spins about a theoretical axis at exactly the same rate, neither slower nor faster. The spin of a particle is related to, but not identical to, our everyday concept of a spin of a top because it does not have any well-defined axis. Like every phenomenon in quantum mechanics, spin is also discontinuous i.e. quantized like energy and charge.

The spin of a subatomic particle is calculated in terms of angular momentum which depends upon the mass, size and rate of rotation of a spinning object. Although spin is a major characteristic, it is too complicated to explain in the present work, We shall try to explain spin in a slightly different way.

A particle of spin zero (o) is like a dot and looks the same from every direction. A particle of spin (l) looks different from opposite directions (like an arrow) but looks the same if turned round a complete revolution (360 degrees). A particle of spin two (2) is like a double-headed arrow, and looks the same if turned round 180°. But a particle of spin $\frac{1}{2}$ has to be turned two complete revolutions for looking the same. Particles of spin $\frac{1}{2}$ make up the

matter in the universe (proton, electron, etc.); particles of spin 0,1, and 2 give rise to forces between matter-particles. In quantum physics, forces or interaction between matter-particles (spin $\frac{1}{2}$) are all supposed to be carried by particles of integrated spins – 0,1,2. These force-carrying particles can be grouped into four categories as we have seen. Graviton, a particle of spin 2, carries the force of gravity. Electromagnetic force is carried by photons, the massless particle of spin 1. The strong nuclear force is earned by another spin-1 particle called 'gluon' which interacts only with itself and with quarks.

SELF-INTERACTION OF PARTICLES

Subatomic particles do not just sit around being subatomic particles. They are beehives of activity. An electron, for example. is constantly emitting and absorbing photons. These photons, again, are not 'real' photons but now-you-see-it-now-you-don't variety—virtual photons (virtual means being so in effect or essence, although not in actual fact). They are exactly like real photons except that they don't fly off on their own. They are reabsorbed almost as soon as they are emitted by electrons. In other words, first there is an electron, then there is an electron and a photon and then there is an electron again. Lifetime of a virtual photon is 10^{-15} of a second.

Protons and neutrons, like electrons interact with themselves in more ways than one. The simplest proton self-interaction is the emission and reabsorption of a virtual neutral pion. In addition, a proton can emit a positive pion and transforms itself into a neutron. So there is a neutron plus a positive pion. Reabsorption of the positive pion transforms the neutron again into a proton. In other words proton continually changes into a neutron and back into a proton again. In a similar manner, neutrons emit and reabsorb neutral pions or negative pions and momentarily transform into protons and back again into neutrons.

Particle self-interaction becomes quite intricate when virtual particles themselves emit virtual particles which again emit virtual particles in a diminishing sequence. For instance, a negative pion transforms itself into two virtual particles—a neutron and an anti-proton (anti-protons were discovered at Berkeley in 1955). This is the simplest example of self-interaction.

Thus, a proton never remains a simple proton and a neutron never remains a simple neutron. A negative pion never remains a simple negative pion. A proton alternates between being a proton and a neutral pion on the one hand and being a neutron and a positive pion on the other hand. A neutron alternates between being a neutron and a neutral pion on the one hand and being a proton and a negative pion on the other hand. A negative pion alternates between being a neutron and an anti-proton on the one hand, etc. etc. Eleven particles make their transient appearance between the time the original proton transforms itself into a neutron and a pion and the time it becomes a single proton again.[1]

QUANTUM FIELD THEORY

Our natural assumption that 'particles' are real things is repudiated by quantum mechanics, which is the most **successful theory** of physics. It has explained successfully everything from subatomic particles to stellar phenomena.

Quantum theory tells us that 'particles' are actually interactions between fields. When two fields interact with each other, they do it **instantaneously** and at **one single point** in space. These instantaneous and localized interactions are 'particles'. The countinual creation and annihilation of particles as discussed above is the result of the continual interaction of different fields and the theory which deals with these interactions is called 'quantum' field theory. Quantum field theory merges quantum mechanics and relativity, albeit in a limited way. It is an *ad hoc* but a successful physical theory premised on the assumption that physical reality is essentially non-substantial and fields alone are real. Fields, and not particles, are the substance of the universe.

A quantum is an indivisible whole—a piece of something while a field is a whole area of something. Thus, a 'quantum field' is the juxtaposition of two irreconcilable concepts—a paradox. Whereas our logical mentality would demand that something is either **this** or **that**, but not **both**, the quantum theory boldly states that something can be **this** as well as **that** (a **wave** as well as a **particle**). The language of quantum theory is considered to be

1. Compare the *arthaparyāya of pudgala* as per Jain Physics in Section III of Chapter II.

precise but tricky. It does not state that something, for instance, light can be wave-like and particle-like **at the same time.** According to Bohr's 'complementarity', light reveals a particle-like aspect or a wave-like aspect, depending upon the context, i.e., the nature of the experiment. It is not possible to observe both – the wave-like and the particle-like aspects in the same situation. However, **both of these** mutually exclusive (complementary) aspects are needed to fully understand 'light'. In this sense light is both – particle-like and wave-like.

Complementarity is the concept developed by Niels Bohr (one of the founders of the quantum theory) to explain the wave-particle duality of light. Although one of them always excludes the other, **both of them** are necessary to understand (the nature of) light. Light or anything else cannot be both wave-like and particle-like **in the same context.**[1] Individual events are always **particle-like**; wave behaviour is detected as a statistical pattern – interference. However, in the words of Paul Dirac (another founder of quantum mechanics), even a single subatomic particle interferes with itself. But how a single subatomic particle, like an electron, can interfere with itself is a basic quantum paradox.

CHARACTERISTICS OF ELEMENTARY PARTICLES

INHERENT SYMMETRIES OF PARTICLES

The continual change and constant movement in the subatomic world is not arbitrary and chaotic but is symmetrical and rhythmic. Firstly all particles of a given kind have exactly the same mass, electric charges and other characteristic properties. The electric charges carried by them are exactly equal (or opposite) to that of electron or exactly twice that amount. The definite and clear patterns in the structure of particles follow the same regularity observed in the world of atoms, For example, all hadrons which are the strongly interacting particles and which include protons and neutrons, seem to fall into sequences whose members have identical properties except for their masses and

1. This precisely is the Jain position with regard to any two opposites. For further discussion, see chapter III of this book.

the masses also increase in a well-defined way within each sequence. These regularities suggest an analogy to the excited states of atoms. The similarities between the atoms and hadrons suggest that the latter too are **composite** structures capable of absorbing energy to form a variety of patterns.

Now, it should be clarified that the classical notion of "composite objects" consisting of "constituent parts" cannot be applied to subatomic particles. For example, two protons when they collide with high velocities, can break up into 'fragments', but there will never be fractions of a proton among them. The fragments will always be entire hadrons which are created out of the energies and masses of the colliding protons. The decomposition of a hadron into its "constituents" depends on the energy involved in the breaking-up process. In the sixties, therefore, when most of the presently known particles were discovered, most physicists concentrated their efforts on mapping out the emerging regularities rather than finding out the constituents.

The notion of symmetry played an important role in this search. All material processes are governed by conservation laws. There are roughly twelve conservation laws[1] and most of them can be called the laws of symmetry.[2] E.g. all interactions are symmetric in space and look exactly the same whether they take place in Bombay or Sydney; they are also symmetric in time and will occur in the same way on any day of the week. The law simply states that the "total momentum and the total energy (including masses)" will be exactly the same before and after the interaction.

1. There are twelve Conservation Laws : (i) Energy (ii) Momentum (iii) Angular momentum (iv) Charge (v) Electro-family number (vi) Baryon family number (vii) Time-reversal (T) (viii) Confined space inversion and charge conjugation (PC (ix) Space inversion alone (P) (x) Charge conjugation alone (C) (xi) Strangeness and (xii) Isotopic Spin.

   Strong Interactions are restrained by all the twelve. Electromagnetic interactions by all except the last. Weak interactions lose (xi) Strangeness (x) Charge conjugation and (ix) Space inversion but the Combination PC remains valid.

2. Something is symmetrical if certain aspects of it remain the same under varying conditions. A mirror reflection is the most common case and one half of a circle always mirrors the other half. Regardless of how we turn a circle the right half always mirrors the left half. The position changes but the symmetry remains.

The other laws correspond to such quantum numbers[1] as isospio and hypercharge which are too complicated for our discussion. Suffice is to say that these are used to arrange particles into families forming neat symmetrical patterns called 'meson sextet' and 'baryon octet' etc.

Now, if one assumes that all hadrons are composed of smaller elementary entities, most of these regularities can be represented in a very simple way. Such entities have been called "quarks"[2] by Murray Gell Mann who postulated their existence in 1964 as stated earlier. Strong nuclear force binds and holds the quarks together in the proton and neutron and holds the protons and neutrons tightly together in the nuclei of atoms. It is believed that this force is carried by a 'spin-1' particle, called the 'gluon' which interacts only with itself and with quarks. A curious property of the strong nuclear force called 'confinement' prevents one from observing an isolated quark or 'gluon' and might seem to make the whole notion of quarks and gluons as particles somewhat metaphysical, and a few years ago, it was believed that quarks are permanently 'confined' within hadrons and will never be detected. However, there is another property of the strong nuclear force called 'asymptotic freedom' that makes the concept of quarks and gluons well-defined. At normal energies, the strong nuclear force is indeed strong and it binds the quarks tightly together. However, at high energies, it becomes much weaker, and the quarks and gluons behave almost like free particles. By collision between a high-energy proton and anti-proton, several almost free quarks have been produced.

On the theoretical side, the quark model is very successful in accounting for the regularities found in particle-world. From three kinds of quarks in the original model of Gell Mann, the number has increased to at least eighteen quarks plus eight gluons to account for the observed patterns in the hadron spectrum. The terms 'colours' and 'flavours' have been introduced to distinguish different kinds of quarks and so there are quarks of different 'colors' and 'flavours'.[3]

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1. The basic quantum numbers are spin, isotopic spin, charge, strangeness, charm, baryon number and lepton number.

2. The fanciful name caught the fancy of its postulator from a line in James Joyce's book "Finnegan's Wake"

3. This is comparable to the laws of combination of *paramāṇus* which will be discussed in Chapter II.

Property of confinement always binds particles together into combinations that have no colour, e.g., one cannot have a single quark because it would have a single colour (red, green or blue). Instead a red quark has to be joined to a green and a blue quark by a string of gluons (red+green+blue=white). Such a triplet constitutes a proton or a neutron.

Another possibility of combination is a pair consisting of a quark and an anti-quark (red+anti-red and so on=white). Such combinations make up the particles known as mesons which are unstable. Similarly, confinement prevents one having a single gluon on its own, because gluons also have colour. Instead, one has to have a collection of gluons whose colours add up to white. Such a collection forms an unstable particle called a 'glueball'.

Inspite of severe theoretical difficulties for accepting the existence of physical quarks, the fact cannot be denied that hadrons do often behave exactly as if they consisted of pointlike elementary constituents.

Inspite of all these difficulties, many physicists still hang on to the idea of classical 'building blocks' of matter which is so deeply ingrained in western scientific tradition.

UNIFICATION OF FORCES FOUND IN NATURE

In 1967, theories for unifying the electromagnetic force and weak nuclear force were proposed by Abdus Salam and Steven Weinberg, just as Maxwell had unified electricity and magnetism about a hundred years earlier. They suggested that in addition to photon, there were three other 'spin 1' particles, known collectively as "massive vector bosons" that carried weak force. Each had a mass of around 100 Gev.1 At energies much greater than 100 Gev the three new particles and the photon would all behave in a similar manner. Particle-accelerators were not powerful enough to reach the energies of 100 Gev. at that time. But over the next 10 years or so, the other predictions of the theories at lower energies agreed so well with experiment that in 1979, Salam and Weinberg were awarded Nobel Prize for Physics together with Sheldon Glashow who had suggested similar unified theories of the

1. Gev. stands for giga-electron-volt or 1000 million electron volt.

electromagnetic and weak nuclear forces. In 1983, the three massive partners of photon were discovered at ECNR (European Centre for Nuclear Research) in Switzerland.

The success of the unification of the electromagnetic and weak nuclear forces led to a number of attempts to combine these two forces with the strong nuclear force. The basic idea is : At high energies, the strong nuclear force gets weaker (as mentioned earlier), while the other two forces which are not 'asymptotically' free, get stronger. At some very high energy called the 'grand unification energy,' these three forces would all have the same strength and so could just be different aspects of a single force. It is also predicted that at this energy (at least a thousand million Gev), the different 'spin-$\frac{1}{2}$' matter- particles like quarks and electrons would also all be essentially the same, thus achieving another unification.

At 'grand unification energy', there is no essential difference between a quark and a positron (anti-electron). There is, thus, a possibility of spontaneous decay of protons which make up the most of the mass of ordinary matter, into lighter particles such as positrons. 'Grand Unified Theories' (GUT) do not include the force of gravity. This does not matter too much, because gravity is such a weak force that its effects can usually be neglected when we are dealing with microcosmos i.e., sub-atomic particles or atoms. However, the fact that it is both long range and always attractive means that its effects all add up. So, for a sufficiently large number of matter-particles, gravitational forces can dominate over all other forces. This is why it is gravity that determines the evolution of the Universe. For macrocosmos i.e., objects of the size of stars, gravity can win over all the other forces and cause the star to collapse.[1] Already there are first hints of a quantum theory of gravity yet to come.

Since the postulation of quark in 1968, quarter of a century has passed during which a spate of new theories—S-matrix, bootstrap, Bell's theorem, quantum field theories, quantum-electrodynamics, Gauge theory etc. have appeared in the field. All these are too complicated, though relevant for

1. See, "Nuclear Transformation in Nature" in the last Section of this Chapter.

discussion in the present book. In the meantime physicists have become philosophers as was the case 2500 years ago. For instance, according to Geoffrey Chew, who is the originator of the bootstrap idea and has been the unifying force and philosophical leader in S-matrix theory for the past two decades, the extension of bootstrap approach beyond hadrons may lead to the possibility of being forced to include the study of human consciousness.

Since he wrote these words, almost twenty years ago, the new developments have brought them (the physicists and philosophers), considerably close to dealing with consciousness explicitly. David Bohm has perhaps gone further than anybody else in studying the relations between consciousness and matter in a scientific context. We shall further discuss this phenomenon of reversing the Cartesian division in the succeeding section.

SECTION IV

UNIFICATION OF PHYSICS AND PHILOSOPHY

A. INHERENT UNITY OF PHYSICAL REALITY

The aspect of inherent unity and connectedness of the physical reality manifests itself in several ways in modern science. In the 'double-slit experiment', when both slits are open, the light-waves going through them interfere with each other to form a pattern of alternating light and dark bands on a screen. When only one slit is open, the light-waves going through it illuminate the screen in the ordinary way. The great multitude of photons, of which a single photon eventually will be a part, distributes itself in one way if both slits are open. The question is, assuming that a single photon goes through one of the two slits, how **does it know whether or not the other slit is open?** Somehow it does. An interference pattern **always** forms when we open both slits, and it **never** forms when we close one of the slits.

E.P.R. EFFECT

The connectedness is even more perplexing in another experiment. In twin-particle-system of Zero spin[1], spin of each of the particles cancels the other. If one of the particles has a spin **'up'** the other particle has spin **'down'**. If the first particle has a spin **'right'**, the second one has a spin **'left'**. No matter how the particles are oriented, their spins are always equal and opposite. Now, if these particles are made to go off in opposite directions, i.e., if one goes to New York, and the other to Bombay or one on the earth and the other on the moon, their combined spins will still always be Zero. Suppose the particle in New York is given[2] a spin 'up', we do not have to make a measurement on the other particle

1. In some sense, particle-spin is a rotation about its own axis, but this classical concept is limited. The electron can spin clockwise or counter-clockwise, and these two values are denoted by spin 'up' and spin 'down'.

2. A particle can be given a desired spin through a Stern-Gerlach device, in which electrons are made to pass through a magnetic field.

in Bombay, because we know that its spin is equal and opposite to its twin, i.e. 'down'. Somehow, the particle in Bombay knows that its twin is spinning up. In other words, what was done in New York affected what happened in Bombay. This strange phenomenon is known as the Einstein-Podosky-Rosen (EPR) effect. How does the particle in Bombay know which axis has been chosen? There is no time for it to receive the information from the other particle by any conventional signal. EPR's thought experiment is the Pandora's Box of modern physics. It inadvertently illustrated an inexplicable connectedness between particles in two far away different places. This is the crux of the EPR experiment, and this is where Einstein disagreed with Bohr.

EINSTEIN VS. BOHR

Einstein asserted that no signal can be instantaneous i.e. faster than the speed of light. According to Bohr, the twin-particle system is an indivisible whole, even if they are separated by a great distance. But the connections are not 'signals' in the Einsteinian sense; they transcend our conventional notions of 'information-transfer'. EPR's thought experiment indicates that the signal between the two particles is transmitted at superluminal speed, i.e. faster than the speed of light. The concept of a "faster-than-light" communication between events, which cannot be connected by a signal (the definition of space- like), is as much a radical departure from current physical theory as Einstein's special Theory of Relativity was for the accepted (classical) physics of 1905. Nonetheless, it is logically consistent with canonical physical thought. In fact, it can be derived from the indivisibility of Planck's quantum for action, which is the basic element of quantum theory.

Relativity permits the hypothetical existence of particles called "tachyons", which come into existence already travelling faster than light. In the formalism of the special theory of relativity, tachyons have an imaginary rest-mass. Unfortunately, it is difficult to interpret what an "imaginary rest-mass" means in physical terms, or what the interaction forces would be between tachyons and the ordinary particles with real rest-mass.

Dr. Bell's[1] theorem supports Bohr's position and proves rigourously that Einstein's view of physical reality as consisting of independent, specially separated elements is incompatible with the laws of quantum theory. Dr. Bell's theorem is a mathematical construct which is indecipherable to the non-mathematician. It was reworked and refined over the following ten years, until it emerged in its present form which is dramatic, to say the least. Some physicists are convinced that it is the most important single work in the history of physics. One of the implications of Dr. Bell's theroem is that at a deep and fundamental level, "the separate parts" of the universe are connected in an intimate, and immediate way. It unambiguously proves that the Universe is fundamentally inter-connected, inter- dependent and inseparable system.

B. TOWARDS PHILOSOPHY

LIMITATION OF KNOWLEDGE

In 1927, the most famous group of international physicists in history decided that it might never be possible to explain all aspects of physical reality. Since then a tidal wave of knowledge has swept over us for more than half-a-century.

Recently, a small group of physicists found it necessary to acknowledge that it might not be possible to constuct a model of physical reality. This acknowledgement is a recognition emerging throughout the west that **knowledge itself** is limited. In other words, it is a recognition of the difference between knowledge and wisdom. In fact most physicists today side with Bohr rather than with Einstein, on the question of the utility of seeking a model of a physical reality, that can be conceived of independently of our experience of it. Effort to understand the quantum theory more deeply is not productive for science but leads to perplexity which appears to most physicists to be more philosophical than physical.

To summarize, classical science had concerned itself with how separate parts which together constitute physical reality are related. Newton's great work showed that the earth, the moon

1. Dr. Bell is a physicist at the European Centre for Nuclear Research (ECNR) in Switzerland.

and the planets are governed by the same laws as falling apples. The most fundamental difference between Newtonian physics and quantum mechanics is the fact that the latter is based upon observations (measurements). It constitutes a philosophy of science, unlike any before it. Bohr's principle of complementarity addresses the underline relation of physics to consciousness. Likewise, Heisenberg's Uncertainty Principle demonstrates that we cannot observe a phenomenon without changing it.

BOHM'S PHYSICS

David Bohm, Professor of Physics at Birkback College, University of London, proposes that quantum physics is based upon a perception of a new order. According to Bohm, instead of starting with parts and showing how they work together (the Cartesian division), we must start with the whole.

Bohm's theory is, thus, compatible with Dr. Bell's theorem as stated above.[1] Bohm asserts that the most fundamental level is an **unbroken wholeness.** All things, including space, time and matter are forms of 'that-which-is'. There is an order which is enfolded into the very process of the universe. But that enfolded order may not be readily apparent. Bohm points out, "Description is totally incompatible with what we want to say." Actually both being and non-being are 'that-which-is'. There is nothing which is not 'that-which-is'. This way of looking at Reality requires a new instrument of thought, and raises the question of 'consciousness' of the observer. Such requirement upon which Bohm's physics is to be based may not be as much of an obstacle as it first appears, because there already exists a number of sophisticated psychologies, distilled from 2500 years of practice and introspection, whose sole purpose is to develop this 'thought-instrument'.

These psychologies are what is commonly called 'Eastern Mysticism' of 'Eastern Religions'. All of them in general and Jainism[2] in particular are compatible in a very fundamental way

1. See, p. 2

2. We shall elaborate this comparison is chapter III.

with Bohm's physics and philosophy as they are based upon the experience of a pure reality which is 'that-which-is.'

The question is: "If pure awareness is considered distinct from the content of awareness, in what ways specifically does the latter affect the realization of the former?" It is rather difficult to answer this question, because the mind deals in forms of limitation. Nonetheless, there is a relationship between the content of awareness and ability of the human mind to transcend itself.

To summarize, the development of Physics in the 20th century has already transformed the consciousness of those involved with it. The study of the complementarity, the Uncertainty principle, quantum field-theory, and the Copenhagen nterpretation of Quantum Mechanics produces insights into the nature of reality very similar to those produced by the study of Eastern philosophies.

If Bohm's physics, or one similar to it, should become the main thrust of physics in the future, it is possible that physics-curricula of the 21st century include classes in meditation.[1]

1. Gary Zukav; Dancing Wu-Li Masters, p. 327.

SECTION V

APPLICATION OF NUCLEAR TRANSFORMATIONS

A. NUCLEAR ENERGY

We have already observed that matter and energy are two different manifestations of one and the same cosmic entity, instead of being two different entities. Matter instead of being immutable was energy in a frozen state, while, conversely, energy was matter in a fluid state. The liberation of energy in any form — chemical, electrical or nuclear—involves the loss of an equivalent amount of mass.

LIBERATION OF ENERGY

It is well known that most chemical reactions liberate energy, simplest instance being burning of coal. The chemical union, in this case, is that of carbon and oxygen in the form of molecular fusion. When 3000 tons of coal are burnt to ashes, the residual ashes and the gaseous products weigh one gram less than 3000 tons, that is, one three-billionth part of the original mass will have been converted into energy.

Thus oxygen (O) + carbon (C) = carbon monoxide (CO) + energy.

This reaction would give 92 units of energy per gram of mixture. If instead of molecular fusion of these two atomic species, we have a nuclear fusion between their nuclei ${}_6C^{12} + {}_8O^{16} = {}_{14}Si^{28}$ + energy — the energy liberated per gram of mixture will be 14×10^9 Units, i.e. 15,00,000 times as great. In the liberation of chemical energy by the burning of coal, the energy comes from a very small mass i.e. loss of mass resulting from the rearrangement of the electrons on the surface of atoms. The nuclei of the carbon and oxygen atoms are not involved in any way, remaining exactly the same as before. The amount of mass lost by the surface electrons is one thirteenth of one millionth of one percent. On the

other hand, nuclear energy involves vital changes in the atomic nucleus itself, with a consequent loss of as high as one tenth to nearly eight-tenths of one percent in the original mass of the nucleus. This means that from one to nearly eight grams per thousand grams are liberated in the form of energy, as compared with only one gram in three billion grams liberated in the burning of coal. In other words, the amount of nuclear energy liberated in the transmutation of atomic nuclei is from 30,00,000 to 2,40,00,000 times as great as the chemical energy released by the burning of an equal amount of coal. Whereas most chemical reactions would take place easily at temperatures of a few hundred degrees, corresponding nuclear transformation would not even start before the temperature reached many million degrees.

Nuclear energy can be liberated by two diametrically opposite methods. One is fission—the splitting of the nuclei of the heaviest chemical elements into two uneven fragments consisting of nuclei of two lighter elements. The other is fusion—combining or fusing two nuclei of the lightest elements into one nucleus of a heavier element. In both methods the resulting elements are lighter than the original nuclei. The loss of mass in each case manifests itself in the release of enormous amounts of nuclear energy.

At the turn of the century, Bacquere's discovery of radio-activity indicated that a break-up process of nucleus can really take place. Atoms of heaviest element uranium (and thorium) spontaneously emitted highly penetrating radiations (similar to X-rays). This process of slow spontaneous decay of the so-called radio-active elements consists in emitting a small segment of its nucleus known as 'alpha' particles and internal electric adjustment followed by emission of two electrons. A series of emission continues until we come finally to the nucleus of the lead atom.

Theoretically speaking all elements heavier than silver are radio-active and subject to the process of decay. But the spontaneous decay is so slow—say one or two atoms in a gram of gold or mercury in many centuries compared to several thousand per second per gram in uranium—that the most sensitive physical instrument cannot record it.

As we have already seen, the discovery of radio-activity proved the complexity of nuclear structure beyond any doubt and paved the way for artificial nuclear transformations. Earlier, bombardment of the nuclei by artificially accelerated charged particles such as alpha, protons, etc. was the method employed for nuclear transformations. But the electric charges carried by such particles caused them to lose much of its kinetic energy while passing through the atomic bodies and prevented them from coming sufficiently close to nuclei of the bombarded material. The bullets to be used for more efficient bombardment are neutrons which, because, they do not have an electric charge, can penetrate the heavily fortified electrical wall surrounding the positively charged nuclei. Just as coal fire needs oxygen to keep it going, a nuclear fire needs the neutrons to maintain it. but uncharged projectiles viz., neutrons are not easily available in free form as they are tightly locked up within the nuclei of atoms recaptured as soon as they are kicked out. There is only one way to sustain the nuclear reaction and that is to create a self-multiplication process i.e. each bombarding neutron must liberate more than one other neutron which in their turn would act as bullets.

Late in 1938, Rahn and Strassman discovered that atomic energy can be released through the fission process of uranium nuclei. Like the two pieces of a broken spring, the two halves of a broken heavy nucleus begin their existence in a state of violent vibrations. Before coming to rest, each of the fragments emits a neutron.

It must be remembered that, although the neutrons are much more effective nuclear projectiles than the charged particles, their effectiveness in producing the fission is, however, not cent percent. The important condition for a sustained nuclear transformation is progressive neutron-production or a chain-reaction for which it is necessary that a hundred neutrons entering the substance must release many more than a hundred neutrons.

There are two types of chain reactions : controlled and uncontrolled. The controlled reaction is analogous to the burning of petrol in automobile engine. The atom-splitting bullets – the neutrons – are first slowed down from speeds of more than ten

thousand miles per second to less than one mile per second by being made to pass through a moderator before they reach the atoms at which they are aimed. Thus the liberation of neutrons is under complete control and acts as a slow but steady nuclear fire.

The uncontrolled chain reaction is one in which there is no moderator—and no neutron-absorbers. It is analogous to the dropping of a match in a petrol tank. In the uncontrolled chain reaction the fast neutrons with nothing to slow them down or to devour them, build up by the trillion and quadrillion in a corresponding number of atoms, resulting in the release of unbelievable quantities of nuclear energy at a tremendously explosive rate.

It can be concluded from the general theory of nuclear structure that the fission effectiveness of neutrons increases with the increasing atomic weight of the element in question. Thus, the fission of uranium nuclei gives on the average a cent percent result; plutonium, a still heavier element would give a better result. If with each new generation the number of neutrons grows by, say, about 50 percent, there will be enough of them to attack and break-up any single nucleus of the material. This is called the progressive branch chain reaction and the substance in which such a reaction will take place is called fissionable substance. Among all the variety of nuclear species existing in nature, there is only one type of nuclei where such reaction is possible. These are the nuclei of the famous isotope of uranium, U-235, the only natural fissionable substance.

Other fissionable substances, not existing in nature, have been artificially built. An artificial element which is known as Plutonium has the atomic number 94 and is even more fissionable than U-235. It is obtained by transforming the nucleus of natural uranium.

Another artificial fissionable substance U-233 is obtained by similar transformation of the nuclei of natural radio-active element Thorium (Th-232). In fact, it is possible, in principle at any rate to turn the entire supply of natural uranium and thorium into fissionable products which can be used as concentrated sources of nuclear energy.

ATOM IN WAR

The requirement to start the fission process of U-235 and also the two man-made elements mentioned above (all these being known as nuclear fuels), is simple. All that is necessary for the spontaneous combustion, to use a familiar phrase, of any one of the three atomic fuels, is to assemble a lump of a certain weight known as critical-mass which is between ten and thirty kilograms. This would mean that a lump of any of the three atomic fuels weighing ten or thirty kilograms (exact mass is a secret) would explode automatically and release an explosive force of 20 millioin times greater than that of TNT, (on an equal weight basis). Such as, spontaneous combustion destroyed Hiroshima and Nagasaki on 6th & 7th August 1945. In a conventional A-bomb, a critical-mass is assembled by a timing mechanism that brings together, let us say, one-tenth and nine-tenths of a critical-mass in the last split second.

Long before, it was discovered that vast amounts of energy could be liberated by the fission of the nuclei of U-235, scientists had known that fusion of four atoms of hydrogen into one atom of helium would release enormous amount of energy. In 1938, slightly before the discovery of uranium, fission was announced in Germany, Dr. Bethe had published his famous hypothesis about the fusion of four hydrogen atoms to form helium in the sun. This provided the first satisfactory explanation of the mechanism that enables the sun to radiate away staggereing amounts of energy in space every second. While Dr. Bethe was the first to work out the fine details of the process of hydrogen fusion as the source of the sun's radiance, Prof.F.W. Aston, the British Nobel Prize-winner and other scientists indicated the possibility more than 20 years ago. We shall examine the solar process in brief a little later.

Deuterium, popularly known as heavy hydrogen, is an isotope of hydrogen having double the weight of common hydrogen. It was found to exist in nature constituting one five-thousandth part of the earth's waters. Water containing two deuterium atoms in place of the two atoms of common hydrogen is called heavy water.

The most startling fact discovered about deuterium was that it would become explosive at a temperature of the order of 5,00,00,000 degrees centigrade. Explosive of an A-bomb would

generate such high temperatures on earth and such an explosion would then act as a trigger for the hydrogen bombs.

Fission and fusion, however, are also common in everyday phenomenon that occur any time you burn anything. Both are essential whenever energy is released, whether it is the chemical energy from coal or the atomic energy from nuclei of uranium or deuterium. For example, when you light a cigarette, the first fission and fusion occurs in the lighting of the match, the cellulose in the match being fissioned into its components carbon and hydrogen. These are then fusioned with the oxygen of the air. The same thing happens when the tobacco catches fire. In each case, the fusion with oxygen makes possible the fission of the cellulose.

It is a scientific fact that man now has at his disposal means that not only can wipe out all life on earth, but also make the earth itself unfit for life for many generations to come. Here we have indeed what is probably the greatest example of irony in man's history! The very process in the sun that made life possible on earth and is responsible for its being maintained here, can now be used by man to wipe out that very life and to ruin the earth for good. In both, fission and fusion, only a very small fraction of the mass of the protons and neutrons in the nuclei of the atoms used is liberated in the form of energy, while 99.3 to 99.6% of the substance remain in the form of matter.

Scientists are even now engaged in finding means of converting 100% of the matter into energy i.e. complete annihilation of matter by the conversion of the entire mass of protons and neutrons into energy instead of only 0.4 to 0.7% And while the total conversion of protons and neutrons still seems speculative, we already know that such a process actually does take place in the realm of the electron. This is the phenomenon of the mutual annihilation of a positive electron (positron) and a negative electron, achieved numerous times on a small scale in the laboratory which we have already discussed. In this process the entire mass of the two particles is converted into energy. Luckily each positron must be individually produced, since there are hardly any positrons in our part of the universe. But suppose a new process that would release positrons in large numbers is found,

just as the process of liberating large number of neutrons was found, then in such an eventuality, by no means beyond the realm of the possible, would open potentialities of horror alongside which those of the hydrogen bomb would be puny. For any process that would release a large number of positrons in the atmosphere, in a chain reaction similar to the one now liberating neutrons, may envelope the whole earth in one deadly flash of radio-active lightning that would instantly kill all life. And although this is admittedly purely speculative, no one dare say that such a discovery will not be made, not when one remembers how remote and unlikely a process such as fission seemed to be just before it was made.

ATOM FOR PEACE

We have completed the review of the development of the theory of atom over a period of more than 2500 years. It would, however, be highly improper to close the chapter with a sense of utter doom which the above paragraph may forebode. Enormous progress has also been made in the direction of utilising nuclear energy for the benefit of mankind, and it is our duty to give the reader a glimpse of the nuclear research and development work in which some tens of thousands of scientists are busy all over the world today.

At Atomic Research Centers in the United States of America, Russia, the United Kingdom, France, the Federal Republic of Germany and International Centre at Geneva, thousands of research teams are engaged in probing the heart of the atom.

Research work in the sub-nuclear world is based on a law of nature that the smaller the dimensions of the particles to be studied, the higher must be the energies of the beams serving as a probe. By way of comparison, consider the forces that hold the nucleus of an atom together. In order to learn something about the structure of the nuclei, one needs energies about 100 times greater than the binding energy of a proton in a nucleus. But to carry out research into the structure of proton or neutron, one requires energies 1000 times greater i.e. of the order of one thousand million electron volts. No wonder elementary 'particle physics' is, therefore, sometimes called 'high energy physics.'

B. NUCLEAR TRANSFORMATIONS IN NATURE

ORIGIN OF UNIVERSE [1]

There are many theories or models regarding the origin of universe. According to what is known as the "hot big bang model", which is the generally accepted one, the universe, at the time of origin, is thought to have had 'zero' size, and so to have been infinitely hot. But as the universe expanded, the temperature of the radiation decreased. One second after the big bang, it would have fallen to about ten thousand million degrees. This is about a thousand times the temperature at the centre of the sun, but temperatures as high as this are reached in H-bomb explosions. At that time, the universe would have contained mostly photons, electrons and neutrinos (extremely light particles that are affected only by the weak force and gravity) and their antiparticles, together with some protons and neutrons. As the universe continued to expand and the temperature to drop, the rate at which electron/anti-electron pairs were being produced in collisions would have fallen below the rate ar which they were being destroyed by annihilation. So most of the electrons and anti-electrons would have annihilated with each other to produce more photons, leaving only a few electrons left over.

About one hundred seconds after the big bang, the temperature would have fallen to one thousand million degrees, the temperature inside the hottest stars. At this temperature protons and neutrons would no longer have sufficient energy to escape the attraction of the strong nuclear force, and would start to combine together to produce the nuclei of atoms of deuterium (heavy hydrogen), which contain one proton and one neutron. The deuterium nuclei then would have combined with more protons and neutrons to make helium nuclei, which contain two protons and two neutrons, and also small amounts of a couple of heavier elements lithium and beryllium. One can calculate that in the hot big bang model, about a quarter of the protons and neutrons would have been converted into helium nuclei, along with a small amount

1. A Brief Histroy of Time by Stephen Hawking, pp. 117-121.

of heavy hydrogen and other elements. The remaining neutrons would have decayed into protons, which are the nuclei of ordinary hydrogen atoms.

Within only a few hours of the big bang, the production of helium and other elements would have stopped. And after that, for the next million years or so, the universe would have just continued expanding, without anything much happening. Eventually, once the temperature had dropped to a few thousand degrees, and electrons and nuclei no longer had enough energy to overcome the electromagnetic attraction between them, they would have started combining to form atoms. The universe as a whole would have continued expanding and cooling, but in regions that were slightly denser than average, the expansion would have been slowed down by the extra-gravitational attraction. This would eventually stop expansion in some regions and cause them to start to recollapse. As they were collapsing, the gravitational pull of matter outside these regions might start them rotating slightly. As the collapsing region got smaller, it would spin faster—just as skaters spinning on ice spin faster as they draw in their arms. Eventually, when the region got small enough, it would be spinning fast enough to balance the attraction of gravity, and in this way disclike rotating galaxies were born. Other regions, which did not happen to pick up a rotation, would become oval- shaped objects called elliptical galaxies. In these, the region would stop collapsing because individual parts of the galaxy would be orbiting around its centre, but the galaxy would have no overall rotation.

As time went on, the hydrogen and helium gas in the galaxies would break up into smaller clouds that would collapse under their gravity. As these contracted and the atoms within them collided with one another the temperature of the gas would increase, until eventually it became hot enough to start nuclear fusion reaction. These would convert the hydrogen into more helium, and the heat given off would raise the pressure, and so stop the clouds from contracting any further. They would remain stable in this state for a long time as stars like our sun, burning hydrogen into helium and radiating the resulting energy as heat and light. More massive stars would need to be hotter to balance their stronger gravitational

attraction, making the nuclear fusion reactions proceed so much more rapidly that they would use up their hydrogen in as little as a hundred million years. They would then contract slightly, and as they heated up further, would start to convert helium into heavier elements like carbon or oxygen.

The earth was initially very hot and without an atmosphere. In the course of time, it cooled and acquired an atmosphere from the emission of gases from the rocks. This early atmosphere was not one in which we could have survived. It contained no oxygen, but a lot of other gases that are poisonous to us, such as hydrogen sulfide (the gas that gives rotten eggs their smell). There are, however, other primitive forms of life that can flourish under such conditions. It is thought that they developed in the oceans, possibly as a result of chance combinations of atoms into large structures, called macromolecules, which were capable of assembling other atoms in the ocean into similar structures. They would thus have reproduced themselves and multiplied.

A process of evolution was started that led to the development of more and more complicated, self-reproducing organisms. The first primitive forms of life consumed various materials, including hydrogen sulfide, and released oxygen. This gradually changed the atmosphere to the composition that it has to-day and allowed the development of higher forms of life such as fish, reptiles, mammals, and ultimately the human race.

This picture of a universe that started off very hot and cooled as it expanded is in agreement with all the observational evidence that we have today.

EVOLUTION OF A STAR [1]

In the 'hot big bang model' as the universe expands, any matter or radiation in it gets cooler. At very high temperatures, particles would be moving around so fast that they could escape any attraction toward each other due to nuclear or electromagnetic forces, but as they cooled off, they attract each other and start to clump to-gether. A star is formed when a large clump of gas (mostly hydrogen) starts to collapse in on itself due

1. A Brief History of Time by Stephen Hawking, pp. 82-84.

to its gravitational attraction. As it contracts, the atoms of the gas collide with each other more and more frequently and at greater and greater speeds—the gas heats up. Eventually, the gas will be so hot that when the hydrogen atoms collide, they no longer bounce off each other, but instead coalesce to form helium. The heat released in this reaction, which is like a controlled hydrogen bomb explosion, is what makes the star shine. This additional heat also increases the pressure of the gas until it is sufficient to balance the gravitational attraction, and the gas stops contracting. It is somewhat like a balloon—there is a balance between the pressure of the air inside, which is trying to make the balloon expand, and the tension in the rubber, which is trying to make the balloon smaller. Stars will remain stable like this for a long time, with heat from the nuclear reactions balancing the gravitational attraction. Eventually, however, the star will run out of its hydrogen and other nuclear fuels. Paradoxically, the more fuel a star starts off with, the sooner it runs out. This is because the more massive the star is, the hotter it needs to be to balance its gravitational attraction. And the hotter it is, the faster it will use up its fuel. Our sun has probably got enough fuel for another five thousand million years or so, but more massive stars can use up their fuel in as little as one hundred million years, much less than the age of the universe. When a star runs out of fuel, it starts to cool off and so to contract.

After it had used up all its fuel, a star could still support itself against its own gravity. When the star contracts and becomes smaller, the matter particles get very near each other but they must have very different velocities.[1] This makes them, again, move away from each other and so tends to make the star expand. It can, therefore, maintain itself at a constant radius by a balance between the attraction of gravity and the repulsion that arises from the exclusion principle, just as earlier in its life gravity was balanced by the heat.

There is, however, a limit to the repulsion that the exclusion principle can privide. The theory of Relativity limits the maximum difference in the velocities of the matter particles in the star to

1. According to Pauli's exclusion principle.

the speed of light. This means that when the star got sufficiently dense, the repulsion caused by the exclusion principle would be less than the attraction of gravity. A massive star would not be able to support itself against its own gravity.

There are three possible final states of a star. If a star is not very massive, it can settle down to a possible final state as a 'white dwarf' with a radius of a few thousand miles and a density of hundreds of tons per cubic inch. A 'white dwarf' is supported by the exclusion principle repulsion between the electrons in its matter. We observe a large number of these 'white dwarf' stars. One of the first to be discovered is a star that is orbiting around Sirius, the brightest star in the night sky.

There is another possible final state for a star, also with a limiting mass of about one or two times the mass of the sun but much smaller even than a 'white dwarf.' These stars would be supported by the exclusion principle repulsion between neutrons and protons, rather than between electrons. They were, therefore, called "neutron stars". They would have a radius of only ten miles or so and a density of hundreds of million of tons per cubic inch. At the time they were first predicted, there was no way that 'neutron stars' could be observed. They were not actually detected until much later.

For the very massive star, however, the final state is the third alternative, viz, the 'black hole.'[1]

SOLAR PROCESSES

The problem of solar radiations remained one of the most puzzling riddles of science until the discovery of radioactive transformations and the artificial transformations of elements revealed to us tremendous sources of energy hidden in the depths of atomic nuclei. We have seen that practically every element can become a nuclear fuel, liberating tremendous amounts of energy, provided it can be heated up to millions of degrees. Now, while such temperatures are practically unattainable on the face of the earth, they are rather common in the world of stars. In our own

1. See, Chapter III, Section II.

sun, the temperature increases gradually from 6000° C. at the surface to twenty million degrees in the centre.

Two nuclear physicists, H. Bethe and C. Weizsäcker, simultaneously found out that the nuclear process known as "carbon cycle" is responsible for the energy production in the sun. This thermonuclear process is not limited to a single nuclear transformation, but consists of a sequence of transformations forming a reaction chain. A most important feature of this process is that it is a closed circuit, returning to the starting point after every six steps. The main participants of the process are the nuclei of carbon and of nitrogen, together with protons with which they collide.

Briefly the cycle is: (1) A proton on colliding with an atom of normal carbon (C_{12}) liberates some subatomic energy in the form of gamma rays and transforms the atom to the lighter isotope of nitrogen (N_{13}).

(2) The nucleus of N_{13} being unstable adjusts itself by emitting a positive electron, or positive beta particle and becoming the stable nucleus of the heavier isotope or carbon (C_{13}) which is known to be present in small quantities in ordinary coal.

(3) This carbon isotope collides with another proton and is transformed into normal nitrogen (N_{14}) with additional release of energy in the form of gamma rays.

(4) In the next step, the nucleus of nitrogen collides with still another proton (third) and gives rise to an unstable oxygen isotope (O_{15}).

(5) Which very rapidly transforms into stable N_{15} by emitting a positron.

(6) Finally N_{15} receiving in its heart the fourth proton, splits into two unequal parts one of which is the C_{12} nucleus with which the process started and the other is a helium nucleus or alpha particle which is composed of two protons and two neutrons. The same result would have been obtained if the process was started with normal nitrogen atom instead of carbon.

The net result of the chain of reaction [1] is the formation of one nucleus of helium from the four protons which entered the process cycle successively accompanied with liberation of energy. The nuclei of carbon and nitrogen in the closed circuit of reactions are forever being regenerated. Thus the whole process may be described as the transformation of hydrogen (a proton is the nucleus of hydrogen atom) into helium due to very high temperatures assisted by the catalystic action of carbon and nitrogen.

It is shown that at the temperature of 20 million degrees the energy liberation in the above circuit reaction coincides with actual amount of energy radiated by our sun. Since the astrophysical evidence renders all other possible nuclear reactions inconsistent, it may be accepted that the carbon-nitrogen cycle described above represents the process mainly responsible for the generation of the solar energy. It should also be noted that interior temperature of the sun, the complete circuit requires about five million years.

1. Incidentally this particular reaction is quite well known to nuclear physicists and has been obtained under laboratory conditions by the use of artificially accelerated high energy protons.

CHAPTER 2

Atom In Jain Philosophy

INTRODUCTORY

"Ever since men became capable of rational thinking, their actions have mostly depended upon their theories about the universe and its contents and also as to what is good and what is evil. This is an almost eternal truth. Men's environments play an important part to determine their way of living, bur conversely their philosophy does much to determine their circumstances.

"Philosophy is neither theology nor science but something of both. It appeals to reason, rather than authority, like science, but like theology it speculates on matters about which definite knowledge is not ascertained. Science is bounded by definite knowledge while dogma as to what surpasses definite knowledge belongs to theology. Intermediate between them is philosophy.

"Science will not, because it cannot, answer all the questions of great interest to human mind and if we forget what we cannot know, we become insensitive to many things of great value. Are there two orders of existence? Is the universe a systematic unity or a conglomeration of multiplicity? Is reality objective or merely subjective? Answers to these and many other such questions cannot be found in the laboratories. On the other hand, dogmatic belief that we have knowledge, where in fact, we have ignorance, induced by theologies and the very definiteness of the answers given by them causes modern mind to view them with suspicion.

It is the business of philosophy to study such problems and discuss them even if they cannot be solved." [1]

Jain philosophy is one of the most ancient Indian philosophies. According to the Jain canonical literature the same tenets are propounded again and again by various Tīrthaṅkaras by whom the truth is realised, and whose mission is to propagate right knowledge.

Bhagawān Ṛṣabha was the first of the 24 **Tīrthaṅkaras**. References to him are found in Vedas, in **Viṣṇu Purāṇa** and **Bhāgavata Purāṇa.** 23 **Tīrthaṅkaras** followed Bhagawān Ṛṣabha. Bhagawān Ariṣṭnemi, the 22nd **Tīrthaṅkara** was contemporary with Lord Kṛṣṇa. Bhagawān Pārśva, the 23rd Tīrthaṅkara, is accepted by the modern histrorians to have lived in the 8th century B.C. After 250 years, Pārśva was followed by Vardhamāna Mahāvīra, the 24th and the last **Tīrthaṅkara.** Bhagawān Mahāvīra was a senior contemporary of Lord Buddha. He lived for 72 years and attained **Nirvāṇa** at Pāvāpurī in Bihār in 527 B.C. Like all other **Tīrthaṅkara** Bhagawān Mahāvīra was also omniscient,[2] which means that he had developed the capability of an absolute all-containing coherent experience of the Reality. Consequently, his philosophy was based on an unbiased Truth which is fortunately available to us in the Jain canonical literature which dates back to the 5th-6th century B.C. The discussion of physical existence in general and of atom in particular has been very exhaustive in the Jain canonical literature. Other Indian (and non-Indian) schools of philosophy have not treated this subject with such thoroughness.

In the following pages, we shall briefly deal with the theory of atom as discussed in Jain canonical literature and its commentaries by ancient Jain saints and seers.

1. Sir B. Russell, History of Western Philosophy, pp. 13, 14.
2. Omniscience can be defined as a pure and perfect (i.e. all comprehensive and all harmonious) extra-sensory experience to which the whole Universe of Reality is presented in the form of a 'complete system' as it really is in its entirety. Thus consciousness of an omniscient directly embraces the totality of existence in the form of a perfect systematic unit as the contents of a single experience.

SECTION I

METAPHYSICAL VIEW

IDEALISM VS. REALISM

To grasp properly the Jain views, regarding the theory of atom, it is necessary to understand the Non-absolutist attitude of the Jains regarding the nature of Reality. We shall, therefore, very briefly discuss the Non-absolutist Realism of the Jain Philosophy.

The Jains have developed, perhaps, a unique system of metaphysical thinking based upon their unique epistemology which recognizes both empirical and transcendental experience to be within the scope of human knowledge. According to them, reality is self-existing, self-consistent, and self-contained. It does not depend upon something outside it for its existence. Secondly, the Jain system is free from all absolutism. It does not deprecate common sense interpretation of experience in favour of abstract *a priori* logic. The logical attitude is intimately bound up with its empiricism. This realistic view stands in a close relation of kinship not only to the other realistic philosophies but also to science.

Since we want to make an attempt to compare the findings of Jain philosophical inquiry with the results of scientific pursuit, it would not be improper to devote a little space to a brief study of Western philosophical views, both ancient and modern.

Jain Philosophy, however, has the misfortune of not being able to attract Western scholars to rediscover it for its interpretation in terms of modern scientific concepts, unlike Buddhism and other systems of Indian Philosophy.

Over the centuries, the philosophical attitude in the west has never been constant but undulated between idealism and realism. The difference between these two appears to be irreconcilable, being more or less bound up with the innate difference of predispositions and tendencies varying from person to person. The result is an uncompromising antagonism. The Western scholars, who were brought up in the tradition of Kant and Hegel, and who studied Indian Philosophies, were more sympathetic towards the

Idealistic systems of India. In the 19th century, there was a predominant wave of Monism and scholars like Max Müller were naturally attracted towards the metaphysical views of Śaṅkara, etc. and the uncompromising Monism of *Vedānta* was much admired as the cream of the oriental wisdom.

REALISM OF JAINS DESERVES MORE ATTENTION

Recently, however, a set-back to Idealism has been observed, and staunch Idealists like Bradley are being openly challenged. Idealism is now virtually condemned because it does not satisfy the philosophical curiosities. It is generally accepted that the mind, even with its active contribution is, after all, an instrument of discovery and not a creator of facts. *Vedānta* appears to be the perfect philosophy from the Idealistic standpoint, and Jain Philosophy, being the complete anti-thesis of Vedānta, should be entitled to equally extensive study. New-Realism, (the real opponent of Idealism), is further intensified because it is intimately associated with modern science. Can anybody remain blind to the claim of science to be a safe means of revealing Truth, specially when it is substantiated by its achievements? Hence any system of Metaphysics which aspires to unlock the secrets of Reality cannot afford to totally disagree with modern science. We shall see in the following pages that the ancient Jain system of thought is more consistent with modern science than any other Indian philosophy.

The Non-absolutist realism—*Anekāntavāda*—of Jain is,at least, 2500 years old, if not older. The discussion on physical existence in general, and atom in particular, is very exhaustive in the Jain canonical and other literature. Other Indian (and non-Indian) philosophies have not treated this subject with such thoroughness. It is, therefore, ironical that when physicists referred to ancient theories of atom, they talked about Democritus and Kaṇāda, the propounder of Indain school of Vaiśeṣika Philosophy, while the Jain philosophy is hardly mentioned.

NON-ABSOLUTIST CHARACTER OF REALITY

Jains assert that if philosophy is not to stultify itself in its mission to organize our thought and experience into an ordered

whole, it must directly approach and study its character and behaviour free from preconceived bias. Dispassionate study reveals reality to be a synthesis of opposites—change and permanence, universal and particular—and we have no warrant to override the plain delivery of experience in deference to abstract considerations. In this respect, the other Indian Philosophies, particularly Vedānta and Buddhism, are regarded as absolutists by the Jains. For instance, the Vedāntists maintain that Reality is one universal existence and the multiplicity is only an illusory appearance called into existence by the inherent nescience of the percipient; on the other hand, the Buddhist Fluxists believe in atomic particulars, each absolutely different from the rest, and having nothing underlying them to bind them together. The Jains differ from them both, and maintain that the 'universal' and 'particular' are qualities, (and not substances), i.e. they are distinguishable traits in a substance (real). A real is neither a particular nor a universal in an exclusive (absolute) manner but a synthesis embracing both of them in its fold. A real is *sui generis*, and therefore, answers all demands of experience and all the requirements of thought. Thus, the Jains insist that the nature of reality must be determined in conformity with the evidence of experience, undeterred by abstract logic. Loyalty to experience and to fundamental concepts of philosophy alike makes the conclusion inevitable that absolutism is to be surrendered.

"Our Universe", emphatically assert the Jains, "must be an orderly whole or system. To be a system, it must most certainly be one. But again, because it is a system, it must be the expression of a single binding principle in and through a multiplicity of constituents (and not a medley of independent particulars as asserted by the fluxists). In practice, a thing is one or many according to the point of view from which it is looked at i.e. according to the purpose in the light of which it is studied. Not only must it be both—one and many, but it must be many precisely because it is many. Taking a further most important step forward, the Jains maintain that in the all embracing systematic whole, the unity and the multiplicity must be equally real, and each must be real through the other (and not an illusionary appearance as asserted by the Vedāntists).

SUBSTANCE, QUALITIES, MODES

SUBSTANCE

In the Jain metaphysical terminology, *'dravya'* (substance) denoted a real existence which is characterized by persistence-through-change. The Non-absolutist Realism of Jains is based on the doctrine of persistence-through-change. While the absolutists find self-contradiction in asserting both permanence and change in the same reality with reference to identical space and time, the Non-absolutist Jains maintain that one need not be afraid of accepting this as the Truth, as the very nature of things—since our common experience—gives this as a fact. They, therefore, reject both—an unchanging permanent real of Vedāntist and Parmenides and also mere eternal flux of Nihilists and Heraclitus. An unchanging permanent as well as mere change without a substratum are impossible abstractions. The Jains therefore, define substance **(dravya)** as "what is capable of eternal continuous existence through infinite succession of origination and cessation." [1] They also define it as "what possesses an infinite number of attributes." [2] and alternately as "the substratum of both qualities and modes."[3]

According to the Jains,"Substance is a real" because they assert the dynamic reality of **dravya** with permanent substantiality manifesting itself through (change in the form of) origination and cessation. The trinity of **utpāda** (orignination), **vyaya** (cessation), **dhrauvya** (permanence) form the triple characteristics of reality.

QUALITIES AND MODES

Thus, the dynamic substance i.e. **dravya** is always associated with certain intrinsic and unalienable attributes called *guṇas* (qualities). A **substance** does not exist without qualities because nothing can be (or exist) with being in some determinate

1. (a) Bhagavatī, uppaṇṇei vā, vigamei vā, dhuvei vā
   (b) Tat. Sū., 5.30: utpāda-vyaya-dhrauvya yuktam sat
2. Uttarādhyayana, 28-6: guṇānāmāsao dravvam
3. I.J.T., 1-3: "guṇa-paryâyāśrayo-dravyam"

way and the possession of qualities by a substance means its existence in a determinate way. One cannot divorce the existence of a 'real' from its determinate mode of being. Again, a substance and its quality must exist in some state or form, and so each one of them is a substratum for infinite modes called *paryāya*. *Paryāya* like *guṇa* is another technical term demanding careful understanding. The modes subsist in both substance and quality.[1] They are infinite in number and transitional in nature. In other words, cessation of the precedent mode is followed by the origination of the succeeding one.[2]

The intrinsic change in substance is called *arthaparyāya* (or intrinsic mode) which is subtle and continues without any external influence. Thus molecular disintegration and aggregation that occur every moment in a physical object is an intrinsic mode. A particular gross mode of existence, on the other hand, which is stable, and lasts for some time is called *vyañjana paryāya* or 'extrinsic' mode. A physical object may have a particular mode – say, as a pen – for a certain duration of time. This state of pen is *vyañjana-paryāya* of *pudgala*. Similarly, the continuous change that takes place in consciousness is *jīva's artha-paryāya* while its existence as a particular organism – say, a man – is *jīva's vyañjana paryāya* which is with a determinate life-span. It should be noted that *jīva* and *pudgala* have both kinds of *paryāya* whereas the other four substances have got only *arthaparyāya*.

As we shall presently see, we have to deal with six distinct substances or *dravyas* and each *dravya* has its own characteristic attributes. Thus, "colour" is an attribute of the physical substance *(pudgala)* and "yellowness" is a *paryāya* of the colour.

In the Non-absolutist Realism, all change must be change 'of' and 'in' something, i.e. a succession within a permanent identity. Thus, while a mode originates and ceases, the constitutive substratum of change can neither be destroyed nor created.

1 Uttar. 28-6: "Lakkhaṇam pajjavaṇam tu, ubhao assiyā bhave"

2. Approximate parallel conceptions in the Western thought are Spinoza's substance, qualities and modes. The term 'attribute' which is used in a technical sense by Spinoza, merely means quality (*guṇa*) in the Jain Metaphysics.

This brings us to an irritating problem in metaphysics, viz., the problem of relation. We shall discuss this in greater detail in the succeeding chapter of this book. Here, we shall only mention that the reality of relation is a fundamental concept of the Jains. A *"dravya"* is the identity of an infinite multiplicity of modes. It is a unity and diversity in one, and the relation involved is neither one of absolute identity nor one of absolute otherness, but something different from both. It is *sui generis* which does not permit of being determined by absolute criteria. A substance exists 'in' and 'through' its attributes, and the latter, related and organized, constitutes a 'substance'. In simple language, quality *(guṇa)* and 'mode' *(paryāya)* cannot be absolutely different from the substance nor can they be absolutely identical with it. The difference is only that of reference and not that of existence.

Earlier, it has been stated that the Non-absolutist Jains assert that while the universe is an order by whole, it is, at the same time, a plurality of its constituents. The six substances to be described below are deductions from experiential data. Each substance is distinct from another by virtue of possessing one or more particular qualities which are not possessed by the others. Besides, since all substances are constituents of a single Reality, a thread of unity runs through all of them in the form of universal qualities. In subsequent pages, we shall first deal briefly with the particular qualities of each substance, which shall be followed by the discussion of universal qualities.

SIX ULTIMATE SUBSTANCES

Jains believe in the existence of six ultimate real substances as under—

(1) *Dharmāstikāya*—Medium of Motion.

(2) *Adharmāstikāya*—Medium of Rest.

(3) *Ākāśāstikāya*—Space.

(4) *Jīvāstkāya*—Psychical Existence (Soul).

(5) *Pudgalāstikāya*—Physical Existence (Matter and Energy).

and (6) *Kāla*—Time.[1]

1. *Bhagavatī Sūtra*, 13-4-55, J.V.B. Edition.

The first five substances are called *astikāya*, because each of them is a homogeneous continuum composed of multiple parts. *Kāla* (i.e. time) is also included in the above list as the sixth substance, but it is not an *"astikāya"*. The term *astikāya* is a compound word made up of *'asti'* and *'kāya'*, which respectively mean *'(real)* existence' and 'extensive body'.[1] The term *astikāya* thus means a real extensive magnitude, i.e. having plurality of parts *(pradeśa)* in its constitution. The primal attribute of 'Existence, is the foundational element of the nature of an *astikāya* (existent). An existent is not a mental phenomenon or a figment of imagination but an extra-mental or objective reality. While such concepts as : substance, attribute etc. are, no doubt, the ways in which the mind works up the data of experience, but this does not mean that they are only mental and have no extra-mental reality. *Kāla*, the sixth substance, has neither extension in space nor plurality of parts and is, therefore, not an *astikāya*. Each of these substances continues to exist as an entity eternally, and though they co-exist spatially and temporally, they are mutually inconvertible.

We shall examine very briefly the nature and characteristics of these substances before taking up the detailed discussion on *pudgalāstikāya* which is the Jain name for 'physical substance'.

(1) DHARMĀSTIKĀYA & (2) ADHARMĀSTIKĀYA

These are the non-physical real substances as the media of motion and rest respectively. The existence of these two as reals is not accepted by any other metaphysical school of thought. The classical physics, however, had accepted the existence of substance called ether as a medium of motion. We shall, for the sake of convenience, translate these terms as positive and negative ethers respectively.

Each of them is a single, indivisible, homogeneous continuum pervading the entire occupied universe *(loka)*, but does not extend beyond it. In fact, they are the causes of the finiteness of the *loka*. Temporally, they are beginningless and eternal. Being non-physical

1. *Illuminator of Jain Tenets*, 1-1 (gloss).

and non-corporeal (*amūrta*), they are deviod of sense-qualities of smell, taste, etc., and, therefore, imperceptible to the sense-organs and physical instruments. Immobile themselves they passively assist the motion or rest of mobile stationary objects; positive ether *(dharmāstikāya)* is the medium of dynamic state and the negative ether *(adharmāstikāya)* is that of the static state. Not even the minutest vibration is possible without the assistance of positive ether. Hence, where there is no ether, there is neither psychical nor physical existence.

(3) ĀKĀŚĀSTIKĀYA (SPACE)

According to the Jains, space is a real substance, because it satisfies the requirement of substance as well as a real. It is the container of all other substances. It is boundless/infinite. Ethers and other substances do not occupy the whole space as they are finite. That portion of space which is occupied by other substances is called *loka* (cosmos).[1] *Loka* is finite and is surrounded in all direction by *aloka* which is inert, empty pure space – a boundless void.[2] Beyond *loka*, there is no object – animate or inanimate. Not a single tiny atom of matter nor a *Jīva* would be able to cross the boundary and go beyond the limit of *loka*. Actually, the space is one indivisible entity. The ethers determine the boundary of the *loka-ākāśa* by their own finiteness.

Before proceeding further, let us emphasize the utmost importance of the three reals mentioned above viz. *Dharmāstikāya, adharmāstikāya* and *ākāśāstikāya* (space). *Dharmāstikāya* and *adharmāstikāya* are mutually inter-penetrating and concomitant with *loka-ākāśa*. They are real constituents of the cosmos. Their existence and influence do not extend beyond the *loka-ākāśa*, but within cosmos they are all-pervading and co-extensive, Their separate existence cannot be inferred from their difference of locality as there is no such difference, but they have fundamentally different functions. In other words, they have a unity of locality with diversity of functions. Being devoid of physical qualities as well as consciousness, they can be distinguished by their respective functions.

1. Bhagavatī Sūtra, 13-4-60.

2. Pravacanasāia, Pradīpikā Vṛtti, 2-36.

Conception of these is essential to the conception of motion, If one accepts the reality of the physical object, one must also accept the reality of motion. Although looked upon with suspicion by idealistic metaphysicians, the doctrine of reality of motion is accepted by both realistic philosophers as well as scientific thought.

In order to accept the reality of motion of physical objects, the reality not only of space but media of motion and rest must also be postulated. None of the non-Jain Indian schools of thought has paid attention to this problem. *Vedānta* uses the term *ākāśa* rather indifferently to denote space and ether. It is to the credit of the ancient Jain sages alone that they boldly attacked the problem with significant success.

In the scientific world, the problem of motion was first dealt with by Galileo, considered as father of modern science and later on by Newton. Before them, Aristotelian tradition of absolute rest was generally believed. But Newton's theory got rid of the idea of absolute rest and introduced conception of a substance called the "ether", that was present everywhere, even in the empty space. Einstein pointed out that the conception of ether was unnecessary provided that one was willing to abandon the idea of absolute time.

The discoveries of modern science – the dual nature of matter, the standing wave-patterns of electrons – are all associated with the reality of space and its contents. Now the space itself, according to the Jains, is infinite extension and only a portion of it is filled with other real substances. It is this finite portion (which must curve upon itself as per Einstein's suggestion), which is the theatre of all the drama of cosmic dance. And the finiteness of the cosmos is due to the two other substances viz. media of motion and rest. Without these two, the systematic structure of the cosmos would have been a chaos. We shall have occasion to revert to this in the following chapter.

(4) JĪVĀSTIKĀYA

Jīvāstikāya is the psychic order of existence and *cetanā* or consciousness is its chief characteristic. Individual *jīva* is the SELF,

ultimatic Reality of which is self-evident. It is the central conception of Jain thought. Life and consciousness are co-extensive. Wherever there is life, there is consciousness, and the vice versa, But there are degrees of explicitness or manifestations of *cetanā* in different organisms. In the lowest class of organisms, it is very much latent; while in human beings, it is very much manifest. It is entirely distinct from all inanimate existence. Characteristic qualities viz. colour, odour, etc. inherent in physical existence have no relevance in the case of *jīva*, and hence, it cannot be cognized by sense-perception. *Cetanā* manifests itself in several ways : intuition, perception (cognitive elements), emotions, will, attitide and behaviour, awareness of pleasure and pain.

(UNION OF) SOUL AND BODY

Every animate organism is an organic union of non-physical *jīva*—soul—and physical body. This is the state of soul in mundane existence. But in the state of emancipation, (or *mokṣa* which literally means freedom) the union of the self (soul) with the non-self (body) ends once and for all. In both these states, the existence of *jīva* is real. Bondage in not merely empirical, and emancipation does not mean total cessation of the individual *jīva* but freedom from passions, cycles of births and deaths and worldly existence. It is the pure and perfect state of the *SELF*—the same old self which was once in bondage.

Emancipation presupposes contamination (which in itself is beginningless) of the self by non-self called *kārmic matter* or *karma śarīra*.

It is beyond the scope of this book to discuss the *modus operandi* of *karma* comprising the processess of attraction, assimilation, rise, fruition and dissociation of kārmic matter. Suffice to say here that the association of self and non-self generates passions and the passions reaffirm the association. The Doctrine of Karma explains the diversities and inequalities that undeniably exist in the world. Worldly happiness or misery, good or bad health, high or low status, riches and poverty of an individual are all results of karma. But the soul can free itself from the contamination and become emancipated. Until then, the soul and body interact and a change in one (or the other) always involves both physical and

psychical antecedents. If this is not admitted, ethical value will remain unintelligible.

(5) PUDGALĀSTIKĀYA – PHYSICAL EXISTENCE (MATTER & ENERGY)

Matter and energy of modern science are called *pudgala* by Jains. The use of this word is almost exclusive to the Jain literature. It is a derivative made up of two words: *pud* meaning combining or fusion and *gala* meaning dissociation or fission.[1] The properties of fusion and fission which characterize all matter are also responsible for the name *pudgala* given to this subtance. They are also responsible for giving it an atomic constitution.

The characteristic attribute of *pudgala* is that it possesses the properties which can be perceived by sense-organs viz. colour, smell, taste and touch.[2] Concomitance of all the four is emphasized by the Jains. In other words, if a thing is perceived by the sense of touch, it must also necessarily possess smell, taste and colour. The atomic structure of *pudgala* is, as its name implies, absent in the other *astikāyas*. Whereas the other four *astikāyas* are indivisible i.e. not disintegrable, *pudgala* is divisible. The ultimate indivisible unit of *pudgala* is called *paramāṇu* or ultimate primary atom. This atomic structure of the physical universe is the most interesting part of the Jain physics. The *paramāṇu* can neither be created nor can it be destroyed. It is eternal. Although it possesses sense-qualities, it cannot be an object of sense-perception. It is the subtlemost physical entity. By itself it transcends the sense experience, though it is basic constituent of all perceivable objects. We shall deal with this primordial physical existence, at length, in the section five of this chapter.

(6) *KĀLA – TIME*

Time is not included in the list of *astikāyas* but is included in the list of six *dravyas*.

Time possesses the characteristic of 'persistence-through-change' and is, therefore, a *dravya*. It is the necessary

1. Tat. Rāj., p. 190

2. Tat. Sūt. 5/23.

condition of duration (continuity), change (modification), motion. newness and oldness of substances. Time by itself cannot cause a substance to exist, but continuity of existence implies duration in terms of time. Mutation or change or modes also cannot be conceived without time, because change implies temporal succession in which modification takes place. Similarly, motion implies different positions of an object in space in temporal succession. Lastly, time causes the distinction between the old and the new, the 'before' and the 'after'. Ultimate indivisible unit of time i.e. time-point is called *samaya*.

Notions of space and time figure prominently on the map of Reality, and are, therefore, of paramount importance in our efforts to understand it (Reality) through philosophy as well as science. It would, therefore, be more appropriate to discuss this elaborately in the next chapter.

SIX UNIVERSAL QUALITIES

The following are the six universal qualities (*sāmānya guṇa*) i.e. they are possessed by all the six substances :

1. (Eternal) Existence (*Astitva*)
2. Causal Efficiency (*Vastutva*)
3. Substancehood (*Dravyatva*)
4. Objectivity (*Prameyatva*)
5. Extension-in-space (*Pradeśavatva*)
6. (Eternal) Persistence/Permanence (*Agurulaghutva*)

1. (ETERNAL) EXISTENCE (*ASTITVA*)

Eternal existence means continuous duration by reason of which each substance maintains its 'BEING' and is never confronted by extinction. It is by virtue of this quality that a substance is neither created nor destroyed, but maintains its identity eternally.

While emphasizing the plurality of the six substances, it is also emphasized by the Jains that plurality is not an unrelated chaos but a system, inasmuch as each substance is cemented with the rest by definite bonds of relationship.

The Non-absolutism of Jains is not the result of negation of absolute and extremes but their unification and integration as a system. Absolutism consists in maintaining *either* unity *or* multiplicity as absolute truth and holding that one is in absolute opposition to the other, e.g. Vedāntists hold the unity (of Reality) as the whole truth, whereas the Buddhist nihilists accept multipticity as the only truth, but the non-absolutist Jains accept both unity and multuplicity as the true determinations of the Reality. Thus, while propounding the division of Universal Reality into six substances each with its own particular characteristics, the Jains also emphasize their unity by propounding certain universal attributes possessed by all of them. The universal attribute "Existence" may be regarded as the highest universal, and is proclaimed by the Jains to be *Mahāsattā* i.e. essence of Reality.[1] This means that inspite of their multiplicity, the six substances comprise one universal system. This aspect of unity (viz. *Mahāsattā*) is emphasized not only in the individual substance's constitution as an individualistic trait (i.e. *Avāntarasattā*) but the unity of all Reals. Existence, however, should not be abstracted and postulated as the unitary substance of which the other substances may be taken as *paryāyas* (modes). The six substances, in spite of their common characteristic of existence, are fundamental and irreducible one to another.

Thus, the metaphysical system propounded by Jain philosophers is not a hopeless chaos of pluralism but a pluralism integrated into a system.

2. CAUSAL EFFICIENCY *(VASTUTVA)*

The *vastutva* is the second universal quality, which emphasizes the dynamic nature of the six substances.

We have already discussed in the previous section that a substance is characterized by permanence-through-change. The quality *vastutva* emphasizes the aspect of 'change'.

Both 'being' and 'becoming' are necessary concomitants of Reality and one is as ultimate as the other. Becoming or change

1. Pañcāstikāya-Saṁgraha, with Tattvapradīpikā, p. 8

presupposes causality, which is again reducible to identity-cum-difference, which is the fundamental nature of all Reals. But what is the occasion or rather the *raison d'etre* of change? According to the Jains, change is integral in a substance and the stimulus of change is seated in the very nature of substance. This is *vastutva* or causal efficiency. As regards the question, whether causal efficiency is different from or identical with substance, the answer is—it is diffierent, and at the same, identical.

3. SUBSTANCEHOOD *(DRAVYATVA)*

The quality of substancehood enables a substance to be the substratum of qualities and modes. As we have seen before, the qualities and modes cannot exist without any support. Such support is the substance. In other words, they will have no basis, if they do not rest in something real. This does not mean, however that *dravya* is merely a prop, supporting an alien fact, the quality. The quality characterizes the substance and the substance has the quality. It should also be remembered that the attributes alone are not sufficient to constitute substance, because for the Jains, *esse* is not identical with *percipi*. Qualities, in order to be objective and not merely subjective, do require an objective base. Such a base the *dravya* is.

The problem of relation between a substance and its attributes has already been discussed.

4. OBJECTIVITY *(PRAMEYATVA)*

By the virtue of this quality, a substance can become an object of knowledge. The Jains are realists and not idealists. A substance is a real and a constituent of the Universal Reality. This quality i.e. *prameyatva* enables the substance to be an objective reality. Realism of Jains has already been discussed earlier.

5. EXTENSION IN SPACE *(PRADEŚAVATTVA)*

By virtue of this quality, the substance extends in space. *Pradeśavattva* is also called as *'kṣetratva'* (i.e. quality of occupying space). This enables us to predicate a substance by the determinant *'kṣetra'*.

6. (ETERNAL) PERSISTENCE/PERMANENCE *(AGURULAGHUTVA)*

While discussing the universal causal efficiency (*vastutva*), it was stated that a substance is characterized by persistence/parmanence-through-change. While the quality 'causal efficiency' emphasizes the aspect of change, this quality viz. *agurulaghutva* emphsizes the aspect of persistence/ permanence. It is precisely this quality which prevents the substance from surrendering its own specific substancehood and prevents the quality from abandoning its 'qualityhood'. Further, both the substance and the quality undergo infinite modifications, intrinsically as well as extrinsically. But they do not lose their identity. Secondly, the interaction between two substances can never change the specific nature of either substance. Thirdly, each substance which is the substratum of infinite qualities of its own, continues to support its substance and they do not scatter away. The inalienability of the respective qualities of each substance also is due to this quality of *agurulaghutva.* All these mean that each substance and its characteristic qualities maintain their individuality in-spite of not only the interaction between two or more substances but 'self-interaction' also. The phenomena of ceaseless self-interaction has its parallel in the 'self-interaction of 'nucleons' very recently discovered in the subatomic reactions. According to Jains, such self-interaction is not restricted to physical existence *(pudgala)* only, but also extends to all the substances. It is called *"ṣaḍguṇa-hāni-vṛddhi"*, i.e. "six-steps of infinitesimal changes in descending as well as ascending order". We shall revert to this important phenomena in the next chapter.

After this brief description of six real existents, we shall take up detailed discussion on *pudgala* i.e. physical existence.

The quality *agurulaghutva* is thus responsible for maintaining the individuality of the substance and its characteristic properties. The intrinsic modifications of the substance is in the form of "self-interaction" and takes place in 12 steps—6 upwards and 6 downwards (*ṣaḍ-guṇa vṛddhi* and *ṣaḍ-guṇa hāni* or *ṣaṭ-sthāna-* patita-vṛddhi-hāni). An infinitesimal chage takes place in each step and can be mathematically explained and expressed as under.

The six steps upwards are:

(1) infinitesimal increase

(2) by a countless fraction,

(3) by a countable fraction,

(4) numerable times

(5) innumerable times

(6) infinite times

The six steps downwards are in exactly reverse order,

SECTION II

PUDGALA : ATTRIBUTES

(A) DEFINITIONS

PUDGALA : REMARKABLY MEANINGFUL NOMENCLATURE

Physical substance is called *pudgala*[1] by Jains. The etymological meaning of the word *pudgala* is that it has the property of intergration and disintergration. It has the following derivation[2] :

'Pud' means to combine/integrate and *'gala'* means to separate/disintegrate. Hence, the basic meaning of the word *pudgala* is : "That which undergoes modifications by integration and disintegration." In the words of the modern science, we can say that "what is fissionable and fusionable is *'pudgala'*."

CHARACTERIZATION

Many definitions of *pudgala* are possible on the basis of numerous varied qualities possessed by it and also numerous aspects[3] from which it is perceived.

There are particular qualities possessed exclusively by *pudgala* which distinguish it from the other substances. Out of these, there are some qualities which are found in all forms and modifications of *pudgala*, while some of them are found in some forms of *pudgala* and are absent in other. Characteristic qualities are those which distinguish it from other substances and are found in all modifications of *pudgala*.

According to Jain canonical literature, physical substance *(pudgalāstikāya)* is characterized by four qualities viz. colour, taste, odour, and touch, Possession of these qualities makes

1. The terms physical existence or *pudgala* used in the book stand for the entire range of sub-atomic particles, atoms/elements, molecules and material bodies as well as all forms of material energy of science.

2. Śabdakalpa-druma-koṣa.

3. 'Aspect' implies that the perception of an object is a quality inherent in the thing perceived—a quality that is drawn out into focus by the percipient.

pudgala perceivable by sense-organs of an animate organism. Out of the five *astikāyas*, which constitute the universe, *pudgala* is the only one which possesses the quality of *mūrtatva*, that is, it is perceivable by the sense-organs.[1]

In *Bhagavatī Sūtra*, which is one of most ancient and important canons, *pudgala* is elaborately described from many aspects. In Jain philosophy, a typically frequent method of describing the character of an object is the use of fourfold determinants : substance *(dravya)*, location in space *(kṣetra)*, time *(kāla)* and attributes *(bhāva)*.

Thus,

1. Substantially, *pudgala* is infinite in number, that is to say, there are infinite number of different physical entities.
2. Spatially, *pudgala* fills the whole cosmic space *(lokākāśa)*.
3. Temporally, *pudgala* is eternal i.e. without beginning and without end.
4. Qualitatively, *pudgala* possesses colour, taste, odour and touch.
5. Interactionwise, *pudgala* is capable of being taken in and transformed by *jīva* (psychic order of existence). The interaction between the psychic order and the physical existence is threefold:
   (a) *Karma* : A specific group of matter called *karmavargaṇā* is attracted and assimilated by *jīva*. Each individual *jīva*, during its worldly existence, continuously interacts with *karma-pudgala*.
   (b) Body : Each *jīva* must have a body as the instrument for the experience of pleasure and pain during its worldly existence. Four groups of *pudgala* are assimilated by *jīva* for this purpose. They are—*audārika*, *vaikriyā*, āhāraka, and *taijas*.[2]
   (c) Vital Functions : Breathing, nutrition, speech and thought—all these physiological functions of a living

1. *Bṛhad-dravya-saṁgraha*, verse 15.
2. See, also section IV of this chaper.

oranism are possible only with the help of different groups of *pudgala* possessing specific properties useful for specific function.

Besides, *pudgala* has form and extension, it is devoid of consciousness and life, it is eternal in its nature, constant in quantity (i.e. neither increasing nor decreasing) and it is a fundamental constituent of the universe. It pervades the whole of *lokākāśa*.[1]

(B) PUDGALA : CHARACTERISTIC ATTRIBUTES

The characteristic qualities *(lakṣaṇa)* of a substance are those which distinguish it from other substances. As we have already seen, *pudgala* is the only substance which is perceivable (i.e. cognizable by sense-organs, *mūrta*),[2] whereas all other five substances are imperceptible *(amūrta)* through sense-organs. This is because only *pudgala* possesses the qualities of colour, smell, taste and touch.[3] Each of these qualities is capable of stimulating a specific sensory equipment of an animate organism.

The stimuli are then conveyed by the respective sense-organs to the congnizing apparatus, enabling it to perceive the physical object.

All the other five substances are totally incapable of any of these qualities and are, therefore, incapable of being the objects of sense-data and being perceived by the sense-organs. Thus, whatever is perceived or is perceivable must necessarily belong to the physical order of existence.[4] Conversely, whatever is bereft of sensory qualities is non-physical.[5]

Rūpatva/mūrtatva or sensory perceptibility is the sum total of the four sensuous qualities named above. Colour and/or extension by itself is not the cause of perceptibility of the matter. All the four qualities are concomitant.[6] No modification of matter is such that it possesses three, two or one of the four qualities. Nor

1. Bhagavatī Sūtra, 1/10/129.
2. Tat. Sūt. Siddhasena's Commentary. 5/3.
3. Ibid, 5/23.
4. Ibid, 5/4 (Bhāṣya).
5. Ibid, 5/4 (Siddhasena's Commentary).
6. Yatra rūpa-pariṇāmaḥ tatrāvaśyaṁtayā sparśa-rasa-gandhairapi byāvyam; ataḥ sahacarametac catuṣṭayam – Tat. Sūt. Siddhasena's Commentary, 5/3.

is there a modification of a substance other than matter which can possess one, two or three or all the four above qualities.

All mutation of matter, be it a single ultimate atom or an aggregate constituted by innumerable such ultimate atoms, must possess all the four qualities.

TYPES OF CHARACTERISTIC QUALITIES

Five types of primary colour	:	Black, blue, red, yellow & white
Five types of taste	:	Sweet, bitter, acrid, acidic (sour) and astringent.
Two types of odour	:	Good smell and bad smell.
Eight types of touch	:	Hot, cold; gluey, dry; hard, soft and light, heavy.

C. OTHER IMPORTANT ATTRIBUTES (MODES)

Some important modes of the physical substance (*pudgala*) are : sound, light and darkness; integration and disintegration; microscopicness and macroscopicness & shape or configuration.[1]

1. SOUND :

Sound is produced by collision or separation of two or more physical objects. It is the agitation set up by knocking together or splitting of two aggregates.[2] An ultimate atom cannot produce sound by itself.[3] It is of two kinds (in respect of genesis) – (i) Natural or spontaneous, e.g. thunder and (ii) that produced by conscious effort. The latter is again of two kinds – (i) lingual and (ii) non-lingual[4]. The lingual sound is again of two kinds – (i) articulate i.e. made up of alphabetical composition, and (ii) inarticulate i.e. sound produced by subhuman animals.

Non-lingual sound is produced with the help of (musical) instruments and is of four kinds :

1. Tat. Sūt., 5/24.
2. (a) Utt. 28/12, 13.
   (b) I.J.T., 2/15.
3. Pañca., verse 79.
4. Tat. Rāj. 5/24.

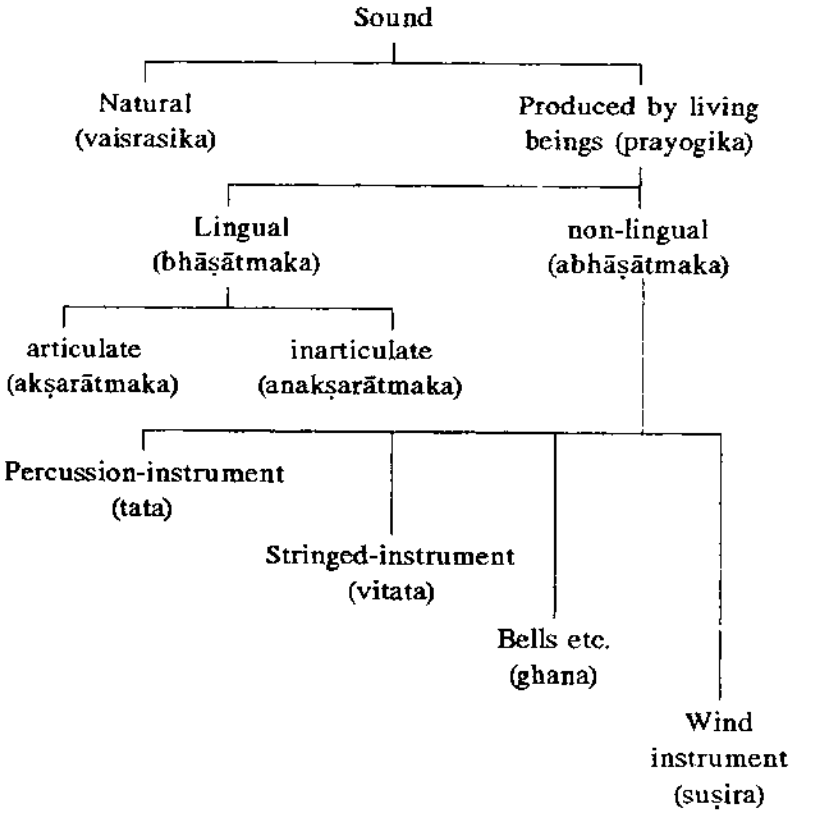
(a) *tata*—sound produced by percussion instruments like drum.

(b) *vitata*—sound produced by stringed instruments like violin[1].

(c) *ghana*—sound produced by bells, etc.

(d) *suṣira*—sound produced by flute, and such other wind-instruments[2].

Classification of sound can be tabulated as under :



1. There is slight difference between the Jain and lexicographer's terminology for sound of musical instruments. According to the latter, *tata* stands for the sound produced by stringed instruments, while *anaddha* stands for that by percussion instruments.

2. Sarvārthasiddhi, 5/24.

From a different aspect, sound may be divided into three kinds :

(i) Sound produced by animate organisms.

(ii) Sound produced by inanimate objects.

(iii) Sound produced jointly by both.

Thus, sound is not a quality (*guṇa*) but modification (*paryāya*) of *pudgala*. Sound is in the form of waves produced by the vibrations of sound-producing aggregates and is propagated by material medium such as air or water but not by space i.e. in vacuum. Sound is perceived by the sense-organ of hearing.

The *Vaiśeṣika* philosophy does not accept sound as the modification of *pudgala*, but an attribute of space. This view is patently untenable. Firstly, sound is *mūrta*—perceivable by a sense-organ, while space is *amūrta*—devoid of sense-data. The attribute of an *amūrta* substance can never be *mūrta*. For the sound to be an attribute of space, either the space must be considered as *mūrta* of the sound to be *amūrta* which is obviously not the case. Moreover, sound-waves are propagated, and therefore, dynamic, while space is static (*niṣkriya*). According to science, sound-waves cannot be propagated in vacuum (space). If it was an attribute of space, it must inhere everywhere in space.

2. LIGHT AND DARKNESS

Light is an attribute of *pudgala* and is the cause of visibility. Darkness, the anti-thesis of light and the cause of invisibility is also an attribute of *pudgala*[1]. Darkness, according to Jain belief, is not merely absence of light but is a specific combination of physical bodies in which black colour is predominant.

There are three kinds of light radiations :—

(i) Hot effulgence (ātapa)

(ii) Cold effulgence (udyota)

(iii) Lustre (prabhā)

1. Sarvārthasiddhi, 5/24.

Hot effulgence is the sun-light or light from a fire or a lamp etc. The emission from such sources is composed of a larger proportion of heat radiations than light, e.g. sun-light is only 35% light; lamp-light is 7 to 10%. Cold effulgence, on the other hand, predominates in light radiations, and there is very little heat, if at all. Reflection of sun-light by moon etc, falls into this kind. Light radiated from the tiny body of a glow-worm is 99% light and only 1% heat. Lustre is light rays emitted by certain gems and the like.

Shadows (*chhāyā*) and images are also produced by light, and are, therefore, physical objects.

3. INTEGRATION (*BANDHA*) AND DISINTEGRATION (*BHEDA*)

The ultimate atom is the permanent basis of the physical existence. All physical objects are constituted by the ultimate atoms which combine together to form composite bodies or aggregates. Smaller and simpler aggregates also combine together to form larger and more complex objects. Conversely, large and complex objects break up into smaller and simpler components. This synthesis or fusion and break-up or fission are eternal phenomena in the physical universe. All physical objects are the result of either integration *(bandha)* or disintegration *(bheda)*.

(a) The integration is of two kinds – (i) Natural (*vaiśrasika*) and (ii) Made by animate organisms (*prāyogika*). The natural kind is again of two types (in respect of time) : with a definite beginning and (ii) without a beginning. Some instances of natural integration which have a beginning are : clouds, lightning, rainbow etc. As far as the physical existence is concerned, there is no integration without a beginning, either natural or made by organisms. The only instances of eternal or beginningless integration are *dharmāstikāya* (positive ether), *adharmāstikāya* (negative ether) and *ākāśāstikāya* (Space) which are non-physical.[1]

Integration made by living organisms is necessarily with a definite beginning and can be divided into two kinds from another aspect.

(i) Integration of one kind of matter with another, e.g., production of chemical compounds.

1. Ṣaṭkhaṇḍa., 14/5, 6/30/29, 37/34.

(ii) Combination of matter with living beings (*jīva*).

The last one is again of two types : (i) *karma-bandha*– Bondage or Combination of *karma-vargaṇā* with *jīva*; and (ii) *No-karma-bandha*– Combination of other groups[1] of *pudgala* with *jīva* in vital functions,

(b) Disintegration or break-up of physical bodies is also of two kinds: (i) Natural and (ii) Made by animate organisms.

Natural disintegration is the spontaneous decay of the physical substances e.g. radioactive elements due to their own inherent structural properties. This kind also includes disintegration by natural forces such as wind, rain, flow of water, etc.

Disintegration produced by animate organisms is of many varieties depending upon the methods of division and separation. Some typical methods of break-up are :

(i) division by sawing or splitting (*utkara*).

(ii) division by breaking into smaller pieces (*khaṇḍa*).

(iii) division by grinding (*cūrṇa*).

(iv) layer-by-layer separation (*pratara*).

(v) division by fissures (*anutaṭikā*).

4. MINUTENESS (MICROSCOPICNESS) AND LARGENESS (MACROSCOPICNESS)

The physical universe is composed of innumerable varieties of physical objects, from a microscopic sub-atomic particle to a macroscopic giant star. Both these opposite qualities are, therefore, special attributes of the physical substance (*pudgala*). Largeness and minuteness are, however, mostly relative. An object is large because there is another one which is smaller than it. Largeness of the former is strictly relative to the minuteness of the latter. An ultimate atom (*paramāṇu*) is the smallest indivisible form of *pudgala*, and there is nothing more minute than it. And hence minuteness (microscopicness) is of two kinds :

1. See also section iv of this chapter.

(i) Relative
and (ii) Ultimate.

Similarly largeness (macroscopicness) is also of two kinds :

(i) Relative and

(ii) Ultimate.

The ultimate macroscosmic object is called *acitta mahāskandha* i.e. great aggregate which pervades the entire cosmic space *(lokākāśa)*.

5. SHAPE/CONFIGURATION *(SAṀSTHĀNA)*

This also is an important attribute of the physical existence. It is related to the capability of the physical objects to extend in the three dimensional space. Shapes have infinite varieties, but they can be divided broadly into two groups :

(i) Regular or Symmetrical.

(ii) Irregular or Non-symmetrical.

Some regular configurations are : sphere, cube, pyramid, etc.

SECTION III

GENERAL PROPERTIES OF PUDGALA

1. Pudgala is

   (a) an *astikāya*,[1]

   (b) a real,[2]

   (c) a substance,[3]

   (d) eternal/indestructible,[4]

   (e) *avasthita*[5] (non-transmutable).

2. *Pudgala* is physical order of existence, not psychical.[6]

3. (a) Pudgala possesses qualities of colour, taste, smell and touch.[7]

   (b) Pudgala is sensible/perceivable.[8]

4. (a) Pudgala is *kriyāvān* (i.e. incessantly active).[9]

   (b) Pudgala is *pariṇāmī* (i.e. subject to mutation).[10]

5. Pudgala is fusionable and fissionable.[11]

6. (a) Pudgala is numerically infinite.[12]

   (b) Spatially it fills the entire universe.[13]

7. Pudgala interacts with and influences psychic order of existence, i.e., *jīva* or consciousness.[14]

1. Bhagavatī Sūtra, 13/4/55 (J.V.B. Edition)
2. Ibid., ibid.
3. Utt. 28/8
4. Tat. Sūt. 5/4
5. Ibid., ibid.
6. Ibid., 5/1
7. Bhagavatī Sūtra, 2/10/129
8. (a) Tat. Sūt., 5/4;
   (b) Brh. Dra. Saṁ., verse 15
9. Tat sūt. Bhāṣya, 5/6
10. Bṛh. Dra. Saṁ. 2/1 p. 67
11. Tat. Sūt. Commentary, 5/1
12. Bhag. Sūt. 2/10/129; Utt. 28/8
13. Ibid., ibid
14. (a) Tat. Sūt. 8/2
    (b) Ibid., 5/19

We shall now discuss the above properties of *pudgala* in detail :

1. (a) PUDGALA IS AN ASTIKĀYA

Earlier, *astikāya* was defined as —

(i) a homogeneous continuum composed of multiple parts, and

(ii) having an extended body.

Pudgala is an *astikāya*, as all aggregates of *pudgala* are composed of multiple parts (*pradeśa*). The composite bodies (aggregates) of *pudgala* consist of numerable or innumerable or infinite number of *pradeśa*,[1] depending upon the structure and composition of the bodies. An ultimate atom is a single *pradeśa*, and has no constituents.

As regards extension-in-space, there is remarkable similarity between Jain view and modern science. The extension-in-space of *pudgala* varies from aggregate to aggregate depending upon its density. Since a free ultimate atom is an indivisible point, it will always occupy a single space-point, but a composite of two such atoms—a diatomic aggregate—can extend to two space-points, or after fusion can occupy a single one. Similarly, an aggregate composed of numerable, innumerable or even infinite number of *pradeśa*, can be accommodated in a single space-point on account of its quality of compressibility or may extend to numerable or innumerable space-points.[2]

The extension (number of space-points occupied) of an aggregate cannot exceed the number of its constituent atoms. But the maximum extension of an aggregate of infinite atoms is innumerable, and not infinite space-points. It must be remembered that a number of atoms may occupy a single space-point at the

1. (a) Br. Dr. Saṁ., verse 25
   (b) Niy. Sār., verse 35
   (c) Tat. Sūt., 5/10
2. Tat. Sūt. Sarvārthasiḍhi, 5/14

same time without being fused. Thus, infinitely infinite ultimate atoms in the free state together with infinitely infinite number of aggregates are all accommodated in *lokākāśa* which has innumerable *pradeśa* only, and not infinite[1] This is because of the unique attribute of tremendous compressibility of *pudgala*. This view of Jains is in line with the discoveries of modern science that 99.97% of mass of an atom is condensed in its nucleus which occupies 500,000 billionth part of the space of the whole atom.

1 (b) PUDGALA IS A REAL EXISTENT

(c) PUDGALA IS A SUBSTANCE

The subject of Non-absolutist Realism of Jains as well as that of Substance, Quality and Modes have been already dealt within the previous section. Besides, it is proposed to deal with this again in the subsequent chapter. Hence, suffice here to repeat that *pudgala* is a real existent as well as a substance. As a real, it is both permanent as well as changing, and the change in attributes that occurs at every moment is due both to its internal dynamic constitution as well as its interaction with other reals. The Jains emphasize that all these modifications are events in time, but as a substance, *pudgalāstikāya* has timeless continuity of substancehood which is not an event in time. Whether it is ultimate free atoms or aggregates, the continuity of the substancehood in all its modifications is a fact.

A very simple example to explain the relation between the substance and its modes is that of conversion of a golden bangle and a golden ring by a goldsmith. In both, the specific qualities of the element gold inheres uniformly but the mutability of the gold to be transformed into different shapes and sizes makes it possible to become sometime a bangle and sometime a ring. This transformation of shapes is mutability and the shape for the time being is a mode. The bangle-mode can be destroyed to create the ring-mode, but the goldhood is permanent or identical in both.

1. I.J.T. (Gloss), 1/34.

(b) PUDGALA IS ETERNAL/INDESTRUCTIBLE

(e) PUDGALA IS NON-TRANSMUTABLE

Permanence (eternal existence) and non-transmutability are universal qualities of all substances including *pudgala*. Earlier, we had stated that 'temporally' *pudgala* is eternal, i.e. without a beginning and without an end. In the *Bhagavatī sūtra*, this attribute of *pudgala* is described extensively thus : "*kālao na kayāi na asi, na kayāi natthi, na kayāi na bhavissai—bhavimsu ya, bhavati ya, bhavissai ya—dhruve, nīyae, sāsae, akkhae, avvae, avaṭṭhie, nicce.*"[1]

In this Sūtra, the eternal existence of *pudgala* is described by a group of apparent synonyms with subtle nuances. It would be extremely difficult to translate each term of the *sūtra* by an exact English word. We shall, try to give an appropriate group of words which gives the same sense as the *sūtra*:

"*Kālao.....bhavissai ya*" means—"Temporally, in the past, there was never any time when *pudgala* did not exist; in the present, there is no time when *pudgala* does not exist; in the future, there will not be any time when *pudgala* will not exist; (stated in positive words, it means)—*pudgala* did exist at all times in the past; *pudgala* does exist in the present; *pudgala* shall exist at all times in the future."

"*Pudgala* is *dhruva* i.e., it is perpetual/persistent which emphasizes its endless continuity without pause."

"*Pudgala* is *niyata* i.e., it is quantitatively immutable or fixed which indicates that the law of conservation is strictly applicable. It means that[2] the total quantity of *pudgala* in the universe is always constant; whatever was the quantity in the infinite past will always remain the same in the infinite future. Not a single *paramāṇu* (ultimate atom) has been destroyed in the past nor will it be destroyed in future. Not a single *paramāṇu* was newly created in the past nor will it be created in future."[3]

1. 2/10/129.
2. *Tat. Sūt.* Siddhsena's Commentary, 5/3.
3. A parallel conception of this quality is the "Principle of Conservation of Matter and Energy" in modern science.

"*Pudgala* is *śāśvata*[1], i.e. it is eternal/timeless, which emphasizes that *pudgala* exists irrespective of time, and further implies that it had always existed in the past also; thus, it has neither beginning nor end."

"*Pudgala* is *akṣaya*, i.e., it is imperishable/indestructible, which means that *pudgala* never ceases to exist, and its existence is not affected by the passage of time, and it is immune from extinction."

"*Pudgala* is *avyaya*, i.e., it is immune to loss, which again emphasizes the quantitative steadiness/conservation of *pudgala*."

"*Pudgala* is *avasthita* i.e., it is non-transmutable."

"*Pudgala* is *nitya* i.e., it is permanent/continuous, which emphasizes its uninterrupted continuity."

NON-TRANSMUTABILITY OF PUDGALA

Although the term *avasthita* is generally a synonym of *dhruva*, etc., its meaning carries a profound significance. It means that *pudgala* never becomes a *non-pudgala*.[2] Now, we have been repeatedly saying that Jains emphasize the 'persistence-through-change' as the fundamental nature of a real, and therefore, *pudgala* must positively be subject to change. But the term 'change', generally, refers to 'the process of differentiation, slight or great, in appearance or essence.' Hence, the term *avasthita* does not deny the mutability of *pudgala* in its own modifications but denies the transmutability into another *non-pudgala* substance. That is to say – *pudgala* does persist through modes, but is always eternally *pudgala*. It can never absolutely be destroyed nor be absolutely transmuted i.e. it can never become *non-pudgala*.

Thus, although certain groups (*vargaṇā*) of aggregates of *pudgala* intimately interact with and are attracted, taken in and

1. The word *śāśvata* could also be translated as 'everlasting'. But, this is not appropriate here.

   In Christian Theology, the soul is everlasting but not eternal, because the soul of each new-born infant is a fresh creation which is immortal, and therefore, *everlasting*. In Jainism, each individual soul has no beginning and need never end, and is, therefore, *eternal*.

2. Pravy. Sār. 2/3

transformed (but not transmuted) by the conscious substance (*jīva*); at no time, do these groups lose their own identity and they remain eternally *pudgala*. In short, *pudgala* is mutable, but not transmutable.

2. PUDGALA IS PHYSICAL, NOT PSYCHICAL ORDER OF EXISTENCE

What is devoid of consciousness is *ajiva*. *Pudgala* is eternally *ajiva*; it is not capable of knowing; it is bereft of feeling; it is not psychical. It belongs to the physical order.[1]

3. (a) PUDGALA POSSESSES QUALITIES OF COLOUR, TASTE, SMELL AND TOUCH. (b) PUDGALA IS SENSIBLE/PERCEIVABLE.

These properties of *pudgala* have already been dealt with under the heading "Characteristic Attributes" in Section II.

4. (a) PUDGALA IS PARIṆĀMĪ i.e. SUBJECT TO MUTATION. (b) PUDGALA IS KRIYĀVĀN i.e. INCESSANTLY ACTIVE.[3]

Pudgala has the propensity for being dynamic/active. All forms of *pudgala*—*paramāṇu* as well as composite bodies—do not just sit around doing nothing. They are always beehives of activity. Activity is of two kinds[4]—

(a) *Pariṇāma* (mutation) which does not involve motion in space.

(b) *Kriyā* (motion) which involves movements in space—motion, vibration, oscillation, etc.

(a) *Mutation (Pariṇāma)*

The word *pariṇāma* means change or mutation i.e., change of one state into another. Nothing is absolutely permanent nor absolutely destructible.[5]

1. *Tat. Sūt. Bhā.*, Commentary, 5/1 : *Jīvādānyo(a)jīva iti paryudasaḥ sat eva vastuno(a)bhimataḥ, vidhipradhānatvāt, atastulyāstitveṣū bhāveṣu, caitanya-niṣedhadvāreṇa dharmādisvajīvā ityanuśāsanam.*
2. *Tat. Sūt. Bhā. 5/3*
3. *Ibid. 5/6*
4. *Tat.* Rāj. 5/22 : *"Parispandanātmakaḥ kriyetyākhyāyate, itarah pariṇāmaḥ."*
5. *Syādvādamañjarī : "Pariṇāmaḥ avasthāntara-gamanam, na ca sarvattā vināśaḥ."*

Destruction of the preceding state gives way to the birth of the succeeding state.[1]

Pariṇāma, i.e. change is a universal quality of all substances including *pudgala* and it has been explained in different ways from different aspects in Jain scriptures. In *Rājavārtikam* it is said that *pariṇāma* is mutation of a substance, natural or otherwise, without affecting its own fundamental identity.[2] In order to make a distinction between *pariṇāma* and *kriyā*, *Siddhasena Gaṇi* has defined *pariṇāma* as mutation other than vibration etc.[3]

In the *Tattvārtha Sūtra*, *Pariṇāma* is defined as the inherent nature and the corresponding activities i.e. the change in the character of attributes of each substance.[4] This means that *pariṇāma* and *paryāya* are almost synonymous. Thus *mutation* is not different from modification.

Referring to *pudgala*, five *pariṇāmas* which are listed in the *Bhagavatī Sūtra* are the main attributes of *pudgala* viz., *varṇa* (colour), *rasa* (taste), *gandha* (odour), *sparśa* (touch) and *saṁsthāna* (shape)[5] which render the *pudgala* sensuous or cognizable by senses. Ten *pariṇāmas* of *pudgala* are listed in *Parṇṇavaṇā Sūtra*. Five of the ten are the same as in the *Bhagavatī Sūtra* and the rest are : *bandha* (association), *bheda* (disassociation), *gati* (motion), *śabda* (sound), and *agurulaghu* (masslessness), most of which have already been dealt with earlier.

Temporally *pariṇāma* can be two-fold : (i) beginningless and (ii) with a beginning.[6] *Pariṇāma* of *pudgala* is always with a beginning.[7] There are many varieties of *pariṇāmas* (of *pudgala*) with a beginning.[8]

1. *"Avasthitasya dravyasya pūrva-dharma-nirvṛtau dharmāntarotpattiḥ pariṇāmaḥ"* (Commentary by Vyās).
2. *Tat. Rāj, 5-22-10.*
3. *Tat. Sūt. Siddhasena's Commentary, 5/41.*
4. *Tat. Sūt., 5.42: "Tadbhāvaḥ pariṇāmaḥ."*
5. *Bhag. Sūt., 8/10/467.*
6. (a) *Tat. Sūt., 5/42 :"....anādirādimāmśca."*
   (b) *Tat. Rāj. 5/42.*
7. *Tat. Sūt., 5/43 : " Rupisvādimān."*
8. *Ibid., (Bhāṣya), 5/43.*

MODIFICATION

We have seen that Non-absolutist Jains do not believe in absolute permanence or total cessation. According to them, both transitory and permanent attributes co-exist in a substance. This is the primal nature of the entire real existence. Thus, a substance can be considered eternal and, therefore, immutable, if one examines it from the view-point of *dravya* i.e. its underlying unity and ignoring (but not denying) the other aspect. On the other hand, it must be considered as incessantly changing, if looked at from the view-point of *prayāya*[1] i.e. its transitional attribute which establishes its mutability. And since all substances possess both attributes simultaneously, they are both permanent as well as changing. In short, they are subject to the doctrine of permanence through-modification.

TYPES OF MODIFICATION

Modification is, thus, a primal property of *pudgala* which, therefore, has a propensity of being active (*pariṇāmi*). And since the modification is infinite, activity is also infinite.

All modifications can, however, be grouped under two types:

(i) *Artha-paryāya* (Implicit Mode)

(ii) *Vyañjana-paryāya* (Explicit Mode)

(i) *ARTHA-PARYĀYA* : It is the intrinsic change in *Pudgala*. It is instantaneous, continuous (without pause), and incessant (timeless). This continuous flow of *pudgala* is parallel to the continuous flow of time. It is total self-interaction,[2] and not caused by anything external. The implicit mode is neither perceivable nor expressible.

(ii) *VYAÑJANA-PARYĀYA* : *Vyañjana-paryāya*, on the other hand, may be, intrinsic as well as extrinsic, and it has a duration. It is, in fact, an event in a particular part of space at a particular time. Besides the molecular integration and disintegration, that

1. *Tat. Rāj. 5/7/25.*
2. Cf. the discussion on self-interaction of sub-atomic particles in the first chapter.

occur every moment in a physical object, the object may have a determinate state of existence—say, as a pen—for a certain duration of time. This state of being a pen is a *vyañjana paryāya* of *pudgala*.

The explicit mode is gross, lasting for some time and amenable to verbal expression. The implicit mode, on the other hand, is subtle, lasting for only one *samaya* (the time-point), and inexpressible.

From another point of view, the modes may be said of two types :

(i) *svabhāva paryāya*—that is due to self-interaction.

(ii) *vibhāva paryāya*—that is due to interaction with other substances.

Thus, *arthaparyāya* is always *svabhāva paryāya*, while *vyañjana- paryāya* is both *svabhāva* and *vibhāva*.

(3) MOTION (*KRIYĀ*)

Pariṇāma and *kriyā* are, but, two facets of the dynamic nature of *pudgala*. *Kriyā* differs from *pariṇāma* in a subtle way because it involves motion/movement of some kind or other. Actually, both are manifestations of dynamism, and therefore, *gati* (i.e. motion) has been included as one of the ten *pariṇāma* as we have seen. However, motion in which *kriyā* is involved is gross as well as subtle, while mutation (*paryāya*) involves, perhaps, very subtle type of *gati*. We shall now discuss various kinds of motions which explain *pudgala* as being incessantly active.

In the annotation of Tattvārtha Sūtra, (5/6), if has been stated that pudgala and jīva are active (kriyāvān) substances,1 whereas the other substances are niṣkriyaḥ i.e. motionless2.This means that out of the six substances, dharma, adharma and ākāśa are completely devoid of motion of any kind. Jīva is dynamic only in its worldly existence and its dynamism is due to (i) its association with karma pudgala, and (ii) its interaction with other groups

1. *Tat. Sūt. Bhā.*, 5/6

2. *Tat. Sūt.*, 5/6

(vargaṇā) because of its vital functions of *pudgala*. Ultimately, when *jīva* attains emancipation[1], its association with physical order of existence comes to an end once for all. In its pure state, *jīva* becomes motionless.

Pudgala is, thus, the only substance which has motion as its inherent attribute. At the same time, it should not be construed that the entire physical existence is active everywhere at all times and under all conditions. A physical body is sometimes in motion and sometimes at rest.[2]

Pudgala remains at rest on a single space-point for sometime before moving. In short, the dynamic state of *pudgala* is not continuous, but there are periods of intermittent rest.[3]

Vibratory motion is one type of dynamic activity,[4] being an inherent attribute of *pudgala*. In other words, *pudgala* releases or absorbs energy because of its own competence to vibrate, and is thus dynamic in its own right[5].

There are many types of *kriyā* (activity) and primarily each *kriyā* is different from the other. But different types of energy-manifestations can be grouped together on different basis. On the basis of causality, there are two types of *kriyā* :

(i) Spontaneous release of energy caused by its own innate capacity, and

(ii) Activation caused by external forces.

In another way, *kriyā* is of two types :

(i) motion, and (ii) fusion-fission.

1. Just after emancipation, the emancipated soul goes straight upward in one *samaya* to the top of the cosmic universe. This ultimate upward movement of the emancipated soul is perfectly straight and due to combined causes of (i) an upward push given by the final release from the bodies (as a seed springing upwards from a dry pod when released), and (ii) *Jīva's* inability of sinking downwards, because of masslessness or going in any other direction, because it is bereft of its own motion.

2. *Bhag. Sūt., 5/153-155.*

3. *Bhag. Sūt., 5/170*

4. *Prav. Sār., Prad. Vṛtti, 2/37.*

5. *Tat. Śloka Vār., 5/7/2.*

Again the motion may be vibratory or migratory.

Vibrations are again of two types : (i) simple, and (ii) complex.

Two types of migratory motions are :

(i) without changing direction i.e. in a straight line, and

(ii) with change of direction.

In the *Bhagavatī Sūtra*,[1] a few instances of different kinds of motions are given thus : "Motion may be spontaneous or caused by outside forces. It is not eternal i.e. matter is sometime in motion and sometime at rest. It sometimes vibrates, and also rotates and so on upto the time when it changes its mode. By the word 'so on' here we understand that besides simple and complex vibrations, there are many other types of motion but what these are is a matter of research. We shall again deal with different kinds of vibrations later on in this chapter.

5. PUDGALA IS FISSIONABLE AND FUSIONABLE

(a) As stated before, the very name *pudgala* is derived by the virtue of the *pudgala* possessing the qualities of being fusionable and fissionable.[2] *Put (pūraṇa)* means fusion and *gal (galana)* means fission. In other words, the processes of fusion and fission are inherent properties of the physical universe.

The process of fusion is called *bandha* i.e. integration. The process of fission is called *bheda* i.e. disintegration. The word 'process' *(prakriyā)* is used here to distinguish it from the dynamic activity of motion *(kriyā)*. The infinite variety of the physical universe and colossal energy of *pudgala* is due to its being fissionable and fusionable.

The process of fusion results in the formation of physical objects. The number of *paramāṇus*—ultimate atoms—combining together in a fusion process may vary from two to infinity. The objects formed by fusion of *paramāṇus* are called *skandhas*, i.e. aggregates or composite bodies.3 Two or more aggregates may

1. *Bhag. Sūt., 2-3.*

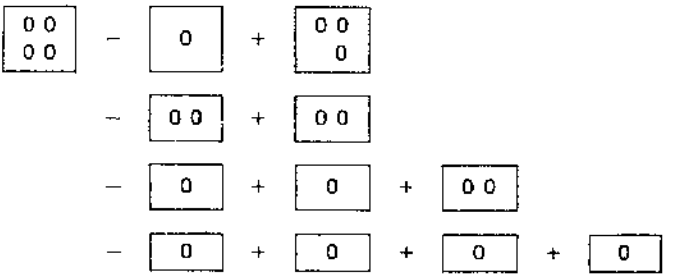
2. *Tat. Rāj, 5/1*

3. *Ibid. 5/25/16*

also unite to form one larger object. Sometimes a few *paramāṇus* only may unite with an aggregate.

In fission, aggregates break up and may result in – (a) smaller aggregates, (b) smaller aggregates and free *paramāṇus*, and (c) free *paramāṇus*. Sometimes a few *paramāṇus* only may separate from the main aggregate.

For instance, an aggregate composed of four primary atoms (*paramāṇus*) may break up in the following four ways :



1. One free atom and a tri-atomic aggregate.

2. Two di-atomic aggregates.

3. Two free atoms and a di-atomic aggregate.

4. Four free atoms.

LAWS CONTROLLING THE PROCESS OF FUSION

Out of the four characteristic qualities of *pudgala*, viz. *sparśa, rasa, gandha and varṇa*, only the first one, i.e. the *sparśa* is mainly responsible for the process of fusion.

Jain sages by their profound knowledge of the structure of *pudgala* have established that the process of fusion of *paramāṇus* and production of *skandhas* follow some definite rules.

All forms of *pudgala* including *paramāṇus* possess the qualities of glueiness *(snigdhatva)* and dryness *(rūkṣatva)* of varying intensities. The minimum intensity is the unit (quantum) of intensities, and the intensity possessed by a composite body or a *paramāṇu* can always be expressed by an integral number and not by a fraction.

Fusion of *paramāṇus* with same as well opposite *sparśa* is possible.

But the fundamental rule is that the *paramāṇus* with unit intensity of dryness or glueiness cannot participate in the process.[1] This means that *paramāṇus* participating in a composition must possess more than unit intensity of dryness or glueiness.

When two *paramāṇus* possessing same kind of *sparśa* (say, glueiness) combine, the minimum difference between the intensities of their glueiness must be two units.[2] Similarly the minimum difference of two units of intensity between dryness of two *paramāṇus* enable them to combine. On the other hand, the *paramāṇus* with opposite *sparśa* i.e. dryness and glueiness would combine without qualifying minimum difference between their intensities. The 615th verse of *Gommaṭsāra* says. "A gluey particle may combine with another gluey particle with a minimum difference of two units of glueiness. And this also is the rule in the case of dry particles. The combination of a gluey particle with a dry one is always possible, be they of the same or different intensities. But in all these three, the particles possessing the unit intensity i.e. one unit of each *sparśa* are excepted.[3]

Thus, the eligibility of *paramāṇus* for the process of fusion can be summarized as follows :

(a) *paramāṇus* possessing one unit of glueiness and one unit of dryness will never unite.

(b) *paramāṇus* possessing opposite *sparśa* of equal and unequal intensities may unite.

(c) *paramāṇus* with similar *sparśa* can unite only if their respective intensities differ by two units or more i.e. there must be a minimum difference of two units in the intensity of dryness or glueiness.

1. T.T., *I/17 "Snigdha-rūkṣatvad ajaghanya guṇānām".*

2. T.T., I:18 *:"Dvyadhikādiguṇatve sadṛśānām".*

3. *Niddhassa niddheṇa duhayiyeṇa, lukhassa lukkheṇa duhayiyeṇa.*
Niddhassa lukkueṇauvei bandho, jahnnavajjo visamo samo vā.
—Gommaṭasāra, Jīvakāṇḍa, gāthā 615.

The following table shows the permissible (or otherwise) combination of *paramāṇus* with different intensities of dryness and glueiness.

Intensity of Sparśa	Dry(+) with Dry(+) Gluey (−) with Gluey (−)	Dry(+) with Gluey (−)
Unit+unit	No	No
Unit+2 units	No	No
Unit+3 units	No	No
Unit+4 or more units	No	No
*X unit + X units	No	Yes
X unit + (X+1) units	No	Yes
X unit + (X+2) units	Yes	Yes
X unit + (X+3) or more units	Yes	Yes

*X is greater than one

Finally, the process of fusion can be classified from various aspects as under :

Fusion is two-fold: (a) natural, and (b) produced by an organism.

It is two-fold from another point of view viz., (a) partial union, and (b) total union.

There are three causes for natural union :

(a) Union caused by the gluey and dry properties of the constituents – *bandha pratyayika.*

(b) Union caused by the contents of a common container – *bhājana pratyayika.*

(c) Union caused by mutation – *pariṇāma-pratyayika.*[1]

1. *Bhag. Sūt.* 8/9/351-353.

6. (a) PUDGALA IS INFINITE (NUMERICALLY). (b) SPATIALLY, IT FILLS THE ENTIRE UNIVERSE.

The ultimate elementary constituents of *pudgala* are *paramāṇus* which are numerically infinite. It follows, therefore, that subtantially *pudgala* is also numerically infinite.

Maximum extension of entire physical existence is cosmos (*loka*) i.e., spatially *pudgala* remains in the cosmos (*loka*) only and it pervades the total space of the cosmos.

7. PUDGALA INTERACTS WITH AND INFLUENCES PSYCHIC ORDER OF EXISTENCE.

Psychical and physical orders of existence act and are acted upon by one another. *Pudgala* has the propensity for being attracted (and transformed) by conscious substance (or *jīva*). Each individual *jīva*, in its worldly existence or unemancipated state, continuously interacts with *karma-pudgala* or karmic matter.

It has already been stated that all the different groups (*vargaṇās*) of *pudgala* do not interact with the *jīva*. The eight groups of *pudgala* which do interact with *jīva* will be briefly described in the next section.

Out of these, the group which interacts ceaselessly with *jīva* is *kārmaṇa* group or *karma pudgala*. The union between the psychical and the physical is devoid of priority and posteriority, and so intimate, that for all practical purposes they appear to be identical and inseparable in the state of worldly existence.

By its own nature, the *jīva* is always changing, but in the state of worldly existence the change is determined mostly by the nature of the *karma* that is associated with it. Again, the nature of the *karma* itself is determined by the nature of the passions and perversion of the *jīva* and the intensities of passions, etc., are again determined by the nature of the *karma*. Thus, they are mutually interdependent.

The karma matter associated with *jīva* determines not only the nature and intensities of passions, but also the life-span type of gross body viz., *audārika* or *vaikriya*, during the life-span etc. The gross body is then the instrument of experiencing pleasure

and pain, happiness and miseries of worldly existence. The *pudgala* of other *vargaṇās* viz. *audārika, śvāsa-ucchvāsa, bhāṣā,* and *manas* are also essential for the vital functions of life viz. metabolism, respiration, speech and thought respectively, which keep the body and soul together.

Physical karma (*dravya karma*) and its spiritual counterpart (*bhāva karma)* viz., passions and perversities of the soul are thus mutually related as cause and effect, each of the other.[1] Thus the bound-*karma* begets *śarīra* (body), mind and speech and their activities—physical, mental and vocal—attract *karma-pudgala* which then is inseparably bound up with the soul.

The entire space is filled up by the *pudgala* of *karma vargaṇā,* but only those aggregates which occupy the same space as the *jīva* can be associated with it. Passions generated by the interaction of *karma* and contaminated *jīva* are the cause of attracting the new *karma-pudgala.* Thus corruption begets corruption., (Emancipated *jīva* is free from passions and, therefore, does not attract contaminating *karma-pudgala*).

It should be remembered that the free *paramāṇus* (i.e. the ultimate atoms) do not interact with the psychic existence.

Although the detailed discussion of Jaina Doctrine of *Karma* is important and interesting, it is, however, far beyond the scope of this book.

1. *Aṣṭasahasrī,* p. 51.

SECTION IV

PUDGALA : CLASSIFICATION

Classification means grouping of similar things in accordance with some system or aspect. The infinite varieties of material objects constituting the physical order of existence can be classified in various ways, and from various aspects, both systematic and arbitrary. As we have already seen, the Jain philosophy describes the character of an object through fourfold determinants: the substance (*dravya*), space (*kṣetra*), time (*kāla*) and attributes (*bhāva*).

Thus, to emphasize infinitely infinite multiplicity of the physical substance, it is described as under :

(i) **Substancewise** : Pudgala is infinite. That is to say that infinitely infinite numerically different ultimate atoms (*paramāṇus*) exist either independently (in free or unattached state) or in combination making infinite composite bodies (*skandhas*). Conversely, infinite composite bodies break up into infinite smaller components or infinitely infinite ultimate atoms.

(ii) **Spacewise** : Each and every space-point of *loka* (cosmos) is occupied by infinite number of ultimate atoms and composite bodies. There is not a single space-point where there is neither an ultimate atom nor a composite body. According to Jain cosmology, there is no vacuum anywhere in the cosmos. That is, the entire cosmic space is 'plenum'. It is only the *aloka* (non- cosmic space) which is totally vacuum.

(iii) **Timewise** : The physical existence is eternal and indestructible, not a single new ultimate atom is created nor destroyed. Inspite of infinite fissions and fusions occuring at every time-point, the total existence persists; it has neither beginning nor end.

(iv) **Qualitywise (Attributewise)**: It is a substratum of infinite qualities making infinite types. Again, since each of these infinite varieties is capable of infinite mutations and transformations, the entrire physical existence is infinitely infinite.

(A) Mono or single Type

We have already seen that non-absolutist Jains do not find any contradiction in the basic unity and the infinite multiplicity of an existent (real). In this case, the reality of infinitely infinite diversity of the physical existence does not contradict its inherent unity, since it is composed of ultimate atoms. The atomic structure of physical substance means that *'paramāṇu'* is the ultimate unit of the entire physical reality. *Paramāṇu* is the indestructible physical reality and in this respect there is only one or single class of *pudgala*.

It should be remembered that this unity is substancewise (*dravyārthika*) and not modificationwise (*paryāyārthika*). Jains do not accept the concept of 'absolute monism' that all ultimate atoms are absolutely identical.

(B) Two Types

Paramāṇu is the ultimate building block of the physical reality. It can exist in a free state and because it has innate capacity to combine with other *paramāṇus*, they unite together and produce composite bodies, which are called *skandha*. Any modification in this would be due to fission or fusion of *paramāṇu*. In this respect, therefore, the physical reality can be classified into two types:

(i) *Paramāṇu* or freely existing ultimate atom, and

(ii) *Skandha* or composite aggregate composed of two to infinite number of atoms.

Composite aggregates (*skandhas*) are again of two types: (i) *catuḥsparśī* and (ii) *aṣṭasparśī*. *Catuḥsparśī* bodies, as the name indicates, have only four *sparśa* viz., hot or cold, dry or glutinous. *Aṣṭasparśī* bodies, on the other hand, have in addition heaviness or lightness and hardness or softness (or roughness or smoothness). This means that *catuḥsparśī* bodies are *agurulaghu* i.e. neither heavy nor light. In other words, they are massless. The quality of mass is acquired when the material bodies become *aṣṭasparśī skandhas*.

From some other aspects, also, *pudgala* can be classified into two types:

One of them is its capability of being perceived by senseorgans, which gives two types : (1) *sūkṣma* and (2) *bādara*. The type which cannot be an object of sensory perception is *sūkṣma* or subtle. While those aggregates which are perceivable by the sense-organs are called *bādara* or gross. It should be noted that *sūkṣma* type is not devoid of sense-data, but it is so miniscule that normal sense-organs are incapable of being stimulated by them. Since sense-organs are incapable of perceiving *paramāṇus*, all *paramāṇus* fall in this class, viz. *sūkṣma*. Again, all aggregates composed of two, five,... ten upto innumerable (*asaṁkhya*) *paramāṇus* are also *sūkṣma*. i.e. *catuḥsparśī* bodies are also always *sūkṣma*. Aggregates composed of intinite particles and which are *aṣṭasparśī* are *bādara* as well as *sūksma*. Only some *aṣṭasparśī* aggregates are perceivable and are therefore *bādara*.

Pudgala can also be classified from yet another aspect, viz., capability of being associated with *jīva* (i.e. conscious substance). We have stated before that some kinds of *pudgala* interact with *jīva* and become associated with it. Thus, we have two types of *pudgala* – (i) capable of interaction or associable and (ii) not capable of interaction or unassociable. All *paramāṇus* in their free state fall in the second category. Amongst the composite bodies, some can interact, while some cannot[1].

(C) Three Types

The *pudgala* can be classified into three types in respect of the cause of transformation viz.,

(i) *prayoga-pariṇata*

(ii) *miśra-pariṇata*

(iii) *visrasā pariṇata*

(i) The *pudgala* which is taken in and transformed by *jīva* is *pudgala-jīva-prayoga-pariṇata*. Bodies of all categories of living beings and those which are being transformed by their vital processes are instances of this class.

(ii) The *pudgala* which was associated with *jīva* in the past, but is now abandoned by it, and therefore, is no longer being

1. See, ""Twenty-three Types" of this section.

transformed by the agency of vital processes, mentioned above but undergoes auto-transformation is *miśra* (mixed) – *pariṇata*. Shoe- leather is an instance of this class. Transformation which is partly under the influence of *jīva* and partly auto-transformation, is also *miśra-pariṇata*.

(iii) Matter which undergoes auto-transformation i.e. which has no interaction with *jīva* is *visrasā-pariṇata*. Clouds, rainbow, meteors, etc. are instances of this class.[1]

(D) Four Types

From structural aspect, physical reality can be classified into four types :

(i) *Skandha*

(ii) *Skandha-deśa*

(iii) *Skandha-pradeśa*

(iv) *Paramāṇu*

These are the four basic structural modification of *pudgala*, out of which infinite modes are produced.

(i) *Skandha : Skandha* is defined as an individual aggregate formed by combination of ultimate atoms or small composite bodies. The smallest *skandha* is a '*dvipradeśīya skandha*' (diatomic aggregate) produced by the combination of only two *paramāṇus* and the largest is '*acitta mahāskandha*' which is the material body extending over the whole cosmos (*loka*).

(ii) *Skandha-deśa : Deśa* means a fraction, and not a whole. A *skandha* is divisible, because it is made up of number of parts. Thus, if a *skandha* is mentally divided, any fractional portion (1/2, 1/4 and so on) is *skandha-deśa*. This is an example of physical division. Chemically a substance may be a compound of two or more elements. In this case, each element is a *skandha- deśa*. For example, a molecule of water is a compound of two elements viz. hydrogen and oxygen. A molecule of water is a *skandha*, while atoms of hydrogen and oxygen unit are *skandha-deśa*. This is an example of chemical division. It should be remembered that

1. Radio-active substances are also the instances of this class.

division is merely conceptual. When, on the other hand, a *skandha* breaks up physically or chemically into fragments, each fragment becomes a whole aggregate i.e. *skandha* and not *skandha-deśa.*

(iii) *Skandha-pradeśa* : *Pradeśa* means an indivisible undetached part of a *skandha.*

The smallest *deśa* which is further indivisible is thus a *pradeśa.* Like *deśa, pradeśa* is also merely conceptual. In other words, a *pradeśa* is an undetached part of a thing whose dimension is equal to that of a *paramāṇu.*

Another term used for *pradeśa* is *avibhāgi pariccheda* (i.e. indivisible fragment). A *paramānu*, however, being a separate entity is different from a *pradeśa.* The former is an objective entity, whereas the latter is only an ideal construct.

(iv) *Paramāṇu* : The word is derived from *'parama'* and *'aṇu'. Parama* means the 'ultimate' and *aṇu* means 'atom'. According to Jain Microcosmology, *paramāṇu* is the eternal and indestructible ultimate atom and also the primary constitutive cause of the entire physical universe. Thus, the infinitesimally small, indivisible and free i.e. unattached to another particle of matter is *paramāṇu.* Paramāṇus are the ultimate building blocks which by mutual combination produce the whole of physical universe. So long as it is considered to be a portion of an aggregate, it is *pradeśa*, while in its free i.e. unattached state, it is *paramāṇu.*

(E) Six Types

Generally, largeness is equated with grossness (*sthaulya*) and smallness is equated with subtlety (*saukṣmya*). However, size is not the criterion in this classification. Gross is that which prevents other subtances to pass and which can be stopped by others; or which cannot occupy space which is already occupied by others or which cannot pass through others and which does not allow others to occupy the space occupied by it.

Conversely, subtle is that which does not hinder others and cannot be hindered by others (or which can occupy the space

which is already occupied by others or can pass through others), E.g. a mustard-seed is smaller in size compared to a drop of water but whereas water can pass through a cloth, the mustard seed cannot. Therefore, water is subtle, mustard is gross.

From the point of view of penetrability *pudgala* is divided into six classes[1].

1. *Bādara-bādara* means gross-gross, i.e., very gross. This kind consists of very large solid aggregates of *pudgala* such as mountains, rocks, wood, etc. which do not unite by themselves when broken or divided, and also such bodies which can be physically transported without a container.

2. *Bādara* means gross. This kind consists of large aggregates of *pudgala* in liquid-form such as water, oil, milk, juice, etc. which become united again by themselves when broken or divided, and which have to be carried in containers.

3. *Bādara-sūkṣma* means gross-subtle. This kind consists of aggregates which can either be cut nor broken, nor can be, physically transported, but are visible, e.g., light, shadow, image, etc.

4. *Sūkṣma-bādara* means subtle-gross. This kind consists of aggregates which are not visible, but can be perceived by other four senses—ultra-visible, but infra-sensual, e.g., gases.

5. *Sūkṣma* means subtle. This kind consists of aggregates which are *ultra-sensual*, i.e., they are not perceivable by any sense-organ. However, they interact with *jīva* and are transformed by it in the form of thought, speech, *karma*, etc.

6. *Sūkṣma-sūkṣma* means extra-subtle. This kind consists of aggregates which are so subtle that they do not interact with *jīva*. They include the aggregates which are composed of less than infinite number of ultimate atoms upto two atoms.

Five and or Eight Types

The most important types of physical order of existence (*pudgala*) are those which interact with psychic order of existence

1. *Gommaṭasāra, Jīvakāṇḍa*, verse 602; *Niyamasāra*, verses 22-24

(*jīva*) and are, therefore, mostly encountered by us. There are five types of *pudgala* which are associated with *jīva* in the form of 'body'. In addition, there are three types which are associated with the *jīva* to carry out the vital functions of life, viz, breathing, speaking and thinking.

The word *vargaṇā* means a category and applies to the group having the same definable attributes-in-chief.

(i) *Audārika Vargaṇā*

The word *audārika* can etymologically be explained in two ways : (i) *udāraṇa* meaning gross, *audārika* thus means 'constituted by gross matter' and (ii) *udara* meaning womb, *audārika* thus means 'what is produced from the womb'. All organic bodies—human, animal and vegetable are *audārika*.

All physical compositions, large and small, which are/can be made perceivable by sense-organs belong to this category. All organic material which make the cells(blood, bone, skin, etc.) comprising the bodies of all living (including the entire vegetable kingdom) and dead organisms and inorganic atoms, molecules and compounds, in short, almost all things, encountered by us in everyday life belong to *Audārika Vargaṇā*.

(ii) *Vaikriya Vargaṇā*

The term *vaikriya* means a "protean" body, i.e. 'what is capable of transformation at will'. The term *vaikriya* implies transformations (of the body) which are associated with a divine being or *deva* who can transform the body from minute to huge, and *vice versa*. Celestial bodies of the inhabitants of heaven (*devas*) and hell (*nārakīs*) are composed of the material of this group which is very much more subtle than the previous category.

(iii) *Āhāraka Vargaṇā*

The structure of this category is much more subtle than the preceding ones. It is used by ascetics who have acquired special powers to create a unique subtle body (called *āhāraka śarīra*). The learned sage uses this type of body for visiting omniscient persons at far off places, for the purpose of clarifying some doubts about

intricate facets of truth. The subtle body stretches out so as to be in communication with the omniscient (*kevali*) from whom the information sought for, is secured. Thus, *āhāraka-śarīra* means—communication body.

(iv) Taijas Vargaṇā : (Luminous Body)

The material belonging to this group is used by the soul to make a subtle body which always accompanies the soul in its mundane existence i.e. until it achieves emancipation. The body forms an essential link between the soul and its *kārmaṇa śarīra.* Energy required by the vital processes of the living organism such as effulgence and digestion is provided by the *taijas* body.

(v) *Kārmaṇa or Karma-Vargaṇā*

Matter of this group also called *karmic* matter is responsible for contaminating the soul and keeping it in bondage. Minutest activity of a living being—physical, mental or oral—attracts the karmic matter which unites with the soul and is then transformed into *kārmaṇa śarīra* which is the basis of the mundane existence (in bondage) of the soul. Every *jīva* roaming through the cycles of births and deaths (*saṁsāra*) carries the *karma-śarīra* with itself until it is finally emancipated.

Out of the above five bodies, the first alone is perceptible by the sense-organs and the others are subtle and imperceptible bodies. Each succeeding one is more minute than the preceding one in order[1].

(vi) *Śvāsocchvāsa or Ānāpāna Vargaṇā*

Śvāsocchvāsa means respiration, as indicated by its name, matter in this group is what all living organisms need and use for the vital function of breathing.

(vii) *Bhāṣā Vargaṇā*

Bhāṣā means speech. Living organisms which are capable of producing speech give voice to their feelings. The matter of this group is essential for this process.

1. *Tat. Sūt.* 2/38 : "*Param param sūkṣmam.*"

(viii) *Manaḥ or Mānasa Vargaṇā*

Manaḥ means mind. According to Jains, mind is an instrument of thinking which a soul makes for itself out of material bodies and becomes capable of thinking through its agency. The material in this group is fit for this purpose.

It is to be noted that a composite body of the group successively consists of greater number of *paramāṇus* which are more compactly packed and thus occupy less space. Thus, a body of *āhāraka vargaṇā* is more compact and occupies less space than a body of *vaikriya vargaṇā* which itself is more densely packed in comparison with a body of *audārika vargaṇā.*

F. Twenty-Three Types

In Jain Canonical literature, its commentaries, and other literature, most of the above eight important categories are generally included in twenty-three types. Beginning from most minute *paramāṇu vargaṇā* and ending with the largest *achitta-mahāskandha-vargaṇā,* there are infinite number of groups of *pudgala.* But it is possible to reduce the number of *vargaṇās* to twenty-three by grouping them together from certain aspects[1].

1. In the first category, there are free (unattached) solitary *paramāṇus,* which form *"aṇuvargaṇā"* .

2. The second category contains composite bodies (*skandha*) composed of from two *paramāṇus* to the limit of "numerable *paramāṇus."*

3. We, then, come to the category of composite bodies made up of "innumerable (*asamkhyāta*) *paramāṇus".*

4. Next comes the category of the composite bodies constituted by "infinite (*ananta*) *paramāṇus".*

All these four categories are incapable of being attracted, assimilated and transformed by the psychical order of existence. It has been emphasized that it is an immutable physical law of the universe that the quality of associability is for ever absent in the

1. (a) *Gom., Jīva-kāṇḍa;* verses 594, 595;
(b) *Dhavalā,* book XIV, part V, VI, sūtra 97, verses 7,8. p. 117.

composite bodies constituted by less than infinitely infinite (*anantānanta*) *paramāṇus*. Only when the number of constituent ultimate atoms exceeds the threshold of non-associability, then and only then they could be used by the psychic order of existence. This does not mean that all the composite bodies with larger number than mentioned above possess this attribute. Some of them can be associated and some of them cannot be, as we shall see below.

5. *Āhāra-vargaṇā*

The fifth category is the first one which crosses the above-mentioned threshold of associability. In this category fall the groups of *audārika, vaikriya, āhāraka* and *śvasocchvāsa*. *Āhāra* literally means association. Hence, *āhāra vargaṇā* stands for the category of *pudgala* endowed with associability.

6. *Prathama agrāhya* (i.e. First unassociable category)

7. *Taijas* (Luminous)

8. Second unassociable category.

9. *Bhāṣā* (Matter essential for function of speech).

10. Third unassociable category.

11. Manas (Matter essential for the function of thinking).

12. Fourth unassociable category.

13. *Kārmaṇa* (Matter responsible for contaminating souls). This is the most subtle category of *pudgala* which has any practical significance.

14-22. These categories are of little practical significance and are merely of academic interest.

23. The *23rd* category is *mahāskandha* i.e. the largest aggregate which pervades the entire cosmic space.

SECTION V

PARAMĀṆU : THE ULTIMATE INDIVISIBLE UNIT OF PHYSICAL EXISTENCE

A. DEFINITIONS

Paramāṇu can neither be created nor destroyed. It is eternal, i.e., it existed in the past, exists in the present and will continue to exist in the future. It is the permanent basis of the physical existence. The entire physical existence is composed of these ultimate atoms.

The canonical literature, in general, and the *Bhagavatī Sūtra* in particular, defines *paramāṇu* in various ways from different angles. It is the basis (ultimate "building blocks") of physical universe. It is indivisible, indestructible, impenetrable, incombustible and imperceptible to sense-organs. It cannot be split or destroyed by any means whatsoever. The sharpest instrument cannot divide it into two and the highest temperature cannot destroy it by burning. It does not become wet even if it is drenched by the deluge clouds (*puṣkarāvarta mahāmegha*). It will not lose its existence or identity even if it enters a drop of water or a whirlpool of water[1].

Paramāṇu is a true point. It has no half-portion, no middle portion and no *pradeśa*[2]. It has no length, no breadth and no depth. It is dimensionless. It is the ultimate and eternal unit[3].

It is truly infinitesimal. Its beginning, the middle and the end are identical with the whole of itself[4]. Hence the sages have observed : "That of which the start, the centre and the end is the same i.e. which itself is the beginning, itself is the middle and itself

1. Bhag. Sūṭ., 20/6/38.
2. Ibid. 5/7/160.
3. Tat. Rāj. 5/25/1.
4. Tat. Sūt. Sarva., 5-25

is the end, that which (though possessed of sensual qualities) is not perceptible (cognised by sensual perception.), and that which is indivisible is called *paramāṇu*[1].

Paramāṇu is defined by some other characteristics viz., its innate qualities thus[2], "the substance which has a single taste, a single colour, one smell and two kinds of *sparśa*, which is the cause of sound but is not sound itself, which is not the same as *skandhas* (composite) though constituting them. is the *paramāṇu*."

B. CHARACTERISTIC ATTRIBUTES

Earlier, it had been stated that colour, smell, taste and touch are the characteristics (*lakṣaṇa*) of physical substance (*pudgala*). This means that these qualities are innate in all forms of *pudgala*. *Paramāṇu*, being a form of *pudgala*, therefore, must possess these qualities. Thus four sense-data viz., touch, taste, odour and colour are intrinsic qualities of a *paramāṇu*. Sound, being an attribute of *skandhas*, is not the characteristic quality of *paramāṇu*.

The qualities possessed by a *paramāṇu* are : one of the five primary colours, one of the two smells, one of the five tastes and two of the four touches i.e. either hot or cold and either dry or gluey[3]. However, it can never be an object of sense- perception. By itself it transcends the sense-experience though it is the basic constituent of the entire perceptible physical universe.

It can be perceived only by its effects i.e. a single free *paramāṇu* is invisible not only to the naked eyes but also to any other physical instrument. Its existence is to be inferred by the collective action and reaction of infinite *paramāṇus*. Only the omniscient (*kevala jñānī*) and those who possess superlative visual intuition (*paramāvadhi jñānī*) can perceive and cognise the nature of a free *paramāṇu*[4].

1. Ibid. 5/25
2. Pañch. Sār., verse 81.
3. Bhag. Sūt. 20/6/26.
4. Bhag. Sūt. 18/8/178-181.

Although the four qualities are permanently possessed by a *paramāṇu*, the intensity or the potency of the qualities does not remain constant. A *paramāṇu*, possessing one unit of blackness at any moment, may sometimes later possess two, three or many units of blackness. It follows from this that at any given moment there would be *paramāṇus* with different intensities of blackness etc. In the same way there would be *paramāṇus* with various degrees of other qualities.

The term *paramāṇu* is the short form of *dravya paramāṇu* or *paramāṇu-pudgala*. The *Bhagavatī Sūtra*[1] enumerates four types of *paramāṇus* – indivisible units, just as *paramāṇu pudgala* is the indivisible unit of *pudgala*. The four types are :

(a) *dravya paramāṇu* or *pudgala*-paramāṇu – the indivisible unit of *pudgala* substance.

(b) *kṣetra paramāṇu* – the indivisible unit of space i.e. space-point or *ākāśa-pradeśa*,

(c) *kāla paramāṇu* – the indivisible unit of time or time-point called *samaya*.

(d) *bhāva paramāṇu* – the indivisible unit or quantum of intensity of sensuous qualities, viz. colour, odour, taste and touch.

Thus, *paramāṇu* is the direct unit of the physical substance (*pudgala*) and also the indirect unit of space, time and modification. The quantitative difference in matter-space-time as well as the qualitative difference in physical objects may ultimately be traced to constitution of *paramāṇu*. Thus, being the constituent element of physical composite bodies, it may be considered to be the determinant of the difference of aggregates, and for the same reason, it is also their substantial cause. By its own motion (vibration, oscillation, etc.), it becomes the measure of time, i.e., a *samaya* (time-point) corresponds to a unit shift of a *paramāṇu* from one position to the immediately next. (It should be remembered that time itself is quantized, and a *samaya* a quantum of time and is, therefore, indivisible.)

1. Bhag. Sūt. 20/6/37-41.

Since its associated space-point is the constitutive element of space, it is indirectly the cause of quantitative difference of space (*kṣetra-saṁkhyā*).

Since its motion from point-to-point corresponds to duration of time, it is also the basis of quantitative difference of time (*kāla-saṁkhyā*).

Again, because it is the basis of modification of physical objects through combination or separation, it is also the condition of the quantitative difference of modes (*bhāva-saṁkhyā*)[1].

It may be added here that inter-dependence of matter, space and time as described above is comparable to the representation of the movement of a physical object, say, a particle by so-called space-time diagrams in modern physics. We shall discuss this in more detail in the subsequent chapter.

On ultimate analysis, the whole physical universe is *paramāṇu*. As we have seen, *paramāṇus* have the innate capacity of uniting with one another to form composite bodies. The union is subject to certain definite rules, as all types of *paramāṇus* are not eligible to participate in the union[2]. The composite bodies are liable to the process of disintegration (again subject to rules) and the united *paramāṇus* may become free atoms and thus the association and dissociation goes on eternally. The *paramāṇu* is the ultimate cause '*kāraṇa aṇu*'-as well as the ultimate end-product—'*antya aṇu*.'

The following verse succintly summarizes the fundamental nature of *paramāṇu*:

Kāraṇameva tadantyam, sūkṣmo nityaśca bhavati paramāṇuh /
Ekarasa- gandha-varṇo, dvisparśaḥ kāryaliṅgaśca //

1. It is *kāraṇa* i.e. the cause of the creation of the physical universe.

2. It is *antya* i.e. the ultimate end-product of the physical universe.

1. *Pañ. Sār.* verse 80, with *Pradīpikā* Vṛtti, p. 69.
2. We have already discussed this at length. See pp. 106-107.

3. It is *sūkṣma* i.e. infinitesimally subtle.

4. It is *nitya*, i.e. indestructible. It does not lose its individuality even when participating in a union.

5. It possesses one *rasa*, one *gandha* and one *varṇa*.

6. It is *dvisparśī* i.e. it possesses two *sparśa*—either dryness or glueiness and hot or cold i.e. it is either dry-cold or dry-hot, or gluey-cold or glucy-hot.

7. It is *kāryaliṅga* i.e. it can be cognised by inference only through the effects of collective actions. Its qualities can also be cognised through the qualities of the composite bodies. In short, by itself it is not an object of sensuous cognition. Only transcendental and extra-sensory perception can cognise its qualities.

C. PROPERTIES

Let us now see which of the properties of *pudgala* which were discussed in detail in the previous section are applicable to *paramāṇu* :

1. (a) *Paramāṇu* is a real and a substance. By itself it is not *kāya* (extensive body), because being a single point, it is singularity. However, when united with other *paramāṇu* in a composite body, it is a constituent of *kāya*.

(b) It is eternal (*nitya*) and non-transmutable (*avasthita*). This is so because *paramāṇu* never loses its identity even though it participates in the union to produce composite bodies. Thus not a single *paramāṇu* is destroyed nor a new one created. The total number of *paramāṇus* is eternally the same.

2. *Paramāṇu* belongs to the physical order of existence and not psychical, because it is devoid of consciousness.

3. It possesses four primary sensuous qualities—colour, taste, smell, and touch, but is devoid of *saṁsthāna* because it has no shape and it has no length, breadth or thickness.

4. (a). *Paramāṇu* is subject to mutation (*pariṇāmī*). By itself, it is *agurulaghu pariṇāmī*.[1] The mutation is in respect to its innate qualities viz., colour, smell, etc.

4. (b). *Paramāṇu* is capable of being dynamically active (*kriyāvān*). When mobile, it may have vibratory as well as migratory motions. The activity of a *paramāṇu* is not continuous but rather in the form of quantas. When dynamic, it can assume a very high velocity, since it is completely massless, there is no upper limit to its speed, and it can travel from one end of the *loka* to the other within one time-point (*samaya*)[2]. It cannot, however, cross the boundary of *loka* (since there is no *dharmāstikāya* beyond it).

5. *Paramāṇu* is fusionable and not fissionable, because by itself it is indivisible. It unites with other *paramāṇus* to form composite bodies, and therefore, it is fusionable. Fissionability strictly is an attribute of composite bodies only.

A single *paramāṇu* cannot be attracted by *jīva*, and therefore, it does not interact with *jīva*.

D. EXPOSITION

1. *Nomenclature*—Its full name is *paramāṇu pudgala* or *dravya paramāṇu*, but is generaly called '*paramāṇu*'.

Etymologically, the word *paramāṇu* is made up of two terms *parama* and *aṇu*. The extreme limiting unit of the process of division of any material object is *aṇu*. Such ultimate *aṇu* is paramāṇu. Thus, paramāṇu is an ultimate or primary atom.

2. *Substantially*—*Paramāṇu* is the substance *pudgalāstikāya* which is one of the six ultimate substances comprising the Universal Reality. It is a substance because it possesses qualities and modes. There are infinite number of individual *paramāṇus*, each numerically different from one another. Since each *paramāṇu* is a substance, number of *pudgala*-substance is infinite.

3. *Spatially*—A *paramāṇu* occupies a single space-point and can never extend to more than one, a body composed of infinite

1. For discussion on "*agurulaghu*", see "Six Universal Qualities" in the first section of this chapter.

2. Bhag. Sūt., 1/61 : "Eka—Samayalokanta—prapināṃ."

number of densely packed *paramāṇus* may also occupy a single space-point. There is not a single space-point in the whole of the *loka* which is not occupied by *paramāṇus*. Thus, *paramāṇus* pervade the whole of the *loka*, and are confined within their boundary.

4. *Temporally—Paramāṇu* existed in the infinite past, exists in the present and shall exist in the infinite future. it is eternal.

5. *Qualitatively—Paramāṇu* possesses colour, taste, smell and touch. These four are innate characteristics of *paramāṇu*.

(a) *Colour*—Each *paramāṇu* possesses one of the five primary colours (black, blue, red, yellow and white). More than one colour or a mixture of two or more primary colours does not subsist in a free *paramāṇu*. The intensity of the colour possessed by a *paramāṇu* could be one unit, two units and so on upto innumerable (*asaṁkhyāta*) units and even infinite (*ananta*) units.

(b) *Taste*—What has been said about colour and its intensity in the preceding paragraph holds true about taste also. There are five primary tastes viz., sweet, acidic (sour), acrid, astringent and bitter, and each *paramāṇu* possesses one of them.

(c) *Smell*—There are two primary smells—pleasant and unpleasant. For the rest, every word of para (a) holds true by substituting 'smell' instead of 'colour'.

(d) *Touch*—A free *paramāṇu* possesses anyone of the following four combinations of touches. (i) hot and dry (ii) hot and gluey (iii) cold and dry, and (iv) cold and gluey.

Heaviness or lightness and softness or hardness are not the innate qualities of *paramāṇu*. These four subsist only in composite bodies with gross structure. The intensities of dryness etc., possessed by *paramāṇu* could be one unit upto infinite units. On the basis of these four innate qualities of *paramāṇu*, there are (5x5x2x4)=200 primary classes of *paramāṇus*. And on the basis of intensities of these qualities, there would be infinite subclasses of each of these 200 classes.

6. *Rūpatva/Mūrtatva* i.e. *Corporeality*—though *paramāṇu* is beyond sensible cognition, it is *rūpī*—(corporeal) because it can be cognised by extra-sensory perception (such as *avadhi jñāna* or *kevala jñāna*). it is not *arūpī*, because it possesses sensible

qualities of colour, etc. and when synthesized in a composite body, it acquires the quality of *saṁsthāna* (shape) also.

7. *Quantitatively*—The total number of *paramāṇus* in the universe (*loka*) never changes. Not a single *paramāṇu* is destroyed—not a single new one is created. Under all circumstances and for all times, the total remains constant.

8. *Metaphysically*—*Paramāṇu* is real and a constituent of the physical reality. It is subject to the principle of permanence-through-change, and therefore, has an objective real existence. It is neither a figment of mind nor is merely a postulation.

9. *Geometrically*—*Paramāṇu* (by itself) is extensionless, but not *arūpī*. It is a true point and, therefore, has neither length nor breadth nor thickness; extension is a quality of composite bodies only.

10. *Pariṇāma* (mutation)—*Paramāṇu* being a substance undergoes mutation. Its four innate qualities viz., colour, taste, smell and touch undergo mutation. In the free state, all mutations are of the *visrasā* type i.e. self-generated. Also in the free state the mutation is only in the intensities of colour, etc., i.e. X unit black changes to Y unit black but black does not become white or red etc., but during and after union with others, change in colour (black changing to blue) etc., may also take place.

11. *Non-transmutation*—Not a single *paramāṇu* can be destroyed or transmuted into another substance nor another substance be transmuted to create a new paramāṇu. But *paramāṇus* unite together to form composite bodies and the latter may again dissociate into paramāṇus.

12. *Agurulaghu*—*Paramāṇu* is agurulaghu i.e., it is neither heavy nor light. this is another way of emphasizing that it has no mass. The qualities of gurutva and laghutva are acquired later by composite bodies of certain groups and structures.

13. *Permanence-through-change*—*Paramāṇu as* a substance is indestructible and therefore, permanent or eternal. But from the point of view of its qualities which undergo modifications, it is changing. That is why it has been called permanent as well as impermanent[1].

1. *Bhagavatī Sūtra*, 14-4-49.

14. *Interaction with jīva—Paramāṇu* by itself, that is, in its free state, is agrāhya, i.e., not attracted or transformed by *jīva*[1] and, therefore, serves no useful purpose[2] in its free state for the *jīva.*

15. *Singularity-plurality—Paramāṇu* is a primordial singularity. It has an eternal existence of its own and is determinate by its own qualities and modes. *Paramāṇu* as a substance is not a composite body; it is truly indivisible singularity. But as a substratum of many qualities, it does possess plurality. Spatially again, because it occupies a single space-point, it is singularity.

16. *Gati (motion) and Kriyā (dynamic activity)*

Paramāṇu has a propensity to become dynamically active. This does not mean that all *paramāṇus* are active everywhere and at all times under all conditions. There is an element of uncertainty in the origination and cessation of the dynamic activity of *paramāṇu.* A *paramāṇu* can remain at rest on a single space-point for sometime. Maximum period of inactivity is innumerable (*asaṁkhyāt*) samaya, after which it must move. On the other hand, maximum period of activity is innumerableth portion (*asaṁkhyātāṁśa*) of an *āvalikā.* Minimum period of activity and inactivity is one samaya. In short, the dynamic activity of *Paramāṇu* is not continuous, that is, there are alternate periods of rest and motion.

The *Bhagavatī Sūtra* describes the variety of dynamic actions of a paramāṇu; some of these are as follows:—

(1) *"Siya eyati*
(2) *Siya veyati*
(3) *Siya calai*
(4) *Siya phandai*
(5) *Siya ghaṭṭai*
(6) *Siya kouvayai*
(7) *Siya udīrai*
and so on."[3]

1. *Ibid*, 20-5-38.
2. *Ibid*., 18-4-86.
3. 5/7/150.

Thus, more than one type of motion could be simultaneous. Temporally, all these motions may be regular or irregular.

Paramāṇu may be self-activated i.e. may undergo self-interaction without any external influence. It may also be acted upon by other *paramāṇu* (s) or composite bodies. (It may be recalled that *jīva* can never influence the activity of a single *paramāṇu*.)

At what speed does a *paramāṇu* move? At what frequency does it vibrate or if it revolves, at what rate? It is clearly mentioned in the *Bhagavatī Sūtra* that a *paramāṇu* can move from one end of the *loka* to the other in one time-point[1]. This is the maximum velocity of a *paramāṇu*. Its minimum velocity is one time-point for its linear motion from one space-point to the adjacent one.

Whether it moves to an adjacent space-point or crosses the whole loka from one end to the other, if the time taken is a *samaya*, the motion will be in *anuśreṇi* i.e. straight and without changing the direction. If there is a turning, the time will be more than one *samaya*. Turning is always due to external forces.

Laws of Motion and Principle of Uncertainty

From the above it is clear that in some respect *kriyā* and *gati* of *paramāṇu* follow definite rules, while in other respects they follow the principle of uncertainty[2]. We can summarise the definite rules as under:

1. Unless acted upon by external forces *paramāṇu* moves in a straight line (*anuśreṇīgati*).

2. When acted upon by external forces *paramāṇu* may change direction and speed.

3. *Jīva* has no direct influence on the motion of *paramāṇu*.

4. Minimum and maximum distances travelled *paramāṇu* in one *samaya* are, space between two adjacent points and the entire length of the *loka* respectively.

1. Bhag. Sūt. 16/8/116.
2. Tat., Rāj, "Paramāṇorgati aniyatā"

5. Maximum period of inactivity (rest) is *asaṁkhyāta samaya*. Maximum period of activity is *asaṁkhyātāṁśa* of fraction of an *āvalikā*[1].

On the other hand, the principle of uncertainty governs the following:

I. It is uncertain, after what interval of time will a *paramāṇu* at rest will become dynamic (release energy). This time-interval may be from one samaya upto innumerable *samayas*. However, after an interval of innumerable *samayas*, it will become active for sure.

2. Similarly, it is uncertain, upto what duration of time will a dynamic *paramāṇu* continue to be active. It (the duration) could be from one samaya to an *asaṁkhyātāṁśa* (innumerableth) portion of an *āvalikā*. But it will surely cease to be active after this maximum interval.

3. It is uncertain, which direction will a *paramāṇu* take at the commencement of motion. It can move in any possible direction.

4. It is uncertain, what type of dynamic activity will be commenced by an inactive *paramāṇu*. It may just vibrate or rotate or migrate or do all these things simultaneously.

5. It is uncertain, again what will be the intensity of a *paramāṇu's* dynamic activity: what will be its velocity – minimum or maximum or intermediate ?

RESTRICTED AND NON-RESTRICTED MOTION OF *PARAMĀṆU* (*PRATIGHĀTI AṆD APRATIGHĀTI*)

Paramāṇu is generally *apratighātī* i.e. it cannot be stopped, retained or hindered by anything (except under the condition mentioned hereinafter). At the same time, it does not cause hindrance to others. This means that:

(i) The motion and activity of *paramāṇu* cannot be stopped or restrained by another material body or *jīva*. A *paramāṇu* in motion is capable of penetrating and passing through any type of obstruction in its way.

1. *See, glossary.*

(ii) A *paramāṇu* can occupy a space-point which is already occupied by others (*paramāṇu*, composite bodies or *jīva*), without losing its free state.

(iii) A *paramāṇu* can commence and continue its own motion and activities irrespective of the other occupants of the same space.

(iv) A *paramāṇu* can leave the occupied space without any restraint from the other occupants.

Inspite of possessing the unique quality of '*apratighātitva*' as defined above, the *paramāṇu* is subject to *pratighāta* (hindrance) under the following conditions:

1. *Upkārabhāva pratighāta* (restriction due to the absence of media) – It cannot penetrate the boundaries of *loka* and cross over to *aloka*.This is because there is no *dharmāstikāya* (medium of motion) in aloka and without the aid of *dharmāstikāya*, nothing can move. And so the *paramāṇu* on reaching the boundary of *loka* is stopped and may be thrown back.

2. *Bandhana-pariṇāma-pratighāta* (restriction due to association) – It loses its free state and the capacity for independent activity for the time being, when it is united with other *paramāṇus* i.e., so long as it remains a constituent of a composite material body.

3. *Ati-vega-pratighāta* (restriction due to high velocity) – Collision between two self-activated *paramāṇus* moving at a high velocity may cause *pratighāta* in the motions of both.

CHAPTER 3

A CRITIQUE

GENERAL INTROCUCTION

In the Orient, science became a part of religion, and the two got so much mixed up that it was impossible to extricate one from the other. But in the Occident, they remained in hostile camps, poles apart. Even, now, according to scholars like A. Toynbee and others, there is no compromise between the two.

Science in the West was born around the 12th century A.D. on the basis of inspiration it received from the Greek philosophers who had lived about 2500 years ago and who had given place to 'reasoning'. But the immediate impetus was provided by the quest of 'truth' which was enshrouded in and discouraged by teachings of the dominant church. The Copernican theory shook the most basic theological and philosophical canons of the day. It proved the intellectual spark for the tremendous acceleration of knowledge. Under the prodding of Galileo, Kepler, Newton and others, questions of nature were thrust directly into the combative public arena of empirical inquiry. Experiments became crucial and theories had to be supported by close observations. Thus, the scientific method stressing reasons and logic was born. So science started in the West by breaking away from the church teachings and since, in the ensuing battle, science proved the stronger of the two, it dominates the Western life today more than the Church.

In course of time, classical science—particularly physics—was replaced by modern science. Under its influence

technology made tremendous progress, and the Industrial Revolution fundamentally changed the life-style in both good and bad ways. Beyond technology, it extended to the realm of thought and culture. Research, in subatomic field, revealed serious limitations of Newtonian Physics and necessitated revision of some fundamental concepts. Not only the concept of matter radically changed, but the world-view underwent radical transformation also. The most unsuspected result was to reveal surprising parallels to the religious philosophies of the Far East and India. Some of the eminent Physicists during their tours to Far Eastern countries notice closed relationship between the ancient and traditional philosophical ideas and the philosophical substance of Quantum Theory[1].

In India, the ancient Jain, Buddhist and other savants engaged themselves in what may appear to Westerners, conjectures and speculations about the origin of matter and material universe based on their spiritual insights. One would search in vain for the use or description of scientific apparatuses in the Jain canonical literature because these were not developed at that time. What then was the source of their knowledge and spiritual insight ? It appears that the capacity of profound thinking (resulting from severe austerities), uninterrupted concentration of thought and meditation enabled the ancient sages to acquire transcendental and extra-sensory perceptive powers. The practice of meditation – *DHYĀNA* – was accorded a very high priority in their daily routine and deep concentration became an easy and effortless achievement.

In meditation, direct insights into the true nature of things extend to long periods and result in a constant non-conceptual awareness of Truth and Reality. Meditation inactivates the thinking mind and shifts the awareness from the rational to the intuitive mode of consciousness. *Concentrated perception* of a single item (i.e., one's own breathing) silences the conceptual activity of the mind, which is emptied of all thoughts. Constant practice of such meditation results in the ability of eliciting direct answers to the enquiries into the Nature of the universe.

1. W. Heisenberg, Physics and Philosophy, p. 202.

Such an experience is not totally unknown to scientists also. In fact, many new scientific discoveries have their origin in sudden non-verbal flashes of intuition, when reality is experienced in a direct way without the hindrance of conceptual thinking. Thinking is considered a distraction in such a state of awareness, and is, therefore, eliminated. Thus in a way, meditation can be compared to a highly sophisticated modern *experiment* in subatomic physics. The, complexity and efficiency of the physicist's technical apparatus is not only matched but even surpassed by that of the practitioner's consciousness in deep meditation.

PROBLEM OF LANGUAGE

Now both the ancient meditators and the modern physicists must communicate the knowledge gained by each of them to others. Both the problem of language to interpret knowledge gained from a direct insight or the observations of an experiment is exactly the same. Thus, whenever the knowledge about reality from whatever source is analyzed by intellect, it must appear absurd or paradoxical.

The knowledge about matter, particularly at the subatomic level is not derived from sensory experience and therefore, ordinary language is not adequate to describe the observed phenomena. Like the meditator, the physicist deals with a non-sensory experience of Reality, and thus, modern physics becomes akin to philosophy. But the question of nature of language is a fundamental problem that underlies all discussions of knowledge, be it scientific or philosophical. Language is a useful tool for conveying information, but if one tries to communicate one's experiences through it, it simply does not work. All, a language can do is to talk *about* an experience, but even the best description of an experience is not the experience, but a talk *about* it.

In atomic physics, as we have seen in the 1st chapter, many paradoxical situations arise because of the dual nature of electro-magnetic radiation. The question which puzzled physicists was how radiations could simultaneously consist of particles which are confined to a very small space and also of waves which are spread over a large area. Neither language nor imagination could deal with this kind of reality satisfactorily.

The Jain Philsosphers, as we have seen in the 2nd chapter, have developed a unique way of dealing with paradoxical aspect of the Reality.

The most striking parallel between the notions of atomic physics and those of Jain philosophy is the principle of the unification of the opposites. In philosophy, the problems of ONE and MANY as well as of *permanence* and *change* are as old as philosophy itself. In modern science, the recent exploration of the subatomic world has revealed unification of concepts which had hitherto seemed opposite and irreconcilable.

Ancient Jain philosophers have been aware of the relativity and polar relationship of all opposites. "Opposites" assert Jains, "are abstract concepts belonging to the realm of thought and as such are relative." Awareness that only what is permanent can change is the mainstay of the law of Non-absolutism (*anekāntavāda*). Similarly, large and small, heavy and light, cold and hot, hard and soft are polar opposites. The Jains always emphasized the paradoxical opposites, instead of by passing or concealing them as done, usually, by the absolutist philosophies of Vedānta and Buddhism. The dual and paradoxical aspect of matter at atomic and subatomic level can be properly understood if one applies the principle of *anekāntavāda*. Since this is a metaphysical subject, it would be more appropriate to deal with it in the succeeding section.

In the mediaeval period, there flourished many Jain scholars, whose interests were wholly literary or spiritual. Even though they contributed a great deal in the fields of mathematics, logic and perhaps astronomy, their contribution to the growth of scientiific knowledge was almost negligible. In the meantime, modern sciences had become firmly established by a wholly independent growth in the West, and was almost wholly put to a material end, with utter disregard to the existence of consciousness, thereby removing any plausible basis for comparison between modern science of the West and traditional knowledge of the East. Surprisingly, however, as we have seen in first chapter (see p. 51), some of the eminent physicists (e.g. David Bohm and Goeffrey Chew) have come to recognise that (non-material) consciousness,

an essential constituent of the universe, will have to be included in the future theory of physical phenomena.

In this regard, the words of an eminent physicist Werner Heisenberg seem to be very relevant. He writes : "It is probably true, quite generally, that in the history of human thinking, the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture, in different times, different environments or different religious traditions : hence if they do meet, that is, if they are at least so much related to each other that a real interaction can take place, then one may hope that new, interesting and useful developments will follow."[1] It is however extremely difficult to adjudge how much scientific the Jain thinkers have been or how far from it. But the Jain scholars did develop an adequate methodology and an admirable terminology for the presentation of their findings which one is free to accept or reject.

The purpose of the following discussion cannot be to make predictions but it may be possible to define some points from which the interaction between the ideas of modern science and the older tradition may begin.

1. W. Heisenberg, Physics and Philosopyh, p. 202

SECTION I

METAPHYSICAL VIEW : NON-ABSOLUTISM—LAW OF ANEKĀNTA

INTRODUCTORY

We have already seen that the non-absolutist realism of the Jains neither endorses absolute eternalism nor absolute fluxism, but explains both these extremes as real with reference to different aspects of the same reality.

While dealing with the quantum field theory in the first chapter, we had seen that the paradox of wave-particle-duality of light could be explained by the concept of complementarity introduced by Neils Bohr (one of the founders of the quantum theory). This concept states that both the wave-aspect and the particle-aspect of light are necessary to fully understand the nature of light. Light or anything else cannot be both wave-like and particle-like in the same context.

This precisely is the Jain position with regard to any two opposites. Neils Bohr visited China in 1937 and was deeply impressed by ancient Chinese notion of the polar opposites. Some other physicists also visited Far Eastern countries and India and were, no doubt, deeply impressed by *Vedānta*, and *Buddhist* philosophies. In the following discussion, we shall see that the Jain Theory of Non-absolutism (*anekāntavāda*) offers the best explanation of wave-particle paradox. Unfortunately, however, the eminent physicist could not contact the Jain scholars who could have shown to them the excellent merits of *anekāntavāda*[1]. In the last fifteen years, a number of books on modern physics have revealed the most striking parallels between some schools of Eastern mysticism and scientific concepts of space and time, cause and effect, etc. In such books, we find the mention of

1. *The Jain Philosophy of Non-absolutism* by Dr. Satkari Mookerjee, Head of the Sanskrit Department, Calcutta University, published by Motilal Banarasidass, New Delhi, Second Edition, 1978 is recommended for critical study of *anekāntavāda. In the following pages, the views expressed in this book are summarized.*

Hinduism, Buddhism, Taoism, etc., but hardly anything about Jain philosophy. Through the brief discussion in the following pages, we hope to convince the scientists in general, and the physicists in particular, that the study of Jain Philosophy deserves much more attention than it has received so far.

D. WHAT IS ANEKĀNTAVĀDA ?

Anekāntavāda is basic to the structure of Jain metaphysics. It seeks to reorient our logical attiude and asks us to accept the unification of contradictions as the true measure of reality. It is the key to unlock the mystery of the paradoxical Reality.

The law of *anekānta* affirms that there is no opposition between the unity of being and plurality of aspects. The identity of a real is not contradicted by the possession of varying attributes. No one can deny that light, for instance, produces multiple effects, viz., the expulsion of darkness, the illumination of the field of perception, radiation of heat and energy and so on. If a plurality of the energies can be possessed by a self-identical entity without offence to logic, why should the spectre of logical incompatibility be raised in the case of a permanent cause possessing diverse powers (i.e. producing diverse effects) ? The law of *anekānta* affirms the possibility of diverse and even contradictory attributes in a unitary entity, i.e., a thing is neither an absolute unity nor a split-up into a irreconcilable plurality. A thing is one and many at the same time—a unity and a plurality rolled into one.

Anekāntavāda also asserts that there is no contradicion between identity and otherness, as they are not absolute characteristics. The contradiction would be unsurmountable if the two opposites were affirmed to be identical in an absolute reference (i.e., same context). But the identity and otherness asserted by the law of *anekānta* are only partial and limited, and not complete and unqualified.

Thus *Anekāntavāda*—non-absolutism—is the law of the multiple nature of Reality. It corrects the partiality of philosophers of supplementing the other side of Reality which escaped them.

Non-absolutism pleads for soberness and insists that the nature of Reality is to be determined in conformity with the evidence of experience undeterred by the considerations of abstract logic. Loyalty to experience and to fundamental concepts of philosophy alike makes the conclusion inevitable that absolutism is to be surrendered. A thing is neither eternal nor non-eternal, neither permanent nor perishable in the absolute sense but partakes of both the characteristics, and this does not mean any offence to the canons of logic.

B. EXPERIENCE VS. PURE *(A PRIORI)* LOGIC

The Jains who are noted for their firmness and sobriety of outlook, maintain that if the nature of reality is allowed to be determined by *a priori* logic, in defiance of experience, the results would be fatal. Certainly logic is not competent to tell us whether anything exists at all. It is only perception which can assure us that anything exists.

Thus, the position that is adopted by the Jains is this : Pure logic, prior to and independent of experience, is a blind guide to the determination of Truth. Logic is to rationalize and systematize what experience offers. All our knowledge is ultimately derived from experience. Even the knowledge that something exists is not capable of being derived from any other source. The existence and behaviour of things and their mutual relationship can be ascertained only on the basis of experience and the function of reason or pure logic is only to reduce the data of experience to order and system. To allow logic to work in vacuo and to dictate term to the data of experience to behave in a way different from their own is neither a sound philosophical procedure nor a safe course of thought. The unfettered exercise of logic in defiance of the testimony of experience, has been responsible for the hopelessly chaotic results achieved by metaphysical speculations. That philosophy has not made progress commensurate with the progress of science is due to the illegitimate freedom usurped by reason by deposition of empirical evidence. The laws of thought, if they are to be the laws of being and becoming must be propounded in a fashion that they may be really helpful to the progress of knowledge.

MUTATION (PARIṆĀMA)

Non-absolutism being the foundation of Jain Philosophy, mutation (change) is as much real as permanence. A substance is a substratum of infinite qualities. Nothing can exist without 'being in some determinate way' and the qualities of a substance means its existence in a 'determinate mode of being'. Thus, assert Jains, the qualities (*guṇas*) and modes (*paryāyas*) cannot be absolutely different from the substance nor can they be absolutely identical with it.

Change or modification is a fundamental characteristic of all that is real. The problem presented by unceasing mutability of existence is one of the earliest as well as one of the most persistent ones in the whole range and history of Eastern as well as Western Philosophy. There is an ominous hint of the central paradox implied in all mutability--namely, that only the identical and permanent can change.

This paradoxical thought has affected philosophy in different ways at different periods of its history. In the West, at the very dawn of Greek Philosophy, it was the guiding principle of the "Ionian physicists." Later on, Parmenides and his Eleatic successors swung to the extreme view that change, being impossible in a permanent homogeneous substance, must be a mere illusion of our deceptive senses.

Later again, Empedocles sought to reconcile the apparent mutability of things with the criticism of Parmenides by the theory of regrouping of atom in space.

At a more developed stage of Greek thought, Plato drew the momentous distinction between two worlds or orders of being—the real with its eternal unvarying self-identity, and the merely apparent, where all is change, confusion, and instability. In the Orient also, there have not been wanting attempts to get rid of the paradox by denying its truth. Vedāntists, like the Eleatics, sought to escape it by reducing change itself to a basless illusion. On the other hand, Buddhists (fluxists), like the disciples of Heraclitus, have evaded it by refusing to admit any permanent identity in the changeable, and they have not been entirely without imitators in the modern world.

Incessant change without underlying unity has had its defenders in the history of Metaphysics. The argument in favour of the doctrine that only incessant change is real seems to be the appeal to direct experience. In any actual experience, it is contended, we are always presented with the fact of change and transition, we never apprehend an absolutely unchanging content.

Now there can, of course, be no gainsaying these facts of experience, but the conclusion based on them evidently goes much farther than the premises warrant. Experience never gives us mere persistence of an unchanging content. Nor does it ever give us mere change without persistence. What we actually experience always exhibits the two aspects of identity and transition together. Usually there will be, side by side with the elements which sensibly change others which remain sensibly constant. And even the successive states of the changing content are not merely momentary, each has its own sensible duration through which it retains its character without perceptible changes. Experience, thus, entirely fails to substantiate the notions of mere change apart from a background of permanent identity.

The positive disproof of the notion must, however, be found in its own inherent absurdity. Change by itself, apart from a background of identity, is impossible for the reason that where there is no underlying identity, there is nothing of change. All change must be change of and in something. And where you have not merely a change of perception but an actual perception of change, the case is even clearer. What we perceive in such a case is the two successive states being held together by the fact that they are successive states of some more permanent unity. Mostly you have not merely a change of perception, but an actual perception of change. What we perceive is the two successive states being held together by the fact that they are successive states of some more permanent unity.

Change, therefore, is a succession *within an identity*, the identity being as essential to the character of the object as the succession. In what way, then, must we think of this identity which, is present throughout the whole succession of changes? This question – how that which changes can be permanent? – is similar

to the old problem of quality and substance, how the many states can belong to one thing, considered with special reference to the case of states which form a succession in time. Thus, whatever is the true nature of the unity to which the many states of one thing belong, will also be the true nature of the identity which connects the successive stages of a process of change.

A group of states is the embodiment of coherent structure. The earlier and later stages of the process are differences in an identity precisely because they constitute one process. The succession of stages is thus welded into a unity which we express by saying that whatever changes possesses an underlying permanent identity of character.

TRIPLE CHARACTERISTICS OF REAL

In order to fully grasp the signficance of Jain view regarding physical existence in the context of new physics, we think it is necessary to allow a little more space to discuss the character of Reality as asserted by the Jain Philosophy of Non-absolutism. We, therefore, apologize to the readers for being repetitive to some extent.

We have seen in the previous sub-section that the Jain conception of Reality avoids the Scylla of fluxism and the Charybdis of illusionism. One cannot conceive of any other philosophy which can maintain realism against the onslaugths of idealists without endorsing the Jain conception. Existence, cessation and persistence are the fundamental characteristics of all that is real. This concept of Reality is the only one which can avoid the conclusion that the world of plurality, which is the world of expereince, is an illusion. Either the world is to be accepted as real or dismissed as an unreal appearance.

The affirmation of origination, cessation and persistence as the triple characteristics in the constitution of reals has to be substantiated. We have seen that change presupposes the persistence of an underlying permanence. So permanence is to be accounted as an element in a real together with change. But change means the cessation of a previous mode or attribute and the coming into being of a new mode. The affirmation of the triple

characteristics has, therefore, nothing paradoxical about it. They are a natural deduction from the reality of change. The Jains believe in the dynamic nature of reals and, in deference to the demands of reason and experience alike, they sum up the triple characteristics as the component factors of the constitution of Reality. One can avoid this triple characteristic only by the declaration of change as appearance, which is the position of the Vedānta. One must offer one's allegiance either to Vedāntic monism or affirm the multiple nature of Reality, which is the teaching of Jaina *anekāntavāda* (non-absolutism).

Viewed from the Jaina standpoint, a real is a continuum through the infinite variation of its modes at every moment of its being. The continuum is a reality as much as the variation. Thus, there is unity as well as multiplicity in perfect harmony. The real viewed as identical with the changing modes is thus coming into being every moment and perishing every moment. That it comes to evolve a new mode implies that the previous mode has ceased to exist. So a real *qua* its modes is becoming into something new by ceasing to be its old self. The birth of the new is thus the logical concomitant of the death of the old. The affirmation of the three apparently incompatible elements as making up the constitution of a real is thus the result of a logical analysis of a real as it is. Either pure (absolute) negation or pure (absolute) affirmation are the only alternatives left for acceptance. The former is the position of the Buddhist *Śūnyavādin* and the latter is that of *Vedānta*. Is the paradox greater in the Jain view than in the two other systems? Is the *Śūnyavādin* who dismisses the whole world of experience as an unfounded illusion, less paradoxical ? Is the Vedāntic view, which endorses the *Śūnyavādin's* repudiation of the whole world of pluralities, calculated to satisfy the abhorrence of paradox in a more satisfying manner ? The paradox is only apparent as it alone provides a satisfactory experience and thought. The criterion should be whether or not it succeeds to explain the world *as we know* it.

Again, the Jains assert the non-absolutistic position in respect of the relation of modes with substance. The mode is a mode of the substance because the identity of substance is

focussed in it and is not annulled. So a mode is identical with substance in that respect. To take an example, clay is transformed into a jar, and so the former is regarded as the cause of the latter. The jar is different from clay, no doubt, but the jar could not be a jar unless it were the same substance as clay. The mode and the substance may be viewed as identical and also as different, as they are both in one. Thus the consequences, are not inevitable, as they are based upon exclusive identity and exlusive difference. But the identity is not exclusive of difference and *vice versa*, as both are the attested traits of Reality. If identity is to be asserted on the evidence of experience, difference also should equally be asserted on the strength of the same evidence. The compartmental way of looking at things leads to the affirmation of one and to the negation of the other. The besetting sin of philosophers has been the habit to put the telescope upon the blind eye and then to deduce that the other aspect is not real. The Jain Philosopher voices the necessity of using both the eyes and of seeing the obverse and reverse of the coin of Reality.

The triple charcteristics gives out the internal constitution of Reality. A real persists through time and thus has these three – past, present and future – temporal determinations. So a real is real for all time. It was real in the past, is real in the present and will be real in future. A 'real' which has no past and no future is a fiction and a non-entity.

Let us sum up the results of our investigation into the nature of Reality. The Jain philosopher has proved that absolute unqualified affirmation of existence is not in conformity with the nature of Reality. He has also proved that absolute negation of existence is self-contradictory. He has further proved that fidelity to experience and thought demands that existence and non-existence both are to be accepted as equally valid traits in the make-up of a real.

In order to guard against the absolutist habit of believing existence and non-existence as whole-characteristics excluding each other from their respective orbit, the Jain Philosopher prefaces each proposition by the limiting phrase 'in some respect' or 'in one particular aspect' *(syāt)*. The insertion of this phrase is

a warning against reading an absolutist sense into the predicates. It is true that the two characteristics—'is' and 'is not'—are not capable of being expressed by one word at a time. The co-existence of these two predicables is sought to be implied by the phrase 'inexpressible' (*avācya*) by some others. But according to the Jains, the word 'inexpressible', used as a predicate, asserts a real characteristic of a real subject and the possibility of such predication means that a real is not entirely incapable of being described. So the predicate 'inexpressible' cannot be taken in its literal absolute sense. 'In some respect, a real is 'inexpressible' is the correct proposition.

The Jains assert that concepts and conceptual thoughts are not in opposition. It is exceedingly difficult to understand why the concepts should not be of service in the emergence of perceptual intuition. The Jains maintain that perceptual judgements are founded upon reality. Parity of reasoning requires that consciousness, with the aid of sense-organs and concepts, can give us the full knowledge of Reality, as it is. The Jains do not regard the concepts as antagonistic to Reality. The concepts are as much the means as the sense organs and consciousness are, of gaining an insight into the nature of Reality. Thus, a real is not a particular alone, but particular-cum-universal, the universal as embodied in the particular. The real is, thus, amenable to verbal communication and to judgement alike.

E. PROBLEM OF RELATION

In the previous sub-section, the problem of relation was discussed briefly. We shall now see how the reality of relation between substance and its qualities and modes, has always been an irritating problem in metaphysics, and has been thoroughly discussed by all the schools of Indian Philosophy. It has also received a serious attention of all Western Philosophers too, since the time of Aristotles.

The reality of relation between substance and qualities is a fundamental concept for the Jains, and it is 'relation' which introduces order and coherence into the world. But the reality of relation has been denied by the Fluxists and the Vedāntists in the

Orient. In Western metaphysics, Kant and Bradley condemned 'the thing with its qualities' as self-contradictory. But such a conclusion goes clean against not only commonsense but against science. It is remarkable that the arguments of Kant and Bradley were anticipated by the ancient Indian Philosophies several centuries ago. The Buddhist Fluxist's position has been summed up by Bradley in these forceful words : "……a relational way of thought……must give appearance and not truth. It is a make-shift, a practical compromise, most necessary, but in the end most indefensible."[1]

The Jains refuse to be brow-beaten by such a flourish of abstract logic. If our intellect is not to be condemned to bankruptcy and if Reality be not declared to be a unfathomable mystery, an explanation must be found. We have already elucidated the Jains' position regarding logic in part B of this section, which clearly states that the denial of experience ends in unqualified scepticism, and if we are to believe and value the testimony of our experience, there is no possibility of denying the validity of relation. Unity of cognition, in spite of the numerical difference of contents (as in the cognition of a variegated carpet) is an attested fact and we have no reason to call in question its authenticity. "Why should there be a relation at all ?" is a question as absurd and equally unanswerable as "why consciousness should be consciousness and not different from it ……"

"Reality", assert the Non-absolutist Jains, "is the identity of a infinite multiplicity of aspects and modes. A real is a unity and diversity in one, and the relation involved is neither one of absolute identity nor one of absolute otherness but something different from both. It is *sui generis (jātyantara)* which does not permit of being determined by absolute criteria."

If 'identity' satisfied a logical necessity, so also should this unique relation. Each is unique and ultimate and there is no reason to condemn it as appearance, when it is equally a given fact with identity or otherness. On the other hand, neither absolute identity, nor absolute otherness has any reality beyond abstractions of thoughts.

1. Bradley, Appearance and Reality, p. 28.

JAIN VIEW COMPARED WITH WESTERN PHILOSOPHERS' AND SCIENTISTS' VIEW

In the previous chapter, we have seen that matter (called '*pudgalāstikāya*' by the Jains) is the only substance which can be the object of sensuous cognition. At the same time, we have seen that *paramāṇu*, the ultimate atom of *pudgala* and some kinds of material aggregates cannot be perceived by sense-organs. Nevertheless, all modifications of *pudgala*—be it a single free ultimate atom (*paramāṇu*) or an aggregate composed of infinite number of *paramāṇus*—do possess the four qualities of touch, taste, smell and colour. These qualities are also real and their existence does not depend upon the percipient. Besides these four innate qualities, *pudgala* possesses innumerable other qualities which are all subject to incessant series of modes.

With these views, it is obvious that Jains will refute all types of philosophical idealism—subjectivism and solipsism. Being non-absolutists, however, Jains will almost always find points of agreement in the views of most schools of thought. We shall, therefore, compare *Jain* views with those of a few Western philosophers and scientists with particular reference to the existence of physical reality.

According to Sir Arthur Eddington, an eminent physicist, who calls his philosophy 'selective subjectivism', though the material world does exist objectively, it does not appear in our experience or observational knowledge. Thus, although he accepts the objective existence of matter in the realm of metaphysics, he denies such status to it in the realm of epistemology because he does not accept that sensory qualities exist objectively in matter.

This is in opposition to the Jain view. Jains' argument in rebuttal to Eddington's view is : if it is the consciousness that creates sensory qualities and if the matter itself is devoid of these qualities, how can a single object be perceived identically by different percipients with normal sensory equipments?

Sir James Jeans, another eminent physicist, is also supporter of philosophical idealism. According to him, "The objective and material universe consist of little more than 'construct' of our own

minds. The universe is created by a pure mathematician who does not concern himself with material substance but with pure thought. His creations are not only created by thought but consist of thought. In his views both subjective and objective fall within what is inside our minds."

Jeans has accepted the reality of mind (psyche) which, according to him, is a non-physical reality. The Jain philosophy also, asserts that soul is a non-physical reality. Thus 'mind' of Jeans and 'soul' of the Jains being non-physical in nature, describe the same reality.

Jeans talks of "Universal Mind' and 'Individual Minds'. The Universal Mind, according to him, is the creator and governor of the realm of matter as well as the individual minds. He believes that atoms out of which our individual minds have grown exist as thought in the Universal Mind.

The Jain view does not accept the existence of any such Universal Mind of which the individual minds are units of excrescences. According to the Jain view, all the souls are independent individual entities having real objective existence. Jeans has not given any reason for his belief which is akin to the pantheistic view.

Now, as we have already seen, the Jain view concedes that the sensory knowledge of the phenomena of the universe may not be wholly objective, but it does not conform with Jeans' views in considering the phenomena of the universe as wholly subjective.

According to Jeans,the objective reality of the real essence of substance is beyond our knowledge. He, thus, seems to accept Kant's transcendentaljsm in which the thing-in-itself is considered to be transcendental. The Jain philosophy also declares that the ultimate essence of substances cannot be comprehended through the sensory knowledge and hence, at least in this respect, Jeans' view is consistent with the Jain view.

Lastly, we shall discuss the concept of substantiality. Jeans defines 'substantiality' as a 'purely mental concept measuring direct effect of objects on our sense of touch.' Now. If it is so,

i.e., if substantiality is not inherent in the substances, how do the objects (or substances) exist without substantiality ?' Also Jeans' discussion of the degrees of substantiality is not only equivocal but almost absurd. On the other hand, the Jain philosophy furnishes us with the crystal clear definitions of the terms substance, substantially, etc., and proves objectiveness of substantiality on logical and empirical grounds. Substantiality as a purely mental concept is definitely not acceptable to the Jain philosophy. Thus both views vehemently differ from each other on this point.

On the other hand, the eminent philosopher-scientist Sir Albert Einstein asserted the reality of atom and the objective existence of the external world. According to him, "Planck's determination of the true size from the law of radiation (for high temperatures) convinced us of the reality of atom."[1]

The dialetical materialism supports and corroborates the realist view saying 'the concept of matter epistemologically implies nothing but objective reality existing independently of the human mind...Electrons, ether, etc., exist as objective realities, just as nature existed prior to man and organic matter...The absence of any other kind of mass in the electron except electromagnetic mass...corroborates the objective existence of matter. The electron is to the atom as a full stop is to the size of a building 200 ft. long, 100 ft. broad and 50 ft. high; it moves with a velocity as high as 2,70,000 kms. per second, its mass is a function of its velocity, it makes 500 trillon revolutions in a second. Human reason has discovered...will discover still more....But this does not mean that nature is the creation of our mind or of an abstract mind, i.e. of Ward's God."[2]

It should not be assumed that all realist views are acceptable to Jains.

The materialists and the Jains – both agree in accepting the objective realism as well as the sensible qualities of matter. "Matter is a philosophical category designating the objective reality which is given to man by his sensations, and which is

1. *Albert Einstein : Philosopher-Scientist*, p 103.
2. *Materialism and Empirio-criticism*, pp. 184-85.

copied, photographed and reflected by our sensations, while existing independently of them." This definition of matter given by the materialists comes very close to the Jain definition of *pudgala* viz., '*pudgala* is that which possesses in itself the qualities of touch, taste, colour and odour. Even though the Jain philosophy denies the possibility of direct perception of the ultimate atom (*paramāṇu*) of matter through sensory means, it accepts the quality of *'mūrtatva'* being objectively existent even in *paramāṇus*. Also both recognise matter as an objective reality. In the words of Lenin "the sole property of matter with whose recognition philosophical material is bound up is the property of being an objective reality, of existing outside our mind."

The fundamental difference between the two views is regarding the ultimate reality of consciousness. According to the Jain view, physical order of existence (a*jīva*) and psychical order of existence (*jīva*) are entirely different substances. Consciousness is the characteristic of *jīva* (psyche), and, therefore, *ajīva* is devoid of consciousness. Only *jīva* is capable of a cognitive experience. Besides passions, emotions, sensation of pleasure or pain, memory, experience, etc., are various manifestations of consciousness alone. Matter is devoid of consciousness and is therefore *ajīva*. Mutual transformation within the two orders of existence is, according to Jains, absolutely impossible. Matter, being entirely devoid of consciousness cannot under any conditions, be transformed into *jīva*. The Greek atomists believed that psychical order was created and composed of certain types of atoms (spherical, dynamic and smooth). Dialectical materialism does not accept the separate existence of psychical order at all. According to it, the entire existence is transformation of matter. The scientists' views are divided on the subject. Some of them agree with the views of the dialectical materialism.

MOTION, SPACE, TIME, ETHER (S)

Each of the above concepts have been discussed in the preceding chapter. Here, we shall briefly compare the Jain views about these concepts with those of modern science.

Having accepted the reality of physical substance, the Jains, naturally accepts the reality of motion. It has also obtained a good standing in the field of modern philosophy and modern science has also emphasized the importance and reality of motion in understanding the nature of physical existence. And, in order to accept the reality of motion of physical objects, the reality of space must also be accepted.

But motion in Jain doctrine is intimately connected with not only space, but also two other substances—positive ether (*dharmāstikāya*) as medium of motion and negative ether (*adharmāstikāya*) as medium of rest. We shall, therefore, be required to discuss all the three substances together with motion.

It may be recalled that we translated the terms *dharmāstikāya* and *adharmāstikāya* as positive and negative ethers respectively, because the classical physics had postulated the existence of medium of motion and called it ether. In the classical physics, the problem of motion was first dealt with by Galileo and later on by Newton. Before them, Aristotlean tradition of absolute rest was generally believed. But Newton's theory got rid of the idea of absolute rest and introduced conception of a substance called the "ether", that was present everywhere, even in the empty space. Maxwell's electromagnetic theory of light predicted that light waves travel at a certain fixed speed through ether. Light waves travelled through ether as sound waves travelled through air. Between 1887 and 1905, the fate of ether was hanging in a balance. In the meanwhile, an important experiment carefully performed by Michelson and Morley suggested that there exists no such substance as ether. Finally, in 1905, Albert Einstein established that the whole idea of an ether was unnecessary, provided that one was willing to abandon the idea of absolute time.

The discoveries of modern science, the dual nature of matter, the standing wave-patterns of electrons are all associated with the reality of space and its contents. Now the space itself according to Jains, has infinite extension and only a portion of it is filled in the other real substances. It is this finite portion which is the theatre of all the drama of cosmic dance. And the finiteness

of the cosmos is due to the two other substances viz. media of motion and rest. Without these two, the systematic structure of the cosmos would have been a chaos.

SPACE-TIME

Physics, the concepts of space and time are so basic for the description of natural phenomena that their modification entails an alteration of the whole framework we use in physics to describe nature. The concepts of space and time underwent radical modification from the time of Aristotles to the present time.

In Newtonian physics, matter particles moved in a three dimensional absolute space, filled with ether (medium of motion). It was an absolute space, always at rest and unchangeable. All changes in the physical world were described in terms of a separate entity called time, which again was absolute having no connection with the material world and flowing smoothly from the past through the present to the future. These concepts of space, time and ether were the basis of physics for almost three centuries.

Both Aristotles and Newton believed in absolute time. That is, one could always measure the interval of time between two events and that it would be the same whoever measured it. Time was completely separate from and independent of space. This commonsense view worked well when dealing with apples or planets that move slowly but they don't work at all for things moving at or near the speed of light.

According to Einstein's relatively theory, space was not three dimensional and time was not a separate entity. Both were intimately connected and formed a four-dimensional continuum-"space – time". Furthermore, there was no universal flow of time. Concepts of an absolute space and an absolute time were, thus, abandoned and became merely elements of language for describing observed phenomena. Concept of ether was also given up.

Einstein's theory, moreover, says that three-dimensional space is curved and the curvature is caused by the gravitational field of massive bodies. Thus according to this theory, the universe is finite with *nothing* beyond it.

SECTION II

PUDGALA : ATTRIBUTES

A. *PUDGALA* : DEFINITIONS

Nomenclature

The nomenclature of *pudgala* is quite peculiar to Jain Philosophy; it does not even exist in the lexicons edited by non-Jain writers. The word *pudgala*, derived fro *pud* = integration or fusion and *gala* = disintegration or fission, emphasizes the Jain sages deep insight into structure and character of physical existence.

The discoveries of immense sources of nuclear energy have thrown the words fission and fusion into popular lime-light. But quite apart from this comparatively recent knowledge of the nuclear physics, we have seen that there are innumerable instances of both fussion and fission of *pudgala* even in everyday life. Both are essential whenever energy is released, as in the common case of lighting of the match-stick. The cellulose of the match fissions into its components of carbon and hydrogen which are then fusioned with the oxygen of the air, to burn and release the chemical engery ; the same thing happens when the coal catches fire. The continuous processes of emission and absorption by the radio-active elements are also example of self-activated *pud* and *gala*. Use of this unique property of the substance in its nomenclature reveals the profoundness of knowledge.

In science, the exploration of the subatomic world has revealed the intrinsically dynamic nature of matter. It has shown that the constituents of atoms, the subatomic particles possess a dynamic character as integral part of an inseparable network of interactions. These interactions involve a dynamic interplay in which particles are emitted and absorbed, created and destroyed in a continual variation of energy patterns. They give rise to the stable structures which build up the infinite variety of material world. The whole physical universe is thus engaged in endless integration and disintegration (=*pud* and *gala*).

CHARACTERIZATION

According to the Jain canonical literature, every *pudgala* (physical object) does possess colour, taste, smell and touch, Conversely *pudgala* is the only substance which is the object of sensuous cognition. The other five substances are devoid of sense-data. Thus, matter alone is '*rūpī*' while the others are *arūpī*. The term *rūpī* does not mean visible but perceivable and signifies the concurrent existence of all the four sense-data. The physical order of existence, according to the modern science, comprises all existence which can be perceived by means of sense-organs. The physical order does not depend for its existence upon the fact of actually being perceived. Thus the Jain views broadly agree with the modern science insofar as the general definition of the physical existence is concerned.

B. CHARACTERISTIC QUALITIES

The objective and simultaneous existence of the qualities of colour, taste, smell and touch in *pudgala* have been amply emphasized in the previous chapter. Five elementary colours,[1] five elementary tastes, good and bad smell and four elementary touches – hot, cold, dry and gluey – makes a total of 16 varieties of characteristic innate qualities of all classes of *pudgala*.

COLOUR

First of all, we should clarify, what is the meaning of the statement 'colour etc., are innate qualities of matter.' Now what is colour? It is some structural peculiarity of a material object which interacts with light and makes the object visible and perceivable by the sensory equipment of vision.

Modern science explains the phenomenon of colour on the basis of the wave-theory of light. According to it, the normal white light from the sun contains the whole visible spectrum. Difference

1. The division of colour into 5 primary types agrees perfectly with the scientfic views. For instance, Colorimetry Committee of the Optical Society of America reported in 1922 as follows :
"Colour is the general term for all sensations arising from activity of the retina and its attached nervous mechanisms. It may be exemplified by the enumeration of characteristic instances as red, yellow, blue, black and white."

of wave-lengths produces difference of colour, each colour having its own specific wave-length and frequency. When white light falls on any material object, it absorbs some of the radiations and reflects the rest. The reflected radiations reach our eyes and we perceive the colour of the object corresponding to wave-lengths of these radiations, Thus, when the light from the sun falls on the grass, it absorbs radiations of all other wave-lengths except one representing green colour. Consequently, only radiations of wave-length representing green colour reaches our eyes. They stimulate the optic equipment and we see the grass as 'green'.[1]

It is obvious that the reflection of the wave-lengths corresponding to green colour and absorption of the rest of the wave-lengths by grass is due to its own specific structual property. Thus, on the basis of the scientific theory of colour, it becomes clear that the perception of grass as green (or rose as red) depends upon the fact as to which wave-length is reflected and not absorbed by the object, and this, in turn, is decided by something inherent in the object—some structural peculiarity of the object itself.

The Jain view regarding colour is similar to the above. Sense-organ 'eye' does not come in direct contact with the object but perceives through the medium of light. That is, the perception of colour is the result of the interaction between the inherent quality of colour possessed by the object, light and the sensory equipment. Expressed symbolically:

C_P denotes the colour perceived,

and C_O denotes the objective colour,

and L denotes the function of light

and S denotes the function representing sensory equipment, then $C_P = f(C_O, L, S)$

The green colour of the grass is the colour percevied by us (C_P) which is created in two steps, firstly, there is an interaction

1. It may be noted that a body which reflects all of the radiations will appear white, while one which absorbs all of the radiations will appear black.

of light (L) with the objective colour of the grass (C_P) and secondly, the resultant products interact with the sensory (optical) equipment (S). Thus all the three factors – the object, light and the subject (sensory equipment) – play an important role in the formation of perceived colour. If anyone of the three factors gets slightly changed, there would be a corresponding change in the perceived colour.

Thus for example,

(1) A sees Grass in white light as Green,

but A sees Rose in white light as Red. (Example of change in object).

(2) A sees Grass in white light as Green,

but B sees Grass in white light as Red. (Example of change in the obsever. B is colour-blind)

(3) A sees Rose in white light as Red, but

A sees Rose in yellow light as Orange. (Example of change in light).

RAMAN'S STUDY OF COLOUR

Sir C.V. Raman, the famous Indian scientist and a Nobel Laureate, has made an intensive research on the phenomenon of colour. His findings published in '*Current Science*' as series of articles entitled '*The New Physiology of Vision*' corroborate the Jain view that it is the internal structure of the material object which is responsible for producing colour. He concludes thus:

"It follows that all aspects of vision including the perception of space and form, the perception of luminosity and the perception of colour, can only be understood in terms of the corpscular concept of the nature of light". Again he clearly states – "Colour as seen in daylight is the sensation resulting from the synthesis by the eye of the whole spectrum of radiation falling upon the object and returned to the eye after scattering or diffusion by the material of which it is composed."

Thus we may conclude that according to Raman, the chromatic sensation (i.e. the perceived colour or C_P in our notation)

depends upon the energy of light corpuscles reflected or transmitted by the object. That is, it is dependent on some peculiar property inherent in the material of the object and therefore, the quality possessed by the material of the object is the deciding factor in the perception of colour. It should be noted that the perceived colour (C_P) is not identical with C_P because Cp is a function of C_O, L and S.

We may summarise the above discussion thus:—

The difference in emission and absorption of light by different coloured surfaces is the effect of some innate quality in the material object and light acts merely as a medium for the perception of the colour and not for its existence.

From the above discussion we can get a fair idea of the characteristic quality called colour which, according to the Jain view, is an inseparable innate property of all material objects.

COLOUR IN COSMOLOGICAL STUDIES

Colour, one of the four inherent qualities of matter has been a boon to inquisitive mankind in general and scientists in particular. More than that, it has been the cause of many spectacular advances in some of the sciences (and even arts). Astronomers in their quest of knowledge of the universe are able to probe and pry into the macrocosmos and see millions of distant stars and galaxies which are thousands of millions light years away. With the growth of knowledge from their insights, astronomy developed a whole new kind of study called Astrophysics. The science of spectroscopy became an indispensable branch of astronomy. On its findings are based all the modern theories about the universe.

The secrets of the universe are written largely in code language of light and can be known by deciphering light itself. Everybody knows that white sunlight bent apart by a prism[1] becomes a rainbow of all the colours. This is called a spectrum. It was found many years ago that the sun's spectrum was not a perfect rainbow but slashed by many dark lines, but noblody knew

1. The prism is now replaced by a more efficient light-splitting instrument viz. diffraction gratings of lines closely ruled on glass.

what they meant at that time. Later studies showed that light emitted by elements at very high temperatures showed bright slashes in their spectrum. Today the knowledge of atomic theory and the true nature of light has established that each element or kind of atom can emit and absorb energy only at the specific wave-length determined by its atomic structure. Its pattern may have many lines or a few but its position on the spectrum is always the same and unlike that of any other. Thus every element can reveal its identity by its spectral line signature written by the ink of its own unique colour or the fingerprint of its individual personality.

The discovery of Helium, christened as the sun element by its discoverer, Sir Joseph Norman Lockyer, more than a hundred years ago, was the result of the accurate interpretation of the sun's spectral lines with elements in its atmosphere. Indeed, the white radiance of the cosmos shattered into its component colours can reveal the identity of atoms pulsating thousands of millions of miles away. Over the years, the spectral lines from a star proved to hold amazing quantities of information: the composition of the star, the speed of the star moving towards or away from us, the speed of its rotation, temperature of its surface, the strength of its magnetic field, etc. Stars are no longer pin-points of inscrutable light but objects with individual personalities.

All this is possible because colour is an inherent quality of matter. Stars emit coloured light and each star can be pictured as a colourful spectrum which is its finger-print. Its composition is found by identifying the patterns of lines that its chemical elements cast across its spectrum. The speed of a star moving towards or away from us is indicated by the so-called 'Doppler effect' or shift of its spectral lines. The shift is towards the blue (or left) end of the spectrum if the star is advancing, towards the red (or right) if receding. The greater the star's speed, the more its lines shift. The amount of shift is calculated by comparing the lines with those of a laboratory specimen.

TOUCH (*SPARŚA*)

The quality of touch (*sparśa*) is also of great importance. It should be carefully noted that besides the four touch given above which are inherent in all states of *pudgala* there are four additional touch viz. light, heavy, hard and soft which are acquired by certain types of composite bodies.

The four additional touch are formed by combination of four basic touch as follows :–

(i) The negative charge (i.e. *rūkṣa*) is associated with lightness.

(ii) The positive charge (i.e. *snigdha*) is associated with heaviness.

(iii) Combination of cold *sparśa* and positive charge results in production of soft *sparśa*.

(iv) Combination of hot *sparśa* and negative charge results in production of hard *sparśa*.[1]

Thus, there are two classes of material objects (i) those possessing four touch i.e., *catuḥsparśī* and (ii) those possessing eight touch i.e., *aṣṭasparśi*. Out of the eight *vargaṇās*[2] (categories) of *pudgala* which interact with the psychical existence, the last four are *chatuḥsparśi* while the first four are *aṣṭasparśī*.[3]

The eight touch which can be grouped into four pairs refer to the following four physical properties of modern science :

(i) Hot, cold correspond to temperature.

(ii) Dry, gluey correspond to positive and negative electrical charges.

(iii) Light, heavy correspond to mass (density).

(iv) Hard, soft correspond to measure of hardness.

(i) *Temperature (Hot, Cold)*

The first pair hot (*uṣṇa*) and cold (*śīta*) refers to the physical property of temperature, which is the measurement of heat level. The range of temperature existing in nature is very wide.[4]

(ii) *Electric Charge (Dry, Gluey)*

The qualities of dryness and glueyness refer to the physical property of electric charge. The qualities play an important part in

1. *Bhag. Joḍa* : 18/6/117; *Jīva-ajīva*, p. 76.
2. See pp.
3. Out of the last four categories, the category of *śvāsocchawās* is considered to be aṣṭasparśī by some *ācāryas*.
4. The highest temperature is found in stars, which is estimated to be nearly 40 million degree celcius, by Eddington. The lowest tenperature, on the other hand, cannot be less than minus 270 degree C. which is called absolute zero, according to modern science.

the formation of aggregates[1] (*skandha*), just as positive and negative electric charges of subatomic particles play important role in the formation of atoms and molecules.

(iii) Mass or Density (Light, *Heavy)*

The third pair – light (*laghu*) and heavy (*guru*) refers to the physical property of mass or density. According to the Jain concept, this pair is acquired by *aṣṭasparśī* aggregates only, and therefore, the *catuḥsparśī* aggregates are devoid of mass. They are *agurulaghu* i.e. neither heavy, nor light. When compared with the modern particle physics, it can be said that all *catuḥsparśī* aggregates are in the form of energy and their entire mass is in their motion.

DENSITY AND EXTENSION

A *paramāṇu* being truly indivisible has no extension and will, therefore, logically occupy one space-point. The space occupied by a *skandha* will depend upon its density. The number of space- points occupied by *a skandha* of lowest density will be equal to the number of *paramāṇus* in the *skandha*. Thus, a diatomic *skandha* will occupy two space-points, a triatomic *skandha* three, and so on upto innumerable (*asaṁkhyāta*). However, a *skandha* with infinite number of *paramāṇus* will have to be densely packed so as to occupy more than innumerable (*asaṁkhyāta*) space-points. When more tightly packed, however, a *skandha* would occupy space-points much less than the number of *paramāṇus* constituting it. A *skandha* with infinite number of *paramāṇus*, if densely packed, may occupy only a single space-point.

And in the extreme case, infinite number of *skandhas*, each composed of infintely infinite (*anantānanta*) number of *paramāṇus*, may occupy only a single space-point. Such is the property of compressibility of *pudgala*.

In modern science, density varies from element to element. In each atom, 99.97% of the total mass is concentrated in the

1. We shall discuss this in greater detail while discussing the qualities of *paramāṇu*

densely packed tiny nucleus, whereas in the rest of the atom, the density is very low.

That is, in the nucleus of an atom, the matter is so dense that an object of the size of a paisā would weigh 600 million tons if its atoms were as densely packed as the particles in the nucleus. Of the 92 elements found on earth, hydrogen is the lightest and plutonium and osmium are among the heaviest.

Matter, thousands of times denser than the densest substance on earth, exists in the interior of stars. It varies from 1 ton to 620 tons per cubic inch. On the other hand, the density of matter in nabulae is of the order of 10^{-24} of the density of water. The high density matter in stars sometimes results in the most mysterious and fascinating objects called "black holes". The effects of the extremely high density of matter are manifested during the gravitational collapse of a massive star.

BLACK HOLE

A black hole begins to form when a star runs out of fuel and starts to cool off and so to contract. As it contracts, it becomes more and more dense, its gravitational field at the surface gets stronger and makes it more difficult for any thing, even a ray of light to escape from the star. Eventually, when a star has shrunk to a certain critical radius, the gravitational field at the surface becomes so strong that the light can no longer escape. Since nothing can travel faster than light, nothing else also can escape, everything is dragged back by the attraction of the gravitational field. Such a region of space- time from which it is not possible to escape is called black hole. Though a black hole is invisible, one would feel the force of its gravitational attraction. One such black hole is thought to exist in our own galaxy. The star called "Cygnus X-1" in our galaxy appears to consist of a black hole and a normal star, orbiting around each other.

BLACK HOLES IN JAIN ASTROPHYSICS

While the theory of black hole is very modern, centuries ago, the Jain seers were actually aware of the existence of black

holes. In the Jain canon, *Bhagavatī Sūtra*, two types of black holes are described in some detail.[1] They are (i) *tamaskāya*, (ii) *kṛṣṇarāyī, (kṛṣṇarājī, kṛṣṇarāti).*[2]

Tamaskāya literally means a body composed of darkness. its shape is described as conical with the base having the shape of a cowrie (i.e. elliptical ?) and the surface parabolic. It has neither planets nor satellites. It is a huge area of space, but contains nothing except swirling gaseous matter, which is infinitely destroyed, created and destroyed again. Brightest sunlight would be transformed into utter darkness, if it nears *tamaskāya.* It is totally black and is described as "terror-producing." Even a *deva* (celestial being) will be horrified if he happens to remotely experience the force of one of these black bodies, and would instantly fly away to escape from its clutches.

There are two sizes of *tamaskāya*—

(a) with base diameter of numerable *yojanas* and a volume of innumerable *yojanas.*

(b) with base diameter as well as a volume of innumerable *yojanas.*

Kṛṣṇarāyī literally means black mustard or mass of darkness. Two of them exist in each of the four directions making a total of eight *Kṛṣṇarāyīs.* All the four internal ones are rectangular in shape while the two external ones in north and south are triangular and east and west are hexagonal. Like *tamaskāya,* a *Kṛṣṇarāyī* contains nothing but swirling gaseous matter, which is infinitely destroyed, created and destroyed again. It is totally dark and black in colour. The rest of the description is similar to that of *tamaskāya.*

(iv) *Measure of Hardness (Hard, Soft)*

Hardness (*kaṭhoratva*) and softness (*mṛdutva*) or roughness and smoothness indicate the condition of the surface of the object to the sense-organ of touch.

1. *Bhag. Sūt.* 6/5/70-106.

2. *Kṛṣṇarāyī* could also be *kṛṣṇarāśi* which means mass of blackness.

In science, the relative hardness of material objects is determined empirically by scratching. Thus, steel is harder than copper, and diamond is harder than steel.

Smoothness/roughness of the surface of the body fundamentally depends upon the arrangement of the crystals in the surface.

Chatuḥsparśī aggregates are devoid of this pair like mass.

(iii) SMELL AND TASTE

By virtue of their inherent quality of smell, material objects can be perceived by the olfactory organs. There are infinite varieties of smell but they are broadly divided into two categories (i) pleasant and (ii) unpleasant. The scientific view of smell is that there are volatile components in the composition of material objects, which stimulate the olfactory organs of living beings. Like colour, smell can be split and analysed by gas chromatographic and mass spectroscopic methods. For instance, roasted coffee is found to contain as many as 100 or more volatiles which together give the characteristic pleasant aroma of coffee.

Unlike smell, taste is not given 'out' by *pudgala*. The object itself has to come in intimate contact with the sense-organs of taste. As in the case of other qualities, there are infinite varieties of taste which can be grouped together to form five categories. The taste of any object is the resultant of all different taste possessed by its composing elements.

C. SOME OTHER IMPORTANT QUALITIES

We had discussed the Jain view about some other important qualities of physical substance (*pudgala*). We shall compare them here with the corresponding scientific concepts.

That, mass/matter is nothing but a form of energy, that is, both matter and energy are but two modifications of a single principle, has been only recently realized. Jain physics has identified all forms of matter and energy as modifications of the same substance – *pudgala*. Intra-*convertibility* of various forms of energy – mechanical into electrical, electrical into heat, light,

sound etc.,—which is the basis of modern technology, has been recognized by Jain philosophers as the basic attritutes of *pudgala*, since all forms of energy are fundamentally the modifications of the same substance.

1. SOUND

Both the Jain and scientific views agree on the basic concept that sound is in the forms of waves generated by vibrations as an attribute of physical substance, unlike some other Indian Schools of thought, (e.g. Vaiśeṣika) which consider sound as a property of *ākāśa* (space).

If sound were generated by *ākāśa* or space (as is supposed by the Vaiśeṣika school), sound would be still heard in vacuum. But sound waves do not travel in vacuum. In modern acoustics the sound is classified into (a) musical and (b) noises. This also agrees with the Jain view expressed earlier.

2. LIGHT AND DARKNESS

There is remarkable agreement between the views of the Jains and modern physics regarding the fundamentally material character of light. Photoelectric effect of light proves that light is a stream of photons which are essentially particles. On the other hand, the wave-character of light has been proved by the splitting of white light into beautiful colours of rainbow and many other experiments/phenomena. The paradox of wave-particle duality,which was one of the thorniest problems of modern physics forced physicists into radically new ways of perceiving the entire physical reality, and the new perceptual frames[1] were found to be more compatible with experience than were the old. In fact, the duality was the end of the absolute classical view of the physical reality. The physicists had to abandon the 'Either-Or' way of looking at the Reality. They could no longer accept the proposition that light/energy/matter is *either* a particle *or* a wave, because they had convinced themselves that it was both, depending upon how they looked at it. Niels Bohr's concept of

1. These follow the unique principle of non-absolutism—*Anekāntavāda* of

complementarity[1] is the best explanation of the dual character of light (and no one has thought of a better one yet) by emphasizing the complementary nature of both aspects—both of them are essential to understand the nature of light. But one of them always excludes the other, because light or anything else cannot be both—wave-like and particle-like—in the same context. It is meaningless to ask which one of them, alone, is the way light really is. It behaves like waves or particles depending upon which experiment we perform. And this, precisely, is the Jain position as we have seen earlier.

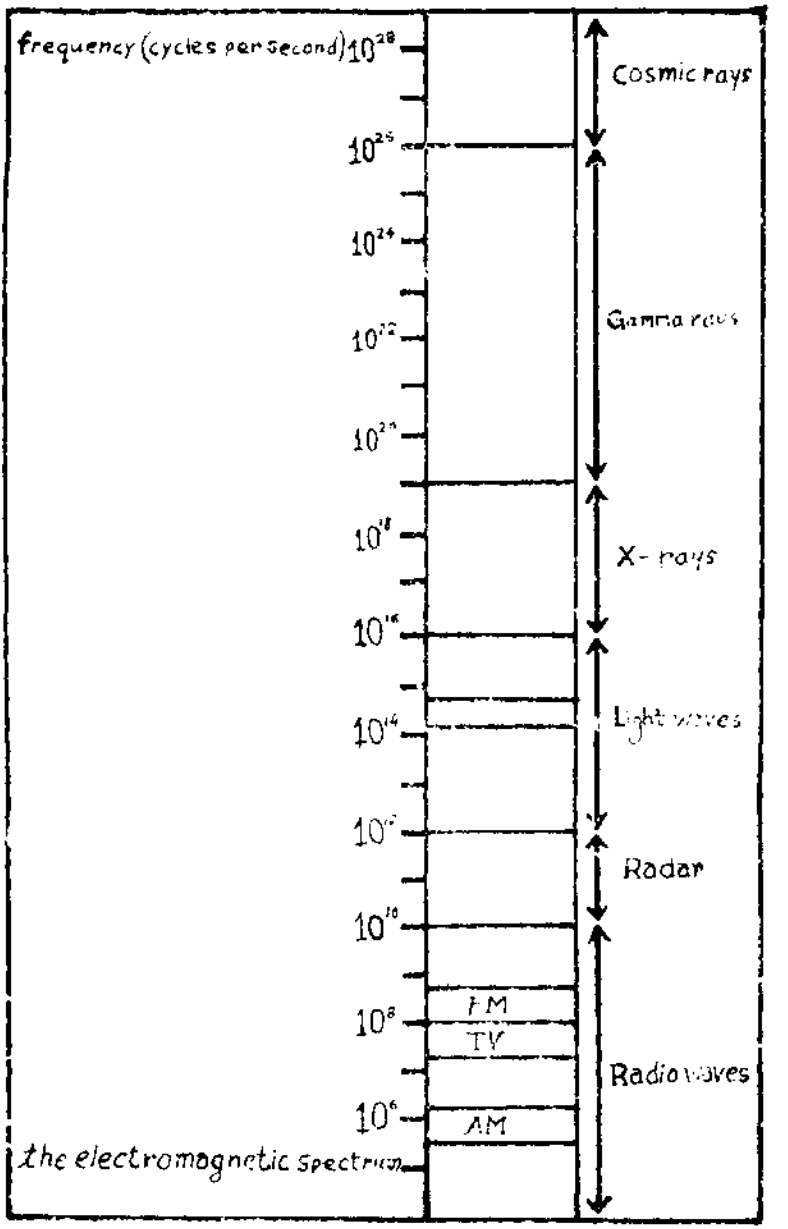
Neither the wave-like nor the particle-like behaviour is the quality (*guṇa*) of light, but both are its modes (*paryāya*), just as sound is not a quality of *pudgala*, as 'colour' is, but its modification. Each aspect is produced by the interaction of light to manifest either particle-like or wave-like characteristics or both as in the famous Arthur Compton's 'Scattering of X-rays" in 1923. It should be noted that by denying the dual aspects to be qualities, we are not denying the objective reality of light. Both qualities and modes are real and are determinate ways of manifesting a real substance, which in this case, is *pudgala*.

DARKNESS

While light is universally accepted as the cause of visibility and a form of material energy, darkness is regarded by some as mere absence of light and not as a separate entity (modification of matter). In Jain view, *tamaḥ* or darkness, which is the antithesis of light and the cause of reduced visibility, is regarded as an entity

1. The Copenhagen Interpretation (CI) of Quantum Mechanics was the first consistent formulation of quantum physics and marks the emergence of the new physics as a consistent way of viewing the physical reality. It was arrived at the 5th Solvey Congress in 1927, at which Bohr and Einstein conducted their now famous debates. The term 'Copenhagen' reflects the dominant influence of Bohr (From Copenhagen) and his school of thought.

   Bohr's principle of complementarity is an essential feature of CI of quantum physics. Some physicists practically equate CI and complementarity. It is subsumed in a general way in Stapp's pragmatic interpretation of quantum physics, but the special emphasis on complementarity is characteristic of CI. The CI. is considered to be the beginning of the reunion of the Cartesian division. It says that quantum theory is about correlations in our experiences. It is about what will be observed under specified conditions.



the electromagnetic spectrum

separate from light. This view is fully supported by modern science. Light according to science, is a small portion of a large spectrum of electromagnetic radiations. Radiations with wave-lengths smaller or larger than visible spectrum are not perceivable by our sense organ of sight and are, therefore, invisible or dark to us. For instance, infra-red radiations, (or x-rays) can be 'perceived' by the eyes of special photographic plates and make photography possible even in the pitch darkness. Thus, darkness has a separate existence and both science and Jain views agree on this point.

Division of light into hot effulgence (*ātapa*) and cold effulgence (*udyota*) is also more scientific than arbitrary. When heat is predominant in a radiation, it will be 'hot' and when a radiation is accompanied with little or no heat, it will be 'cold'. The terms *ātapa* and *udyota* appropriately denote the nature of light. Radiations called *prabhā* are emitted by certain types of jewels. They cause visibility and are, therefore, special forms of light.

The term '*chāyā*' stands for two phenomena of light : image and shadow. When light is obstructed by an opaque object, it throws a 'shadow', but reflection of light by a mirror produces an 'image'.[1]

INTEGRATION (BANDHA) AND DISINTEGRATION (BHEDA)

The quest for 'basic building blocks' of the physical reality is fundamentally the result of (*bandha*) and (*bheda*) which are the modes of *pudgala*. 'Being' and 'becoming' characterized equally the first epoch of Greek philosophy as well as the modern science. The entire discussion under 'particle physics' in the first chapter emphasizes the above modes and underlines a number of parallels between the Jain view and the modern science. The high-energy scattering experiments of the recent years have shown us the dynamic and ever-changing nature of the physical reality in the most striking way. They have proved the complete mutability of matter. All particles can be transmuted into other particles : they can be created from energy and can vanish into energy. Thus, the

1. Cf. Paṇṇavaṇā, pada XV : "A person perceives not his body nor the mirror but the image in the mirror."

entire physical reality is a dynamic world of integrating and disintegrating patterns of matter, revealing the intrinsically dynamic character of matter as propounded by the Jain seers. These aspects of *pudgala* show that the different attributes of *pudgala* can be understood only in terms of its activity and modification — that is its interaction with itself and other substances.

Both integration and disintegration are of two kinds : (i) natural (ii) poduced by animate organisms and they have been discussed in the preceding chapters. All the natural elements found on earth are the result of natural integration of subatomic particles but none of them is without a beginning. Space and ethers are the only instances of natural and beginningless integration. All integrated physical objects found anywhere in the universe have a beginning. The ultimate atom (*paramāṇu*) is the only physical reality that is eternal and has no beginning, but it is singularity not an integrated identity.

Two kinds of touch—glueyness (*snigdha*) and dryness (*rūkṣa*) are important characteristics of integrating constituents. These are, to some extent, equivalent to the positive and negative charges of subatomic particles. Precise rules for integration vis-a-vis these two kinds of touch have been discovered and formulated by Jains and we shall discuss them in a subsequent section.

SECTION III

GENERAL PROPERTIES OF PUDGALA

Paryāya, Pariṇāma, Kriyā, Bheda (Fission) and *Bandha* (Fusion)—the above terms are used by Jains to show various aspects of the dynamic nature of matter. They are meant to indicate that various kinds of energies inhere and are potentially available in the different states of matter and each change of state is accompanied with release or transformation of energy.

Pudgalāstikāya, assert the Jains, is an energetic and active substance. Various kinds of multifarious activities are attributed to it. First of all, there is the *artha-paryāya* which is the change of state due to its own basic transitory element. This type of modification is incessant and continuous and affects the structure of the substance itself. Secondly, there is the *vyañjana-paryāya* which is intermittent and may be the result of interaction between the two substances. This type of modification may affect the substance or the inherent qualities of the substance. Thirdly, we have *pariṇāma* which means mutation or transformation i.e. change of qualities like *saṁsthāna* (shape) etc. Then we have different types of motions—simple and complex oscillation, vibration, rotation, revolution and migration, collectively called *kriyā* which describes the dynamic nature of the substance. And finally, we have *bheda* i.e. splitting or fission and *bandha* i.e. union or fusion.

PARYĀYA

The quantum view that all particles possess potentially different combinations of other particles parallels the Jain view that *pudgala* undergoes incessant modification called *paryāya.*

Now, according to the atomic theory of modern science, atoms of all elements are composed of two parts: (1) the nucleus which is normally static (with reference to the atom itself) and (2) electrons which are normally revolving around the nucleus. The relative motion of electrons is incessant and continuous irrespective of the state of the element being solid, liquid or

gaseous. It is an inherent characteristic of the structure of all atoms. This, then, is an instance of *artha-paryāya.*

Two or more atoms of one element combine together to form molecules, and molecules of different elements combine together to form simple and familiar (e.g. water H_2O. and common salt NaCl) or complex and rare (e.g. phenylpiriliumchloride) compounds i.e. composite bodies. But each compound has its own specific chemical and physical properties under certain conditions of temperature, pressure, etc Within the body, the molecules themselves are in state of agitation. This motion of molecules of any material substance is known as *heat motion* or *thermal motion,* for the simple reason that it is responsible for the phenomenon of heat. For, it is molecular motion that produces a certain irritation in the nervous fibres of our sense of touch and produces the sensation that we call heat. This, thermal motion exists in solid, liquid and gaseous states of matter because the amount of energy in every molecule is the same for all substance at a given temperature and the only difference is that while in some cases the molecules are able to move around, in other cases they can only vibrate in fixed position. This thermal motion appears to be an instance of *vyañjana-paryāya.*

The subatomic particles are dynamic patterns which exist as integral parts of an inseparable network of interactions. These interactions involve a dynamic interplay in which particles are created and destroyed without end in continual variations of energy patterns. If two electrons come close to each other, it is possible that a photon that is emitted from one will be absorbed by the other. The process is two-way with both electron absorbing photons that were emitted by the other. The repulsive force between them is simply the cumulative effect of these exchanges of photons, the number of which increases at close range and decreases at a distance. Every subatomic interaction consists of the annihilation of the original particles and the creation of new subatomic particles. In other words, the subatomic world is a continual activity of creation and annihilation.

Subatomic particles do not just sit around being subatomic particles. There is incessant change of state due to its own basic transitory nature. An electron, for example, constantly emits and absorbs photons. In other words, first there is an electron, then

there is an electron and a photon, and then there is an electron again. The interaction lasts only for about one thousand trillionth (10^{-15}) of a second. The reason that this can happen is the famous Heisenberg's Uncertainly Principle, in which there is also a reciprocal uncertainty of time and energy.

Similarly, protons also interact with themselves. First there is a proton, then there is a proton and a pion,then there is a proton again.

This is the simplest example of self-interaction. Eleven particles make their transient appearance between the time the original proton transforms into a neutron and a pion and the time it becomes a single proton again in the flicker of time permitted by the 'Uncertainty Principle'. All interactions and self- interactions of subatomic particles are instances of *artha-prayāya* and six-fold decrease and increase (*saṭ-guṇa-hāni-vṛddhi*) resulting from the *agurulaghu guṇa* of *pudgala*.

PARIṆĀMA

Physical properties like extension (volume), mass, density, etc., can be changed by change in temperature and/or pressure. For instance water is solid (in the form of ice) at temperature O°C or below. When heated, it becomes liquid and its volume slightly increases. At 100°C, it boils and changes into steam which has very much larger volume. Similary air (or oxygen) which is gaseous at normal temperature and pressure can be liquified under very high pressures. The thermal motion in a solid body is quivering or[1] vibration of molecules. If the body is heated, the quivering becomes stronger and at the melting point the molecules leave their places and begin to move. At still higher temperatures, they fly apart in all directions and the result is gaseous state of matter.[2] But the

1. Temperature of liquid air is 63° absolute or 210° C below zero.

2. If the temperature is raised still farther, thermal dissociation takes place and the molecules are boken up into separate atoms. For instance, molecules of water will be broken up at a temperature over a thousand degress. But when the temperature rises to several thousand degrees, the matter will be a gaseous mixture of pure elements. At still higher temperatures, thermal ionization takes place when outer electrons are chipped off from the atoms. At a few million degrees (temperature common in the interiors of stars) all electronic shells are completely stripped off and matter becomes a mixture of bare nuclei and free electrons. If the temperature goes up to several billion degrees the nuclei themselves break up into protons and neutronss. Thus the effect of thermal agitation is to destroy step by step the elaborate architecture of matter into particles rushing around without any apparent law.

2. Parispandana-laksana kriya—Pravacanasara Pradipika Vrtti, 2-37.

change is in the physical properties only. Ice, water and steam are all chemically the same compound H_2O and molecules retain their molecular identities. The modification of physical properties and the consequent transformation of one kind of energy into another is perhaps a typical instance of *pariṇāma.*

KRIYĀ : MATTER IS ENERGY

Kriyā is characterised by motion[1]. Oscillation and vibrations are inherent attributes of matter and that is why *pudgala* is dynamic. Actually all types of motion come under *kriyā*, but motion is only one type of *kriyā.* Fission and fusion are also *kriyā.* In fact, tranformation of energy of any kinds is *kriyā* and thus *kriyāvān* means capable of exerting forces and producing energy.

Because matter is inherently active. Galileo, Newton and Einstein were able to describe and explain many mysteries of the universe by formulating laws of mechanics. Motion of matter evolved a mechanical universe of forces, pressures, tensions, oscillations, and waves. Two fundamental forces exerted by matter are gravitation and electromagnetism. Save for gravitation, nearly all other forces in the material universe – frictional forces, chemical forces which hold atoms together in molecules, cohesive forces which bind particles of matter, elastic forces which cause bodies to maintain their shape are of electromagnetic origin, for all these involve the interplay of matter which is composed of electrical particles.

To describe the mechanics of dynamic, material universe, three parameters are necessary – distance in space, time and mass.[1] In classical physics the mass of any body is fixed and unchanging property. But Einstein established the relativity of mass, asserting that the mass of a moving body increases with its velocity according to the following equation :

when m_0 is the mass of a body at rest,

m is its mass when moving,

v is the velocity of the body,

and c is the velocity of light,

1. Parispandana-lakṣaṇa kriyā – Pravacanasāra Pradīpikā Vṛtti, 2-37.
2. Mass is not heaviness or weight but denotes a fundamental property of matter, namely resistance to a change of motion.

$$m = \frac{m_o}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

It can be readily seen that if v is small, the difference between m_o and m is practically zero. But when v approaches the value of c, then the increase of mass becomes very great, reaching infinity, when the velocity of the moving body reaches the velocity of light.

By further deduction of this principle of relativity of mass, Einstein concluded that energy has mass and disclosed a fundamental truth about physical reality viz., matter and energy are not different elements as pictured by prerelativity scientists – the former inert, tangible and characterised by a property called mass and the latter active, invisible and without mass. He established that mass is simply concentrated energy. In other words, matter is energy and energy is matter. He expresses the interchangeability of matter and energy by the most famous equation in history: $E=mc^2$. The mass/energy dualism of our ordinary conceptualizaion does not exist in the formalism of relativity or quantum theory. Einstein's equation $E=mc^2$ means that mass is energy and energy is mass. Therefore, strictly speaking, mass is not a particular form of energy. Every form of energy is mass. Mass does not change into energy or vice versa. Wherever energy, E is present, mass m is present also and the amount of mass m is given by $E=mc^2$. The total amount of energy, E, is conserved and hence, the total amount of mass, m, is also conserved. This mass, m, is defined by the fact that it is a source of the gravitational field. It explains how radioactive substances are able to eject particles at enormous velocities for millions of years. It reveals the magnitude of energy that slumbers in the nuclei of atoms. Translated in concrete values, it shows that one kg. of coal, if converted entirely into energy, would yield 25 billion kilowatt-hours of electrical energy. Inter-changeability of matter and energy explains the dual role of the electron as a unit of matter and a unit of electricity and the baffling interplay of matter and radiation, waves and particles becomes more understandable.

The inter-changeability of matter and energy estabished by modern science is analogous with the Jain concepts of *paryāya, pariṇāma, kriyā* etc., being inherent attributes of *pudgalāstikāya.* The energy of electomagnetic radiations and the particles ejected from radioactive substances are but two different *paryāyas* of the same attribute viz., *kriyā*vatva. We shall have occasion to examine this point again while dealing with the nature of paramāṇu a little later.

Finally, we come to the processes of *Bandha* (fusion) and *Bheda* (fission) which are the basis for the nomenclature of matter viz., *pudgala.* These processes are, according to Jain views (as we have seen)[1] inherent properties of the material universe. *Paramāṇu,* being indivisible, is, of course, not fissionable but all other categories of matter undergo both these processes.

Modern science, also, (as we have seen)[2] accepts that fission and fusion are essential whenever energy is released, whether it is the chemical energy from coal or the atomic energy from nuclei of uranium or deuterium. Again, the process of spontaneous decay of the atoms, consisting of emission of alpha particles is not restricted to the so-called radio-active elements ; all elements heavier than silver (which, as we know, occupies the central position in the atomic table) are subject to the process of decay but the process is very very slow. Release of enormous atomic energy through the fission process of uranium nuclei and fusion process of the (heavy) hydrogen nuclei is already described in the previous chapter.

1. Chapter II, pp..
2. Chaper I, pp.

SECTION IV

CLASSIFICATION

We have already said that according to Jains, material objects are composed of elementary particles called *paramāṇus*. There are infinite types of matter and because they are capable of infinte mutations, the entire material universe is infinitely infinite. The fundamental reason for the infinite variety is the infinite multiplicity of the four innate qualites, colour etc., of matter and the difference in the number of *paramāṇus*.

According to the modern science also, there are infinite varieties of organic and inorganic compounds constituted by various combinations of about 100 different kinds of chemical elements. The atoms of the elements are different from one another because of the difference in the number of their constituting elementary particles viz., protons and neutrons in the nucleus of the atom and the electrons orbiting round.

The infinite variety, however, can be grouped together from various aspects to form a few classes or divided into two or three types e.g.,

By Science

(i) Inorganic	(ii) Organic
(i) Solids	(ii) Fluids
(i) Elements	(ii) Compounds
(i) Atoms	(ii) Molecules

By Jains

(i) *Viśrasā-pariṇata*	(ii) *Prayoga-pariṇata*
(i) *Bādara (gross)*	(ii) *Sūkṣma (fine)*
(i) *Paramāṇus*	(ii) *Skandha*

By Science

(i) Solids	(ii) Liquids	(iii) Gases

By Jains

(i) *Paramāṇu* (ii) *Pradeśa* (iii) *Skandha*

Classification of matter by Jains into 23 groups called *vargaṇās* in general and the matter belonging to 8 groups which interact with and serve useful purposes for the living beings, in particular, merits requires further examination.

Five out of the eight groups viz., (1) *Audārika* (2) *Vaikriya* (3) *Āhārka* (4) *Tāījas* and (5) *Kārmaṇa* groups go to make five different kinds of gross and subtle bodies (*śarīra*) for the living being. The first two kinds are gross and the remaining three are subtle ones.

Material of the *audārika* group is composed of all the organic and inorganic objects that we encounter in our ordinary life. All the necessities of our daily life, food, clothing and shelter are made up from the stuff belonging to this group. Our own bodies and the bodies of all animals and plants, in fact, of all living organisms known to us, organs as brain, heart and stomach, tissues of skin, muscles etc., and the biological atoms called cells are all made up from the *audārika* group. When the life becomes extinct, the lifeless body that is left behind is *audārika śarīra*. It either becomes food for some living beings or else rots, putrefies and decomposes into its constituents.

Bodies of celestial and infernal beings are made up from '*vaikriya*' group. The traditional Jain term for the word 'celestial' beings is *devas* or heavenly people. According to the Jain belief, sun, moon, stars etc., are one of the four categories of *devas* viz., *jyotiṣka deva* meaning light-radiating or luminous *deva*. The life-spans of *devas*, though very very long compared to human beings are nevertheless finite and at the end of the life-span, the soul of *deva* leaves his lifeless *vaikriya* body behind. It is, however, believed that the stuff making up the *vaikriya* body does not rot or putrefy like the *audārika* body but disintegrates rapidly into its components. A *vaikriya* body does not cast a shadow.

Science also considers sun, moon, planets and stars celestial or heavenly bodies. Sun is nothing else but a star, planets are

members of the solar family and revolve round it in definite orbits and moons are satellites of the planets. So the most important heavenly bodies are stars. And they are no longer pin points of inscrutable light but objects of the individual personalities. Stars are 'born' and they 'die'. Their life-span is of the order of 50,000 to 1,00,000 million years. Our sun, for example, was born some 5,000 million years ago and quickly came to age assuming the characteristics it has today. For another 5,000 million years, it will continue to be in the prime of life. After that it will expand and burn away fiercely for 2,000 million years and begin to shrink and decline to a long old age. After 50,000 million years it will have turned black and heatless i.e. dead. The bodies of the stars are made up of primordial gas and dust, more than half of which is hydrogen which is transformed into helium by nuclear fusion. The process of nuclear fusion converts matter into energy which is radiated. The amount of hydrogen steadily decreases while that of helium increases. When the entire stock of hydrogen is used up, there is nothing to burn. The star becomes black and heatless and dies. Thus the life-span of this celestial object starts from a cloudy birth and ends into frozen extinction. Thus, if the star is a *jyotiṣka deva*,[1] then the stellar dust is the stuff belonging to the *vaikriya* group.

Āhāraka śarīra is not a common body. It is very occasionally created by learned sages only. *Taijas śarīra* and *kārmaṇa śarīra* are the supersubtle bodies assimilated by every soul from the stuff of the appropriate group. They are permanent companions of the soul, and are abolished only if and when the soul is emancipated. *Taijas śarīra* is the link between the soul and the kārmaṇa *śarīra*. It is the source of energy required by the vital processes of all living organisms. As its name suggests, *taijas* stuff is probably electrical (or electromagnetical), and the electrical characteristic manifested by the bodies of living organisms are caused by the *taijas śarīra*.

We have briefly described the functions of *kārmaṇa śarīra* in the previous chapter and we can hardly add anything more here

1. This statement should not be construed as a belief of the Jains nor that of the author. It is merely a conjecture emanating from circumstantial similarities.

because it is extremely difficult to compare these groups with anything discovered by the modern science.

The stuff belonging to *ānāpāna vargaṇā* is used by all living beings for the process of respiration. Breathing is an essential activity for sustained life. All living beings from *ekendriya* to *pañcendriya*, i.e., those having a single sense-organ of touch to those possessing all the five sense-organs, have to breathe to remain alive.

According to the scientific view also, terresterial and acquatic animals, insects, and plants have to breathe. Of course the respiratory system of fish is different from that of, say, a dog. Plants and insects have again quite different types of systems. But whatever be the system, the stuff that is used in breathing is the element oxygen. Some take it from the air and some take it from the water. Is oxygen, then, the stuff belonging to *ānāpāna vargaṇā* of the Jains?

The stuff belonging to *bhāṣā vargaṇā* is used by those who are able to speak. According to the Jains, *ekendriya jīvas* or *sthāvaras* are unable to do so but others have the ability to give voice to their feelings. Though not essential for sustaining life, this activity is essential for a purposeful life and to this extent the material in this group is useful for the psychic order of existence.

According to the scientific view, the apparatus for producing speech-sounds consists of vocal cords, pharynx (wind-pipe), larynx (voice-box), etc. Only those few who are quite high up on the ladder of evolution possess these organs. Lower animals can only produce inarticulate sounds from their throats and some others can produce sound not from the throat but by rubbing together other parts of the body. Vibration is an essential condition for producing sound waves. Whether a specific class of matter is necessary for producing voice is not known.

We now come to the mental activities. The process of thinking and other mental processes, according to the Jains, requires *dravya manaḥ* and *bhāva manaḥ*. *Bhāva manaḥ* (psychical mind) is the innate capacity of rational thinking possesed by *samjñin* (developed) souls, while *dravya manaḥ* (physical mind) is the

instrument of thinking which the soul makes for itself out of the material beloging to the *manaḥ vargaṇā* which is fit for this purpose. Only the *samjñin pañcendriya* categories of *jīva* have the ability of forming physical mind. But the Jains assert that for the process of rational thinking, physical mind is as essential as the psychical. The stuff covered by this group (*manaḥ* vargaṇā) is very compact. Composite bodies of this group are chatuḥsparśī and not *aṣṭasparśī*, that is, they are *agurulaghu* i.e. devoid of mass.

The branch of science that deals with mental phenomena and their classification and analysis is called psychololgy. It seeks to give an account of the way in which the mind works. Unlike other sciences (e.g. chemistry), it is concerned more with theories than with facts and still belongs very largely to the province of speculations. Though it has, in some respects, attained definite knowledge, it has to emerge from the phase of speculation with regard to a majority of questions, it studies.

The fundamental and controversial question of psychology is : Is there really a mind[1] to study i.e. is there something of an entirely different nature from the body? Can we not explain the facts of psychology without introducing 'mind'? The intimate relationship and interaction between mind and body is a fact without dispute. What is disputable is the adoption of the mental hypothesis which involves the existence of 'mind' i.e., something which is not of the same order of being as the body. We have thus two alternatives : (i) mind as an aspect of body and (ii) mind as distinct from body.

(i) In the first case, the mind consists entirely of physiological instrument such as the sensory nervous systems or receptor nerves which receive the stimuli from outside, the transference machinery to pass on the stimuli to brain, the brain itself and the motor system or effector nerves which govern the movements of the body.

In this case, the emotions are perceptions of a physiological change in ourselves. For example, when we feel the emotion of

1. The word 'mind' does not mean the same as the word 'brain' which is a part of the body and is uncontroversially material.

fear, the adrenal glands discharge a certain amount of fluid secretion, which produces changes in the tension of the muscle and in the blood, resulting in increased rapidity of the heart-beat etc. The awareness of these bodily occurrences constitute the emotion of fear.

In the absence of an independent mental instrument, the process of thinking is explained as simply subvocal talking, involving as it does the same muscular activities of the larynx as those which occur in talking although these activities are not carried so far.

(ii) In the other alternative viz. mind as distinct from body, a unique, distinct and in some sense independent status of mind is contended. For contending an independent status of mind, it is not necessary to refute the existence and working of the physiological systems described in the preceding paras. All that is necessary is to insist that a living organism is something over and above the physiological apparatus of its body, that mind is an expression of the principle of life and it is distinct from the body and brain. Mind, in this case, must be something which is immaterial. Wishes, desires, thoughts, aspirations, hopes, acts of will and all such other events which happen in mind are, therefore, immaterial. Thoughts, for instance, do not exert force nor do they yield to mass ; conversely, mass and material force have no power over thoughts.

From the above, it is not difficult to conclude that, in addition to the body and brain, the composition of the living organism includes an immaterial element which is called mind, that this element, although in very close association with the brain, is in some sense independent of it. Mind so conceived is an active, dynamic, synthesizing force. It is creative, that is, it carries on activities which are due to the presence of a living creative impulse to fulfil a purpose.

We shall now compare both the above scientific theories of mind with the Jain views regarding *manaḥ* or *manas*. The materialist theories of psychology which deny the existence of

mind as distinct from body, also deny the very existence of consciousness and soul as an independent entity. This is entirely in opposition to the Jain views. We have already discussed the materialists' concept in the metaphysical section earlier and we shall only add here a doubt which may be raised by the Jains regarding the materialist theory of emotions stated above. While accepting the invariable accompaniment of the bodily event and the mental event, a question at issue will be : Does the fear emotion precede and cause the gland excretion or does the gland excretion precede and cause the fear emotion?

The concept of an independent psyche or immaterial mind of the mental hypothesis by the other psychological theories is obviously equivalent to the concept of *bhāva manaḥ* of the Jains. *Bhāva manaḥ* as we have stated above, is the innate capacity of *jīva* and is, therefore, immaterial. But, for the rational mental activities, *dravya manaḥ* which is the material counterpart of *bhāva manaḥ* is also essential. We have also seen that only highly developed or *samjñin pañcendriya*-animals and human beings are capable of forming *dravya manaḥ* out of the material atoms of *manaḥ vargaṇā* and, therefore, capable of rational mental activities. Thus, the mental hypothesis to some extent agrees with the Jain view.

INTELLECT (BUDDHI)

It will not be out of place to mention here (very briefly of course) an interesting feature of the Jain epistemology viz., four *buddhis* or intellects. Intellect is a variety of *matijñāna* i.e. perceptual cognition. There are four categories of matijñāna viz., knowledge (i) exclusively due to the sense-organs (ii) exclusively due to the mind (iii) due to the joint activity of the senses and the mind and (iv) knowledge independent of both mind and sense-organs viz., instinctive intuition. According to the Jain epistemology, all cognitions are nothing but different states of soul and as such are only cases of emergence and not origination proper, the senses and the mind being auxiliary conditions or instruments only. Instinctive intuitions of the plant kingdom as well as the underdeveloped animal organisms fall under category

(iv). Memory, recognition and discursive thoughts are cases of *matijñāna* under (ii) and (iii). Sensuous cognition of the *fivefold* sense-data – touch, taste, etc., are instances of (i).

Buddhi or intellect falls under category (ii) inasmuch as, it is a purely mental perception. It is a special gift of nature and independent of the previous education of the perceivers. Fourfold intellects are:

(1) *Autpātikī buddhi* means immediate comprehension. It is defined as the intellect which comprehends the true nature of a previously unknown complicated problem and successfully solves it. It is by a flash of genius that the solution of a difficult and strange problem dawns upon the mind.

(2) *Vainayikī buddhi* means intellect born of humility and service. It is defined as the intellect which is capable of completing a difficult task and is born of humility and faithful service (and not learning).

(3) *Kārmikī or Karmajā buddhi* means intellect acquired by practice. It is defined as intellect which comprehends the truth due to breadth of vision of both the practical and the theoretical sides of actions. Such an intellect is the result of extraordinary development of talent through practical experience rather than theoretical learning e.g. valuation of diamonds and other precious stones.

(4) *Pāriṇāmikī buddhi* means mature intellect. It is defined as the intellect which attains its goal through reasoning, deduction, inference and analogy, developed with the maturity of age.

It can be easily seen that all these intellects are founded on mental faculties. Could flash of genius, humility, reasoning, etc., be constituted and produced by physiological changes alone?

Let us return to the material stuff called *manaḥ vargaṇā* which is fit for the purpose of forming *dravya manaḥ*. Admittedly none of the current theories of psychology conceive the necessity of fine material particles (or are they radiations of extremely short

wave-length?) for the process of thinking and other mental activities.

Many scientists, however, see drastic changes on the horizon. There would have to be some revolutionary paradigm[1] to explain telepathy, psychokinesis and precognition. At-least one serious physicist, Gerald Finberg of Columbia University, thinks that psychic transmissions may one day be linked to yet undiscovered elementary particles which may be called mindons or psychons[2]. If modern scientific instruments became really successful in detecting such particles, they could be equivalent to the group of matter called *manaḥ vargaṇā* by Jains. But since, such matter is devoid of mass, it is extremely unlikely to be found in its original form.

1. Paradigm is the word used by Thomas Kuhn for the model of scientific advancement after each major conceptual shift.
2. Time (Weekly).

SECTION V

ATOMIC THEORY AND PARAMĀṆUVĀDA

HISTORICAL DEVELOPMENT OF ATOMIC THEORY

In the West, Greek philosophy and science were together at the beginning of the 6th century B.C. with the first Milesian philosopher Thales. As we have seen, the idea of the smallest indivisible ultimate building blocks of matter came in connection with the elaboration of the concepts of being and becoming which characterised the first epoch of Greek philosophy. But atomic theory of matter was propounded much later by Democritus about 420 B.C. The Jain doctrine of *paramāṇu* is undoubtedly much more ancient than the Greek atomists. Bhagawān Pārśvanāth (B.C.877- 777) and Bhagavān Mahāvīra (B.C. 599-527) propounded the *paramāṇu* as the ultimate indivisible origin of matter and the Jain canons *Viāhapaṇṇattī* (*Bhagavatī Sūtra*) and *Ṭhāṇaṇga Sūtra* contain elaborate and detailed discussions on the nature, structure and behaviour of matter in general and *paramāṇu* in particular.

PARAMĀṆU IN JAIN PHYSICS

The limiting unit of the process of the division of aggregates is the '*paramāṇu*' or the ultimate atom.

Since it cannot be further sub-divided, it is called *paramāṇu* (*parama+aṇu*).

Since it occupies a single point of space, it is 'unit'.

Since it is the permanent and inalienable substratum of corporeal bodies; it is eternal.

Since it is the constitutive basis of physical objects, it is the generator of the entire physical universe.

Since it cannot by itself generate sound vibrations, it is non-sounding or silent. These are some of the characteristies of the ultimate atom[1].

1. Pañcā, Sār. verse 77.

The ultimate atom is not of four kinds, as some people would have, such as earth, air, fire, and water, but it is the constitutive basis of these four *mahābhūtas* or *dhātus*, which are different modes of physical existence. The atom has its own essential nature which is quite distinct from that of these four *mahābhūtas*.

The very name *paramāṇu* (*parama+aṇu*) implies the atomic structure and the division of *pudgala* (physical objects) which is characterized by the sense-qualities of touch, taste, smell and the colour, all the four being concomitant. *Paramāṇu* is the beginning, the middle and the end in one. From the general principle that substance and its quality are inseparable, it follows that the space-point (*pradeśa*) occupied by the *paramāṇu* is also the space-point accommodating its sensory qualities. And hence, on the basis of our discussion in the fifth section of the second chapter regarding the indivisible units of *pudgala*, space, etc. it can be emphasized that the *paramāṇu* is the direct unit of *pudgala* and the indirect unit of space, time, and quality. The quantitative difference in these things and also the qualitative difference in various physical objects may ultimately be traced to the constitutive, that is, *paramāṇu*.

SCIENTIFIC VERSION

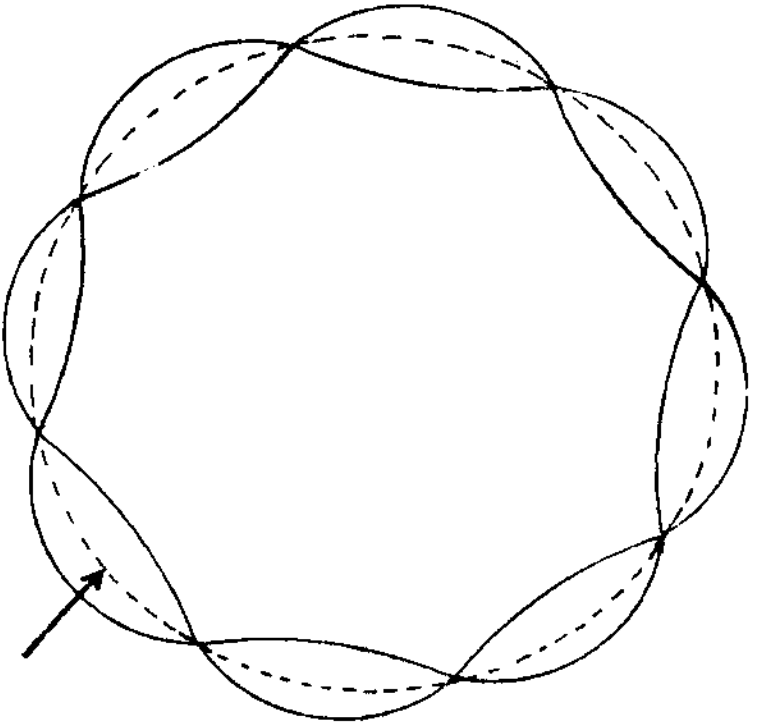
STRUCTURE OF MATTER—SUBATOMIC PARTICLES—QUARKS

Atoms of Democritus were all of the same substance but had different sizes and shapes. They were eternally unchanging (Parmenidian), impenetrable and indivisible. Atoms themselves had neither colour nor smell nor taste, the sensuousness of the material objects being produced by the motion and arrangement of atoms in space. "Sweet and bitter, cold and warm as well as all the colours, all these things exist but in opinion and not in reality, what really exists are unchangeable particles, atoms and their motions in empty space" wrote Democritus.

We now know that the object which were referred to as 'atoms' historically and later during the revival of science in seventeenth century, are not indivisible units of matter. According

to the modern science, the atom of a chemical element is rather a complicated system of smaller units such as protons, neutrons, electrons, etc. which are now called subatomic particles. The number of such subatomic particles has now crossed the figure 200.

It has been established beyond doubt that atoms of various chemical elements are very much similar to our solar system, with a number of negatively charged particles (electrons) rotating round the central nucleus in the form of standing waves,[1] which itself



is composed of a number of positively charged particles (protons) and electrically neutral particles (neutrons). Protons and neutrons are much heavier than electrons so that the necleus contain 99.97% of the total atomic mass. The number of protons, neutrons, electrons are different in different elements but the atom on the whole is electrically neutral because the total change of all

1. See Chapter I, pp.1

negatively charged particles equals the total positive charge. The simplest and lightest atom is that of hydrogen. It is composed of a single proton as the nucleus and a single electron orbitting round it. Its diameter is 10^{-8} centimeter and mass 1.64×10^{-23} grammes. The distance between the nucleus and the rotating electron is such that the atomic diameter is 1,00,000 times greater than the diameter of the nucleus. In the atom of uranium, which is the heaviest natural element, there are as many as 92 protons and 146 neutrons in the nucleus and 92 electrons rotate round it in different orbits.

Later on, theoretical physicists branched into two schools. One of them continued their search for the elementary building blocks, as they were not satisfied that subatomic particles such as protons, neutrons, etc. were indivisible, while the other one abandoned their search. Although no one has so far found the particles which composed the protons, theoretically it has been established that the protons are composed of 'quarks'. The hunt for quarks is going on. But, whether they do actually exist or not, one thing is already certain, viz., a new area of research 'what are quarks made of' has emerged.

PARAMAṆU : INDIVISIBLE UNIT OF *PUDGALA*

Two types of *Paramāṇu*

In *Anuyogadvāra Sūtra*,[1] two types of *paramāṇu* are postulated :

(i) *Sūkṣma* (transcendental/absolute)

(ii) *Vyāvahārika* (empirical).

The *sūkṣma paramāṇu* has been described above in section V of chapter II (pp. 120-132). It is absolutely indivisible.

Vyāvahārika paramāṇu, on the other hand, is composed of infinite *sūkṣma paramāṇus*. Even though it is a composite body, it is too subtle to be cognized singly. It can only be cognized through

1. *Anuyogadvāra : Pramanadvara—*
"Paramāṇu duvihā paṇṇaie, tanjahā suhumeya, vavahāriyeṇa; anantānam suhumaparamāṇupoggalanum samudaya-samiti-samāgameṇam vavahārie paramāṇu-poggale nipphajjanti."

effects of collective action. Its interactions and mutations are very subtle and so it is called *paramāṇu*. We can compare a sub-atomic particle or an atom of modern physics with this *Vyāvahārika paramāṇu*. Thus, applying the law of *Anekāntavāda*, it can be said that in the context of transcendental *paramāṇu*, the *paramāṇu* is absolutely indivisible, whereas in the context of empirical one, *paramāṇu* can be said to be divisible.

SŪKṢMA (TRANSCENDENTAL) PARAMĀṆU

The sūkṣma (transcendental) *paramāṇu*, as defined by Jain philosophy, on the other hand, is a truly indivisible fundamental unit of *pudgala* and therefore has no components. It is not composed of any particles and is dimensionless. Like a true geometrical point, it has no length, no breadth, and no thickness. Its centre is identical with its ends. Thus, it has no extension and occupies only a single space-point. It has no shape and it has no mass. It is however, not an abstract piece of matter deprived of the qualities of colour, smell etc., like the atom of Democritus. It has a real objective existence and does possess colour, smell, etc. Inspite of this, a *paramāṇu* by itself is not perceivable by sense-organs and can only be cognised by inference through the effects of collective actions or by direct experience of a transcendental knowledge. This apparent paradox of being in possession of sensuous qualities like colour. etc., on the one hand and yet not being an object of sensuous cognition on the other is beautifully resolved by the principle of uncertainty. Quantum physicists do not concern themselves with the properties of an individual electron because it is impossible to ascertain them. On the other hand, electron behaviour can be accurately defined when dealt with collectively in great numbers. The individual electron is indeterminate and the indeterminacy is not a symptom of immature science but an ultimate barrier of nature. For, by the very act of observing its position, its velocity is changed, and conversely, the more accurately its velocity is determined the more indefinite its position becomes. Thus, it is impossible to determine the position and velocity of an electron at the same time.

A *paramāṇu* in its unattached free state is as real as a *paramāṇu* within material aggregate and the qualities of colour,

etc., are as much real in a free *paramāṇu* as they are in an attached one. A free *paramāṇu* when captured by an aggregate, loses its free state and is changed to become a component of the aggregate. Similarly its qualities also undergo changes of intensity. Thus the same *paramāṇu* (as substance) which possessed one unit blackness can change to become infinitely black.

Two or more *paramāṇus* mutually combine together to produce composite bodies and the entire physical world is composed of *paramāṇus*. The aggregates composed by *paramāṇus* have shape and extension is space although the *paramāṇu* itself is devoid of shape and has no extension. By this it is meant that single free *paramāṇu* does not occupy two or more space-points. The subatomic particles of modern science are presumed to be spherical in shape. Their diameters though very small are measurable and, therefore, their extension in space cover innumerable space points. This, according to Jains means that the subatomic particles of science viz., protons, electrons, etc., are not indivisible but composed of innumerable *paramāṇus*.

As stated above, theoretical considerations have already established that protons are made of quarks and the question 'what are the quarks made of ?' looms large before the physicists. Thus, the subatomic particles are not the *paramāṇus*—the ultimate or primary atoms—but are infinitely more gross particles than a *paramāṇu*.

QUALITIES AND MODES

Paramāṇu is eternal (*nitya*), indestructible (*anaśvara*), non-transmutable (*avasthita*), and indivisible (*avibhājya*). A *paramāṇu* cannot be split or scattered or fissioned nor can it be composed or created by fusion.

When it was said that the word *pudgala* is derived from the properties of fission and fusion, it meant that the formation of material aggregates by the natural association of a number of *paramāṇus* is fusion and the splitting of aggregates into its components is fission. *Paramāṇu* itself, though subject to mutation, is unfissionable and maintains its individual existence permanently.

The atom of a chemical element as well as its constituents, the subatomic particles – electrons, protons, etc., – are on the other hand, fissionable, and fusionable: radioactive elements emit alpha and other particles and lose energy by radiation. Protons and neutrons are mutually transformable by losing or acquiring a positive charge. Other elementary particles get transformed into electromagnetic waves and radiation. Thus according to the Jain view, the elementary particles are not fundamental units of matter but masses composed of infinite number of *paramāṇus*.

The totality of *paramāṇus* in universe cannot be expressed by numbers. It is infinite. Since a *paramāṇu* can neither be destroyed nor created, totality of *paramāṇus* in the universe is unchangeable. This is comparable to the 'law of conservation of matter and energy' which states that the total amount of matter and energy in the universe is constant and unchangeable. Modification of this law is mooted as a result of some very recent observations and we shall revert to this point in the succeeding paragraphs.

Earlier, we had seen that colour, taste, smell and touch, etc., are intrinsic qualities of all material objects. A *paramāṇu* being the fundamental unit of matter must also possess each of these qualities. Thus a *paramāṇu* will possess the following five qualities:

One (either good or bad) smell,

One of the five elementary colours,

One of the five elementary tastes, and

Two of the four elementary *sparśa* viz., either hot or cold and dry or unctuous.

Thus in respect to the quality of *sparśa* alone there are four types of *paramāṇus* :

1. Unctuous-cold

2. Unctuous-hot

3. Dry-cold

4. Dry-hot

And with different combinations of colour, etc., we have 5x2x5x4=200 types of *paramāṇus*. Now, since the intensities of colour, taste, etc. vary from minimum one unit to maximum infinite units, there will be infinite varieties of *paramāṇus* with different intensities and combinations of colour, taste, etc. e.g. in respect to colour, there will be paramāṇus with one unit blackness, two units of blackness upto infinite units of blackness. The intensities of the qualities of any given *paramāṇu* is subject to increase or decrease by its mutations into different states of association and dissociation within aggregates.

COLOUR

Now, we should be quite clear about the meaning of the statement 'a *paramāṇu* possesses one colour'. We have already said that an individual *paramāṇu* by itself is never an object of sensuous cognition and we have also said that *paramāṇus* are cognised by their collective or group behaviour only. What, then, do we mean by saying that only one out of the five primary colours can be associated with a *paramāṇu*? It should be remembered that though a *paramāṇu* is not an object of sensuous cognition by us, it can be cognised by a *kevalin* or a *parama-avadhi-jñānī*, that is, they are aware of the colour of the *paramāṇu* and that is why it is *rūpī* or *mūrta*. Possession of one colour simply means that a *paramāṇu* will reflect a precisely single wavelength corresponding to multiplicity of colour of its components. Thus, a *paramāṇu* must manifest itself as having a single colour to a super-normal faculty as stated above. Whether it is actually so constituted as to behave in that fashion, it is for the physicists to determine.

Similarly, of the five different tastes and the two different smells, a *paramāṇu* will manifest itself to possess only one of each.

SPARŚA (TOUCH)

We now come to another important characterstic quality of *paramāṇu*, viz. *sparśa* (touch). We have seen that there are two types of composite bodies—(1) *catuḥsparśi* (those with four kinds of touch, and (2) *aṣṭasparśi* (those with eight kinds of touch).

The former are possessed of:

(i) *snigdha* (gluey) and *rūkṣa* (dry)

(ii) *śīta* (cold) and ūṣṇa (hot)

The latter have four additional kinds of touch :

(iii) *laghu* (light) and *guru* (heavy)

(iv) *mṛdu* (soft) and *kaṭhora* (hard)

The *paramāṇus* have only two *sparśa* :

(i) either snigdha or *rūkṣa.*

(ii) either *śīta* or *ūṣṇa.*

Comparing these characteristic qualities of *pudgala* with those of subatomic particles—protons, neutrons, etc., we find that:

(i) snigdha (gluey) and *rūkṣa* (dry) correspond to the electric charges + ive and - ive respectively.

(ii) while guru (heavy) and *laghu* (light) correspond to the quality of 'mass'.

Our identification of snigdha and *rūkṣa* with + ive and - ive charges is based on the following commentary in *Sarvārthasiddhi* on *sūtra* 5/24 of *Tattvārtha sūtra*— *"....Snigdha-rūkṣatva-guṇa-nimitto vidyut....."* That is, lightning in clouds is produced by the qualities of *snigdha* and *rūkṣa*, i.e., due to the development of + ive and – ive charges in the clouds.

Similarly, the *sparśa guru* (heaviness) and *laghu* (lightness) are to be identified with mass. A *paramāṇu* has no mass but it must possess either a + ive electric charge (*snigdhatva*) or a - ive electric charge (*rūkṣtva*). All *caṭuḥsaparśi* compositions have no mass. In other words, *paramāṇu pudgala* and all *catuḥsaparṣi pudgala* are neither *guru* nor *laghu*. They are *agurulaghu* i.e. without mass.

When physicists listed all the known particles by the order of their masses, from the lightest to the heaviest, they discovered that subatomic particles fall roughly into three categories—(1) the light-weight particles, (2) the medium-weight particles, and (3) the

heavy-weight particles. They were called leptons (the light ones), mesons (the medium ones), and baryons (the heavy ones).

Some of the subatomic particles compared with Jain Physics.

Particle's name	*mass*	*elect. charge*	*sparśa*
Electron	A	– ve	*rūkṣa, laghu*
Positron	A	+ve	*snigdha, laghu*
Proton	C	+ve	*snigdha, guru*
Neutron	C	neutral	*snigdha-rūkṣa, guru*
Photon	O	neutral	*snigdha-rūkṣa, agurulaghu*[1] (?)
Pion +ve	B	+ve	*snigdha, laghu*
Pion – ve	B	– ve	*rūkṣa, laghu*
Pion neutral	B	neutral	*snigdha, rūkṣa, laghu*

A=light [lepton]

B=medium (meson)

C=heavy (baryon)

Thus, electron, which is one of the lightest particles is a lepton, while proton which is the lightest of the heavy ones is a baryon. However, a few particles do not fit into the lepton-meson-baryon framework. Some of them are well-known (like the photon) and others have been theorized but not discovered yet (like the gravitation). All of them have, in common, the fact that they are massless particles. A particle that has, zero rest-mass is a massless particle. All its energy is energy of motion. Though physicists know exactly what they mean by 'massless' in a mathematical structure, it is difficult to describe it in non-mathematical language because the very term 'particle' means 'some thing that has mass'.

1. See p. 200 of this book.

There is a remarkable similarity in the views of the Jains and physicists regarding massless particle. Not only a *paramāṇu*, the smallest indivisible particle, is massless but all *catuḥsparśi* compositions also have no mass. The quality of mass is found only in *aṣṭasparśi pudgala*.

The above description of the characteristic qualities of a *paramāṇu* would naturally introduce qualitative difference between *paramāṇus*. But it should be remembered that the difference is only qualitative, that is, in the *paryāya* of the different *paramāṇus*. From the point of view of substance, every paramāṇu is identical to every other. This is the law of *Anekāntavāda*.

The above elaborate analysis by ancient Jains of colour, taste and touch is as minute as that of modern psychology. But their analysis of smell is as arbitrary as the modern one. Smell can be analysed only into (i) agreeable (ii) disagreeable. Several attempts made in recent years to go beyond this crude classification nearly ended in failure. Thus, where the modern scientists succeeded, the ancient Jains also achieved success, that is, in the classification of other sense-data.

MECHANICS AND MATHEMATICS OF PARAMĀṆU AND SUBATOMIC PARTICLES

Universal Constants

In 1900, Max Plank made a major discovery, one which ranked with the discoveries of Newton. The philosophy and the paradigm of physics, after his discovery never were to be the same, although it took another 27 years for quantum mechanics to fall. His discovery dealt with the fundamental units of matter and energy. It provides equations that define with great accuracy the laws governing the propagation of radiant energy. The extraordinary feature of this theory was that it rested on the assumption that radiant energy is emitted not in an unbroken stream but in discontinuous packets which Planck termed 'quanta'.

Planck is the discoverer of the Planck's Constant[1] which is a number which never changes. It is used to calculate the size of

1. The latest value of Planck's constant is determined to be 6.62517×10^{-34} joule-seconds.

the quanta of each light-frequency [colour]. On purely theoretical grounds he concluded that each quantum (packet) carried an amount of energy given by the equation, E=hv where v is the frequency of radiation and h is Planck's constant. A small but inexorable number which has since proved to be one of the most fundamental constants in nature. All forms of radiant energy—light, heat, X-rays—actually travel through space in separate and discontinuous quanta and the amount of emitted energy divided by the frequency is always equal to h. Thus sensation of colour arise from the bombardment of our optic nerves by light quanta which differ from each other just as the frequency varies in the equation E=hv. Thus, energy-packets of each colour would have the same amount of energy. The packets of violet light, however, are larger than the packets of green light and these are again larger than packets of red light.

Another universal constant is the velocity of light, denoted by the letter c, which was accurately determined in 1849 to be 186,284 miles per second[1]. The velocity of light is unaffected by the motion of earth, sun, moon, star or any other system moving anywhere in the universe i.e. it is constant throughout the universe and is unaffected either by the motion of its source or the motion of the receiver. We are already familiar with Einstein's equation giving the increase in mass[2] with velocity of a moving body, where this constant is used—

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

1. The latest corrected value is determined to be 2.997925×10^8 meters per second in vacuum.

2. Units of measurement :

There are three fundamental units of modern scientific measurement. They are units of length, mass and time. The unit of length, metre, was defined earlier as one ten-millionth part of a quarter meridian. In 1967, this was replaced by the wave-length of orange-red radiation of krypton[86]. The present valid definition of the unit of length is "1,650,763,73 wave-lengths of orange-red radiation of krypton[86] in vacuum."

(Contd. on next page)

when m_0 is mass of a stationary object or rest mass, m is its mass when in motion, v is its velocity, c is the velocity of light.

From the above equation, we can see that as v increases, the mass also increases and when v is equal to c, mass will be infinity. We had come across an instance of increase in mass while discussing the characteristics of subatomic particles[1]. From this, it is clear that the speed of a particle of matter is always less than that of light and other radiations.

MOTION OF PARAMĀṆU

Mechanics and mathematics of *paramāṇu* as discussed in the *Bhagavatī Sūtra*[2] shows that the activities and movements of *paramāṇu* are both complex, inexplicable and unpredictable. It is particularly emphasized that there is an element of uncertainty in the activities of the *paramāṇu*. We have already discussed at length the dynamic nature and various types of motion of *paramāṇu*. The alternate periods of rest and motion to a certain extent agrees with quantum mechanics.

Difference in the kinds of motions of a *paramāṇu* are shown by different terms such as eyati, veyati3, etc. Some of these

Initially the unit of mass 'gramme' was considered the mass of a cubic centimetre of water at its maximum density. Later on, in MIS system, this was changed to kilogram ie. the mass of a cubic decimeter of water. But this suffered from the inherent uncertainty associated with the measurement of volume and temperature. In 1960, kilogram was independently defined as the mass of a platinumiridium cylinder which is preserved at International Bureau of Weights & Measures at Serves, Paris.

This definition of mass has been considered in a mode rather than a rule. So the defining of both mass and length in terms of a certain wave-length of light may provide a coherent means. The wave and particle nature of light inspired S.K. Mukherjee and A. Choudhury to conceive the mass-equivalence of the particle assciated with the orange-red radiation of krypton[86] and a suggestion was put forward by them to define kilogram in terms of the mass of a particle whose De Broglie wave-length is already taken for standardisation of length. Thus the kilogram can be considered in terms of the number of particles associated with the radiation in order to follow the international convention of standards. A precise estimation of the number of particles assumes the value $2.74118798 \times 10^{35}$

We shall discuss the unit of time in the subsequent pages. (See p. 198)

1. See chapter I, pp. 38-39.
2. See chapter II, pp. 128-131.
3. See chapter I, pp.

terms indicate simple vibratory motion, whereas some others denote simple migratory motion. While still others indicate complex mixture of vibrations, oscillation, emission, absorption, spin and wave-propagation in space. By the word 'so on' it is understood that besides these, there are many other kinds of motion also. It is extremely difficult to interpret each of these terms into modern scientific terminology. We shall, however, attempt to do so in a general way with the assistance of the available commentaries on this *Sūtra.*

(1) Simple vibrations – *Paramāṇu* sometimes merely vibrates.

(2) simple motion – It sometimes migrates, i.e., it goes from one space-point to another.

(3) Complex motion – It sometimes vibrates and migrates simultaneously.

(4) Complex vibration – It sometimes vibrates and spins simultaneously.

(5) Oscillation – It sometimes oscillates.

(6) Collision – It sometimes collides with other *pudgala.*

(7) Forceful penetration – It sometimes penetrates forcefully into other *pudgala*, and so on. i.e. it is emitted, absorbed etc. Over and above the above-mentioned motion, revolutionary motion or standing wave in a space-point are possibilities. It probably means linear motion accompanied with vibratory motion or state of vibration with changing frequency.

Linear motion of a *paramāṇu* means moving about from one space-point to another. This motion or change of motion may take place under the influence of outside forces exerted by another *paramāṇu* or an aggregate or it may be spontaneous. Jīva, however, can never exert any influence on the motion of a *paramāṇu.*

While discussing the movements of a *paramāṇu* as described in the *Bhagavatī Sūtra*, we had mentioned[1] that while in some respects movements *(gati)* of a *paramāṇu* follow definite rules, in

1. See chapter II, pp. 128-130.

many other respects they are indeterminate and uncertain. Now, as we have seen, Principle of Uncertainty is also a scientific dictum enunciated by an eminent physicist Werner Ḥeisenberg in 1927. At that time, quantum physics had defined with great accuracy the mathematical relationships governing the basic units of radiation and matter. But it had failed to reveal the true nature of either. Werner Heisenberg and other eminent physicists declared that there is an element of caprice in atomic behaviour which stems from the very nature of matter and cannot be blamed on man's coarse-grained implements. They added further that there is an element of indeterminacy about the events of the atomic universe which cannot be dispelled by the refinement of measurements, and hence, it is futile to hope that invention of more delicate tools may enable us to penetrate further into the microcosm. A physicist can give an accurate account of electron behaviour so long as he is dealing with great numbers of them collectively, but he cannot locate an individual electron in space in respect of its position and momentum (velocity x mass). The Principle of Uncertainty asserts that it is impossible to determine the position and velocity of an individual electron at the same time, because by the very act of observing its position, its velocity is changed : and conversely, the more accurately its velocity is determined, the more indefinite its position becomes.

RULES OF MOTION OF PARAMĀṆU

The motion of *paramāṇu* in space is subject to the following rules :

Spontaneous *motion* is in '*anuśreṇi*' which literally means straight line but which really means the minimum distance between the two space-points. If the geometry of the *lokākāśa* is Euclidian, then it will be a straight line, but if this geometry is non-Euclidian, as asserted by General Theory of Relativity, then the minimum distance may be a curved line. Since the space of *lokākāśa* is accepted to close upon itself, the latter alternative is a greater possibility. According to the rules and propagation of radiation in space, light also travels in a straight line (if free from the influence of external forces). But, because, the modern cosmology accepts the geometry of the space as non-Euclidian (i.e. it closes upon itself), the path of light also will be curved. Motion of a paramāṇu under the influence of external forces may also be in viśreṇī i.e. with

change of direction. But if the time of motion is one time-point only, the motion is always in *anuśreṇi*.

The minimum velocity of a *paramāṇu* is one space-point in one samaya[1] (time-point), while the maximum velocity is the entire length of the *lokākāśa* in one *samaya*. When in motion, the minimum distance travelled by a *paramāṇu* in one *samaya* is one space-point i.e. the distance between two adjacent space-points. And the maximum distance travelled by a *paramāṇu* in one *samaya* is between the extremities of the *loka*[2].

How is this Jain view compatible with the Einsteinian equation of the increase of mass and the inference that nothing can travel faster than the speed of light, the theoretical speed limit of the universe?

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1. *Samaya* and *loka* are two terms unique to the Jain Philosophy. *Samaya* is the indivisible quantum of time. A comparatively larger and more practical unit of time which is measurable is called *āvalikā* and is equal to 1.7×10^{-4} seconds. One *āvalikā* covers *'Jaghanya-Yukta-Asamkhyāta'* samayas. This number is impossible to be expressed in numerical figures, but it can be shown to have definite measurable value and its lower limit can be calculated. Jain mathematics expresses this number as greater than x where

$$x = y^{y^{y^{\cdot^{\cdot^{\cdot}}}}} \quad \text{and } y = 10^{10^{10^{143}}}$$

. 10^{134} times

(See, *Viśva Praheliká* by Munisri Mahendra Kumar, pp. 255-270)

A comparison of this Jain view with the most modern scientific attempts and various methods for the accurate measurement of time might be interesting.

'Second', the present unit of time, was earlier defined with reference to the time taken for the rotation of earth and in 1954 the International Committee of Weights & Measures standardized the 'second' as 1/31, 556,925,975 of the tropical year 1900. The 'second', thus, defined was known to vary to the extent of 1 part in 10^8 and did not entirely satisfy the present scientific quest. Subsequently, other considerations compelled them to switch over to a different form of time standard which ultimately led to the advent of atomic standards. In 1964, the above Committee adopted the transition between two specified energy levels of Cesium^{133} for the purpose of defining the basic unit of time. Cesium beam oscillators were developed and in 1967, the Committee defined the unit of time as follows:

"The second is the duration of 9, 192, 631, 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the fundamental state of Cesium^{133} atom." (Contd. on next page)

Now, we have seen that 'mass' is not an intrinsic quality of paramāṇu. Mass, according to the Jain view, is one of the four pairs of sparśa which are (i) hot-cold (ii) gluey-dry (iii) heavy-light and (iv) hard-soft. Paramāṇus (and even material aggregates of some vargaṇās though composed of innumerable paramāṇus) are chatuḥsparśi i.e. are agurulaghu (literally neither heavy nor light) which means that they have no mass.

If we accept the value m_o=0, i.e. a paramāṇu has no mass, then the equation of the increase in mass with velocity becomes inapplicable, and, therefore, paramāṇu can travel at a speed higher than that of light.

SUPER-LUMINAL SPEEDS

In modern science, some particles such as photon, muon, etc. are postulated as massless. But the word 'massless' here probably does not mean that they are actually possessing no mass.

'A massless particle' is an awkward translation from mathematics to English. Physicists know exactly what they mean by a 'massless' particle. A massless particle is a name they give to an element in mathematical structure. What that element represents in the real world, however, is not easy to describe and in all probabilities does not mean that the particle is completely devoid of mass.

Various methods of standardization of time in terms of the frequency of hydrogen measure are also available but the order of accuracy does not seem to exceed that of the former cases.

Some time ago, a new and simple method for standardization of time is suggested by S.K. Mukherjee and A. Choudhury of Jadavpur University. It is based on the velocity of electrons under the action of crossed electric and magnetic fields. It has been shown that under certain conditions, the electron will move in a rectilinear path at a constant velocity and the time taken to traverse a distance of 1 cm. is $0.533,168,432 \times 10^{-9}$ second. This suggestion leads to the conception of a unit of time very much smaller than the second. It will be $533,168,432 \times 10^{-9}$ second. In other words, one second will contain 1.87557997×10^{9} units and one āvalikā will contain 3,00,000 (app.) of these units.

2. The maximum distance betwen two extremities of *loka* is 14 *rajjus* where a *rajju* covers *asamkhyāta yojanas* and can be roughly expressed as $R\ (rajju)=10^{10^{196}}$ light years. Thus the maximum veloity of a *paramāṇu* is not less than N light-years per second where $N=x^2 \times R$.
(For the value of x, see the previous footnote).

It is well-known that light is affected by gravity and bends when passes near a massive star. It is also known that light cannot escape black holes and is, therefore, positively affected by gravity which means photons have mass.

In *paramāṇu*, we have a different situation altogether – not only, it has zero rest mass but the energy of its motion must be such that it can travel with speed much higher than that of light. This may appear, in some ways, quite contrary to the fundamental inference of relativity theory that nothing can travel faster than light. But relativity itself permits the hypothetical existence of particles called tachyons[1] which came into existence, already travelling faster than light. In the formalisation of the special theory of relativity, tachyons have an imaginary rest mass. Unfortunately, no one knows what an 'imaginary rest mass' means in physical terms, or what the interaction forces could be between tachyons and the ordinary particles of real rest mass.

But, there is a fundamental difference between the particles such as tachyons and *paramāṇus*. While tachyons transfer energy and momentum through space, in case of *paramāṇu* there is no transport of momentum at all but pure energy only. Since momentum is a function of mass, there is no question of transport of momentum in the case of *paramāṇu*.

JUMPING WITHOUT PASSING THROUGH SPACE – *APHUSAMĀṆA GATI*

We have seen that quantum physics has discarded the planetary model of the atom in which negatively charged electrons revolved round the positively charged nucleus. It has been established that electrons settle in orbits in such a way that there is an optimal balance between the attraction of nucleus and the relectants of the electron to be confined. The atomic orbits, however,

1. "There are particles, which at rest, would have no mass at all, a rest mass of zero .... light is made up of 'photons' – particles that have a proper mass of zero. Other particles such as 'neutrinos' and 'gravitons' also have a proper mass of zero. Particles with zero mass mean that their inertia is zero and they can be accelerated to any velocity upto infinite. In 1967, physicist Gerald Feinberg, in discussing these faster-than-light particles called then 'tachyons', from a Greek word meaning speed." (– Isaac Asimov, 'SPAN' magazine, 16th July 1973).

are very different from those of the planets in the solar system, the difference arising from the wave-nature of the electrons. Also whenever an atom absorbs energy, its electrons jump to one of the outer orbits and later return to the inner orbits by emitting the energy absorbed earlier. Since the electrons are never found anywhere between the orbits, they appear to keep jumping from one orbit into another, without passing through the intervening space.

"Without passing through the intervening space" means that electrons, changing the orbit, cannot occupy any space between the two orbits even while going from one orbit to another.

This is explained by the quantum mechanics with reference to 'position-momentum' of the subatomic particles. This explanation involves the Uncertainly Principle or the discrete solutions of the quantum mechanics wave-equations. The latter is more difficult to understand than the former.

This sort of motion is also described in the Jain Physics by the term '*aphusamāṇa gati*'[1] which means motion from one area of space to another without passing through the intervening space.

SYNTHESIS OF *PARAMĀṆUS* INTO COMPOSITE BODIES

We had discussed the nature of various forces which are responsible for the disintegration and integration of material objects by interaction between material particles.

In modern physics, the forces of interactions between the matter–particles are also supposed to be carried by other particles. Out of the four types of forces found in nature, the gravitation force, which is the weakest of the four, has practically no effect in the synthesis of subatomic particles into composite bodies. The electromagnetic attraction between – vely charged electrons and +vely charged protons in the nucleus binds together the constituents of an atom and is responsible for the stability of each atom. This force also binds together atoms of different elements into complex molecules of innumerable chemical compounds.

1. *Paṇṇ. Sūt* 16/38, 40 ; 36/92, (JVB. Edition).

Then, there is the weak nuclear force which is recently unified with electromagnetic force.

And finally, there is the strong nuclear force which is many times greater than the electromagnetic force and which acts as the cosmic cement which binds together the subatomic particles of the nucleus of an atom and prevents its breaking up.

The qualities *snigdha* and *rūkṣa sparśa*, according to the Jain view, play the most important role in the synthesis of different *paramāṇus* for the formation of atoms, molecules and small and large objects of matter. The intensity of these two primary qualities varies from a single unit to infinite units in different *paramāṇus*—that is, at a given moment, some *paramāṇus* have a single unit of glueiness, some are with two units, some with three and so on upto infinity. At the same time, there will be some *paramāṇus* with a single unit of dryness, some with two units and so on upto infinity. A summary of the rules in respect of the synthesis of different *paramāṇus* is as under :

1. Synthesis of *paramāṇus* having single units of dryness or glueiness is not possible either with one another or with *paramāṇus* of higher intensities.

2. Synthesis of *paramāṇus* having two or more units of dryness is possible with other dry *paramāṇus* provided there is a difference of two or more units between them. Similarly mutual synthesis of gluey *paramāṇus* is possible only if the difference of their intensities is two or more units.

3. Synthesis of *paramāṇus* having two or more units of dryness with all unctuous *paramāṇus* (except those with a single unit) is possible[1].

The following points of similarity between the views of Jains and the modern science emerge from the above:

The dryness and glueiness have been equated by us with the − ive and + ive electric charges of the elementary particles respectively[2]. The interaction of the electronic shells of neigh-

1. See pp. 105-107 in chapter II.

2. See p. 191 in this chapter.

bouring atoms in a molecule, which creates the chemical bond necessary to keep them united, is then equivalent to the interaction and union between *paramāṇus* of same type of *sparśa* i.e. *sparśa* equivalent to −ive charge. The first completed shell consists of two electrons. The minimum difference between the uniting *paramāṇus* of similar *sparśa* is two units. The quality of mass or guru-laghu *sparśa* does not play any significant role in the process of synthesis of subatomic particles or *paramāṇus*.

DUALITY OF *PARAMĀṆU*

At this stage we may raise some fundamental questions, what is the true nature of *paramāṇu*? Is it a particle or a wave ? Is it matter or energy (radiation) ? Does it have an electromagnetic field or a gravitational field ?

In the final section of the previous chapter we had discussed the *"apratighāti"* property of *paramāṇu* where it was stated that a *paramāṇu* is capable of penetrating and passing through any type of obstruction. Now, we know that the penetrating power of an electromagnetic radiation is inversely proportional to its wavelength i.e. shorter the wave-length of the radiation, higher is its penetrating power. From the stand-point of physics, the only difference between (10^{-8} & 10^{-7} cm) at one end of the electromagnetic spectrum,[1] visible light (between 10^{-4} & 10^{-5} cm) in the middle, and cosmic rays (10^{-11} to 10^{-12}cm) at the other end lies in their wave-length. Visible light can 'pass through' only a few substances like glass. The wave length of red light is .00007 cm and that of violet light .00004 cm. X-rays which are shorter (10^{-6} to 10^{-8} cm) than visible light can pass through many more substances which are opaque to light waves. Shorter than X-rays are gamma rays (10^{-8} to 10^{-13}cm) of radium etc. which can penetrate several feet of cement concrete. The shortest known electromagnetic radiations are cosmic rays with wave lengths of 10^{-10} to 10^{-13} cm which can penetrate even more. Thus shorter the wavelengths, higher is the penetrating power of a radiation. Now if *paramāṇu* is accepted to possess infinitely more penetrating power than the gamma rays or even cosmic rays, it must be regarded as radiant energy with

1. See the figure on p. 166.

an infintesimally small wavelength. This aspect, then, compels us to postulate *paramāṇu* as energy of infinitesimally small wavelength.

On the other hand it is also necessary to postulate *paramāṇu*, the ultimate unit of *pudgala* to be an individual particle. The properties attributed to *paramāṇu* compels us to visualize it as a particle, or a corpuscle rather than a wave. For instance, it has been stated that *paramāṇu* is sometimes at rest and sometimes in motion. What is the meaning of 'at rest' here? Does it mean a stationary wave in space or a stationary particle? Thus *paramāṇu* has both the characters—that of a particle and a wave. In some context, it manifests itself as a particle, while in some other context as a wave. It has, therefore, a dual character, and there is no conflict between the two.

We have already discussed a number of paradoxical dualities pervading the physical universe. The basic aspect of these dualisms is the question—"Is physical reality wave or is it particle?" Light, for example, is classically regarded as electromagnetic-waves and the difference in various colours is explained by the difference in their wave-lengths; And electron, on the other hand, is commonly regarded as a particle with a -ve electric charge. While, certain peculiar effects of light could be explained only by assuming that it is composed of particles or grains of energy called photons, it has been proved by experiments that electrons actually do exhibit wave- characteristics. It has been established that not only electrons, but whole atoms and even molecules produce wave-patterns under certain conditions.

Another dualism of the physical order of existence is the concept of two forms matter and energy—the former inert, tangible and massive and the latter active, invisible and without mass. The two fundamental forces exerted by physical reality—gravitation and electromagnetismcare yet another aspect of the deep duality of physical universe. Almost all the phenomena of physical universe, are produced by these two primordial forces. While the gravitational forces dominate such phenomena of macrocosm as the

motion of planets and stars, the electromagnetic forces are predominant in the microcosm of the heart of atoms.

Einstein's famous equation $E=mc^2$ has shown that matter and energy are mutually transformable. The paradox presented by the waves of atoms and particles of light has been resolved by a new mathematical apparatus that permitted accurate description of quantum phenomena, either in terms of waves or in terms of particles, as one wished. Today the whole complex of the physical universe is almost resolved into homogenous fabric in which matter and energy are indistinguishable ; various forces found in nature, viz., the electromagnetic and weak nuclear forces have been unified ; a grand unified theory combining the strong nuclear force with these two forces is under way ; the abyss between macrocosm and microcosm is almost bridged ; and there are hints of how the theory of quantum mechanics and general relativity might affect each other—a glimpse of the shape of a quantum theory of gravity yet to come.

SECTION VI

BASIC UNITY OF PHYSICS AND PHILOSOPHY

A. REALITY AND EXPERIENCE

Knowledge through Physics

In Physics, knowledge is acquired through the process of scientific investigations. Experimental facts about the observed phenomena are correlated and a mathematical model theory is worked out. Eventually, for the benefit of the nonphysicists, a model/theory, in ordinary language, interpreting the mathematical scheme is formulated. Very often, the theories have to be modified or sometimes even dropped altogether, if the experimental evidences continue to contradict the model/theory. Abstraction is a crucial feature of the whole process and consists a map of reality. This can represent only some features of reality ; and is very much ambiguous and inaccurate, having many contradictory meanings. The realization that all models and theories are approximate is basic to modern science. They can never explain all the aspects of reality, and will, therefore, never give a complete description of the real situation.

Knowledge through Supervision

All schools of philosophy in India are agreed that philosophical speculation is a necessary discipline of the mind which strengthens convictions and attenuates doubts. But the ultimate truth cannot be realized by philosophical discipline alone, which is only a means to that end. Indian philosophers are, also, agreed that the plenum of knowledge can be attained by the development of a super-vision which is a potentiality in all of us. The Jains are emphatic that omniscience is the condition as well as the result of perfection. And however much we may advance in our philosophical enquiry and scientific pursuit (which are not antagonistic in their aim inspite of their difference in method and lines of approach), it cannot by itself bring about the final consummation.

Both physicists and the Jain philosophers agree that physical universe is fundamentally interconnected, interdependent and inseparable. In other words, it is an internally coherent system.

The ideal way, therefore, to perfectly understand the nature and the structure of the physical world, is to apprehend it directly in one super-vision. Being a coherent system, it is possible to apprehend the entire physical universe in a single all-embracing experience by a superhuman observer.[1] Let us first outline a fairly definite ideal of what a completely adequate apprehension of the whole physical reality would be.

Direct apprehension of Reality

A completely adequate apprehension of reality would be one which contained all reality and nothing but reality; it would, in the first place, be all-embracing; it would include in itself every datum of direct experience; it would contain nothing else. In the second place, it would contain all its data without contradiction as a part of single harmonious system and, in the third place, such an all-embracing harmonious apprehension would clearly transcend the separation of existence from content. To such an ideally complete experience, we may give the name, introduced into philosophy by Avenarious, of a 'pure experience,' that is, an experience which is in all its parts experience and nothing else.

Our own human experience clearly falls far short of such an ideal because our experience is incomplete in respect of its data ; there is much in reality which never directly enters into the structure of our experience at all. Again, there may well be much in the real world which never, even in this indirect way, enters into the structure of human knowledge at all. Hence, our human experience and the intellectual constructions, by which we seek to interpret it, have always the character of being piecemeal and fragmentary. Perfect apprehension of systematic reality as a whole would be able to deduce from any one fact in the universe the

1. In words of Einstein, "We can know only the relative truth. The absolute truth is known only to the Universal Observer.
(See, *The Universe and Dr. Einstein* by Lincoln Barnett, New Yourk, 1954.)

nature of every other fact.[1] Or rather, as the whole would be presented at once in its entirety, there would be no need for the deduction. Our facts, on the other hand, appear as bare "casual conjunctions or collocations" and the hypotheses by which we seek to weld them to a system never quite get rid of an element of arbitrary 'free' construction. Our ideal is to connect our presented facts by constructions, but it is an ideal which we are never able to adequately realize. Our science would have to interprect the world of our experience, in ascending order of degrees of truth and reality. The knowledge conveyed by such a science would not be pure or all-embracing experience of reality but the abstract and imperfect one. But it would be final in the sense that no addition of fresh knowledge could modify it in principle.

We may perhaps illustrate this conception of knowledge which, though imperfect, is yet final, by an instance borrowed from elementary mathematics. We know what the symbol π stands for. It is the ratio of a circumference to its diameter. And again both these terms can be defined unequivocally. Thus our knowledge of the meaning of the symbol is clearly final. At the same time, our knowledge of π, though final, is imperfect. For the quantity π is incommensurable and thus we can never precisely evaluate it. All we can do is to assign its value correctly within any desired degree of approximation. Again, one approximation is closer than another[2]. We have said above that scientific method can never explain all the aspects of reality. This is mainly because our finite view of the total physical reality is not only fragmentary but also largely contradictory and internally chaotic. We may, indeed, believe that the contradictions are only apparent and temporary and we would be able to fully explain them by further investigations. But we can never attain an experience in which the entire reality is presented to us as a harmonious whole. We, thus.

1. Āyāro, 3/74 : "*Jo egam Jāṇai, se savvam jāṇai,*
Je savvam jāṇai, se egam janai."
– "He who knows one knows all
He who knows all knows one."
2. For everyday puposes the value of π is taken to be 3.14. Its value up to 13th place after decimal is 3.1415926538979.

seem driven to assert the necessary existence of a super-human experience to which the whole universe of existence and its content is directly present as a complete and a harmonious system.

Common problem before both physics and philosophy is the verbal communication of the results of scientific investigations (for scientists) and/or the direct insight of the experience (for philosophers). Both are confronted with the limit of language. However, it is important to remember that mathematics and English are both languages. They are useful tools for conveying information, but if we try to communicate experience with them, they simply do not work. All a language can do is talk about an experience but a description of an experience is not the experience itself.

B. UNITY AND PLURALITY IN PHYSICS

The Problem

The problem of the unity and the plurality is one of the oldest historically, and it inevitably arises from our attempts to think in a consistent way about the Physical Reality. On the one hand, our experience, which is piecemeal and fragmentary, seems to reveal an indefinite plurality of parts and constituents. And this is how it appeared to Democritus and Newton. On the other hand, there are compelling reasons for regarding the physical world as a single unity. And, today, the modern science looks upon nature as a realm of inter-connected events where nothing is ultimately entirely independent.

Inherent Unity of the "Whole"

The basic oneness of the Physical Universe is one of the most important revelations of modern physics. It becomes apparent at the atomic level and manifests itself more and more as one penetrates deeper into matter, down into the realm of sub-atomic particles. The unity of all things and events will be a recurring theme throughout our comparison of modern physics and Jain philosophy. Various models of sub-atomic physics express again and again, in different ways, the same insight—that the constituents of matter and the basic phenomena involving them are

all inter-connected, inter-related and inter-dependent ; that they cannot be understood as isolated entities, but only as integrated parts of the whole.

Quantum theory, in particular, reveals an essential inter-connectedness of the universe. It shows that we cannot decompose the world into independently existing smallest units. As we penetrate into matter, we find that it is made of particles, but these are not the 'basic building blocks' in the sense in which Democritus and Newton believed them to be. They are merely idealization which are useful from practical point of view but have no fundamental significance. In the words of Niels Bohr, one of the founders of the Quantum Theory, and a protagonist of the Copenhagen Interpretation of Quantum Mechanics, "Isolated material particles are abstractions.....".

The Copenhagen Interpretation of Quantum Theory is not universally accepted. The universal inter-connectedness of things and events, however, seems to be a fundamental feature of the atomic reality. The following passage from a recent article by David Bohm, one of the main opponents of the Copenhagen Interpretation, confirms this fact most eloquently :

"One is led to a new notion of unbroken wholeness which denies the classical idea of analyzability of the world into separately and independently existing parts.....We have reversed the usual classical notion that the independent 'elementary parts' of the world are the fundamental reality, and that the various systems are merely particular contingent forms and arrangements of these parts. Rather, we say that inseparable quantum inter-connectedness of the whole universe is the fundamental reality, and the relatively independently behaving parts are merely particular and contingent forms within this whole[1].

Thus, from the above, it is quite clear that whereas fundamental reality was assigned to the "parts and constituents" of the physical universe by Democritus and Newton, the most

1. D. Bohm and B. Hiley, "On the intuitive Understanding of Non-locality as Implied by Quantum Theory', Foundations of Physics, vol. 5 (1975), pp. 96, 102.

modern physicists are inclined to reverse the position and consider "whole" to be the fundamental reality, relegating the "parts" to mere abstraction as is evident from the above statement of Dr. Bohm.

UNITY AND MULTIPLICITY IN THE JAIN PHILOSOPHY

Non-absolutist Jains, as we have seen, endorse neither absolute separateness nor absolute inseparableness – neither absolute unity nor absolute multiplicity – but explain both these apparently opposite extremes as real with reference to different aspects of the same Physical Reality. In the Jain view, the classical notion that the independent 'elementary parts' are the fundamental Reality is as much far from the whole truth as the modern notion that the whole universe is the fundamental Reality. Neither of these rival aspects of the world of experience can be adopted as absolute truth in isolation from the other. Parts are as much real as the whole and neither the whole nor the parts are absolutely independent of the other. We may summarize the non- absolutist Jain position as under :

"Is Reality", ask the Jains, "one or many, unity of whole or multiplicity of parts and if it is both, how are they connected ?"

"The world", replies the Jain "must be an orderly whole or system. To be a system at all, it must be the development or expression in detail of a single principle (Reality). Therefore, it cannot be a medley of independent elements which somehow luckily happen to form a coherent collection. But again, because it is a system, it cannot be a mere unit ; it must be the expression of a single principle *in* and *through* a multiplicity of *parts* or constituents. Not only must it be one and many, but it must be many precisely because it is truely one, and one because it is truly many[1]. In a complete system, no single part can be missing or be other than it is. Also the number of distinct parts may be actually endless

1. A medley of independent things would not even be really 'many'. For until you can count 'first, second, third . . . . . you have not your Many. And nothing but the terms of a coherent connected series can be counted. What you can count as many is shown by the very fact of your ability to count it to have a common nature or ground which permits of its orderly arrangements, and thus to be part of one system. Compare Plato, *Parmenides*, pp. 164, 165.

while the law of construction is perfectly determinate. And again the individual elements themselves may turn out to be systems of infinite complexity. Thus, the unity of ultimate principle, in no way, excludes its possession of a wealth of detail infinitely infinite."

BOTH ARE EQUALLY REAL

Jains take a further important step forward. In the all-embracing systematic whole—Physical Reality, the unity and the multiplicity are *equally* real and each is real through the other. How is this possible ? Because the whole universe forms a single experience and is truly real and the parts are single experiences and also real. This will perhaps be brought out by examining some typical case of the kind of unity in multiplicity :

(a) The unity of the world cannot be that of mere accumulation or conglomeration. In a mere conglomeration, the elements are real, independently of their relation to one another as elements in the conglomeration. So the conglomeration has no unitary character of its own. Its unity consists in nothing more than the fact that we have found it convenient to think of its elements together.

(b) A machine is much more than a mere conglomeration, because it has a character as a whole. Yet in this case, it cannot be said, that the unity and variety are equally real. Or the whole cannot exist without the parts where as the parts may continue to exist, though not as parts of this whole, without the whole.

(c) Living organism is a truer unity than a mere machine. Here, the whole is not subsequent and generated by the parts. It is not the resultant but the living unity. But even an organism, like a machine, fails to exhibit the perfect systematic unity of the one and the many, because not every member is of vital significance for the life of the whole. But in a complete systematic unity, assert the Jains, the unity and the multiplicity of the system must be equally real and equally interdependent. This can only be the case, if the whole is for its parts as well as the parts for the whole.

A WORD OF CAUTION TO MODERN PHYSICISTS

The above discussion clearly establishes that while the classical physicists had falsely seen the physical world as a conglomeration of parts and constituents *without an inherent unity* [like Buddhist fluxists], the modern physicists have swung to the other extreme and are perhaps falling into the same error as the classical physicists, in concluding that only the 'whole' is real and the world of plurality (of parts) which is the world of experience, is an illusion (like the Vedāntists). In the final reckoning, therefore, both the classical and modern physicists are far from the Truth. If the *unity* of the physical Reality is to be maintained, it can only be done by means of the Jain Conception of Reality (as discussed above and in the beginning of the chapter), where the unity and the multiplicity are *equally* real and each is real through the other.

□

APPENDIX

ATOMIC TABLE

ATOMIC No.	NAME	SYMBOL	ATOMIC WEIGHT	GROUP or FAMILY	Number of Electrons in Each Shell	Special charactaristics
1.	Hydrogen	H	1.008		1	Unique
2.	Helium	He	4.0026	VIIIA	2	Inert Gas
3.	Lithium	Li	6.939	IA	2 1	Alkali & Alkaline Earth Metal.
4.	Beryllium	Be	9.0122	IIA	2 2	
5.	Boron	B	10.811	IIIA	2 3	Boron and Carbon Families
6.	Carbon	C	12.011	IVA	2 4	
7.	Nitrogen	N	14.007	VA	2 5	Nitrogen and
8.	Oxygen	O	15.999	VIA	2 6	Oxygen Families
9.	Fluorine	F	18.998	VIIA	2 7	Halogens
10.	Neon	Ne	20.183	VIIIA	2 8	Inert gas.
11.	Sodium	Na	22.990	IA	2 8 1	A & A.E.M.
12.	Magnesium	Mg	24.312	IIA	2 8 2	
13.	Aluminium	Al	26.982	IIIA	2 8 3	B & C Families
14.	Silicon	Si	28.086	IVA	2 8 4	B & C Families
15.	Phosphorus	P	30.974	VA	2 8 5	N & O Families
16.	Sulphur	S	32.064	VIA	2 8 6	N & O Families
17.	Chlorine	Cl	35.453	VIIA	2 8 7	Halogen
18.	Argon	Ar	39.948	VIIIA	2 8 8	Inert gas
19.	Potassium	K	39.102	IA	2 8 8 1	A & A.E.M
20.	Calcium	Ca	40.08	IIA	2 8 8 2	A & A.E.M.
21.	Scandium	Sc	44.956	IIIB	2 8 9 2	
22.	Titanium	Ti	47.90	IVB	2 8 10 2	First Transition Metals
23.	Vanadium	V	50.942	VB	2 8 11 2	
24.	Chromium	Cr	51.996	VIB	2 8 13 1	
25.	Manganese	Mn	54.938	VIIB	2 8 13 2	
26.	(Ferrum) Iron	Fe	55.847	VIIIB	2 8 14 2	The Triads
27.	Cobalt	Co	58.933	VIIIB	2 8 15 2	Second Transition Metals
28.	Nickel	Ni	58.71	VIIIB	2 8 16 2	
29.	Copper	Cu	63.54 63.74	IB	2 8 18 1	Third Transition Metals
30.	Zinc	Zn	65.37 65.54	IIB	2 8 18 2	
31.	Gallium	Ga	69.72	IIIA	2 8 18 3	B & C Fam.
32.	Germanium	Ge	72.59	IVA	2 8 18 4	B & C Fam.

ATOMIC No.	NAME	SYMBOL	ATOMIC WEIGHT	GROUP or	Number of Electrons in Each Shell						Special characteristics
33.	Arsenic	As	74.922	VA	2	8	18	5			N & O Fam.
34.	Selenium	Se	78.96	VIA	2	8	18	6			N & O Fam.
35.	Bromine	Br	79.909	VIIA	2	8	18	7			Halogen
36.	Krypton	Kr	83.80	VIIIA	2	8	18	8			Inert gas
37.	Rubidium	Rb	85.47	IA	2	8	18	8	1		A & A.E.M
38.	Strontium	Sr	87.62	IIA	2	8	18	8	2		A & A.E.M
39.	Yitrium	Y	88.905	IIIB	2	8	18	9	2		A & A.E.M
40.	Zirconium	Zr	91.22	IVB	2	8	18	10	2		First Transition Metals
41.	Niobium	Nb	92.906	VB	2	8	18	12	1		First Transition Metals
42.	Molybdenum	Mo	95.94	VIB	2	8	18	13	1		First Transition Metals
43.	Technetium	Tc	99.00	VIIB	2	8	18	13	2		
44.	Ruthenium	Ru	101.07	VIIIB	2	8	18	15	1		Triads Second Transition Metals
45.	Rhodium	Rh	102.91	VIIIB	2	8	18	16	1		Triads Second Transition Metals
46.	Palladium	Pd	106.4	VIIIB	2	8	18	18			Triads Second Transition Metals
47.	(Argentum) Silver	Ag	107.87	IB	2	8	18	18	1		Third Transition Metals
48.	Cadmium	Cd	112.40	IIB	2	8	18	18	2		Third Transition Metals
49.	Indium	In	114.82	IIIA	2	8	18	18	3		B & C Fam
50.	(Stannum) Tin	Sn	118.69	IVA	2	8	18	18	4		B & C Fam
51.	Antimony	Sb	121.75	VA	2	8	18	18	5		N & O Fam
52.	Tellurium	Te	127.60	VIA	2	8	18	18	6		N & O Fam
53.	Iodine	I	126.90	VIIA	2	8	18	18	7		Halogen
54.	Xenom	Xe	131.30	VIIIA	2	8	18	18	8		Inert gas
55.	Cesium	Cs	132.91	IA	2	8	18	18	8	1	A & A.E.M
56.	Barium	Ba	137.34	IIA	2	8	18	18	8	2	A & A.E.M
57.	Lanthanum	La	138.91	IIIB	2	8	18	18	9	2	A & A.E.M
58.	Cerium	Ce	140.12		2	8	18	19	9	2	
59.	Praseodymium	Pr	140.91		2	8	18	21	8	2	57 to 71
60.	Neodymium	Nd	144.24		2	8	18	22	8	2	Rare earths.
61.	Promethium	Pm	147.00		2	8	18	23	8	2	
62.	Samarium	Sm	150.35		2	8	18	24	8	2	
63.	Europium	Eu	151.96		2	8	18	25	8	2	
64.	Gadolinium	Gd	157.25		2	8	18	25	9	2	
65.	Terbium	Tb	158.92		2	8	18	26	9	2	
66.	Dysprosium	Dy	162.50		2	8	18	28	8	2	
67.	Holmium	Ho	164.93		2	8	18	29	8	2	
68.	Erbium	Er	167.26		2	8	18	30	8	2	
69.	Thulium	Tm	168.93		2	8	18	31	8	2	
70.	Yitrbium	Yb	173.04		2	8	18	32	8	2	
71.	Lutetium	Lu	174.97		2	8	18	32	9	2	
72.	Hafnium	Hf	178.49	IVB	2	8	18	32	10	2	72 to 74 Transition
73.	Tantalum	Ta	180.95	VB	2	8	18	32	11	2	72 to 74 Transition

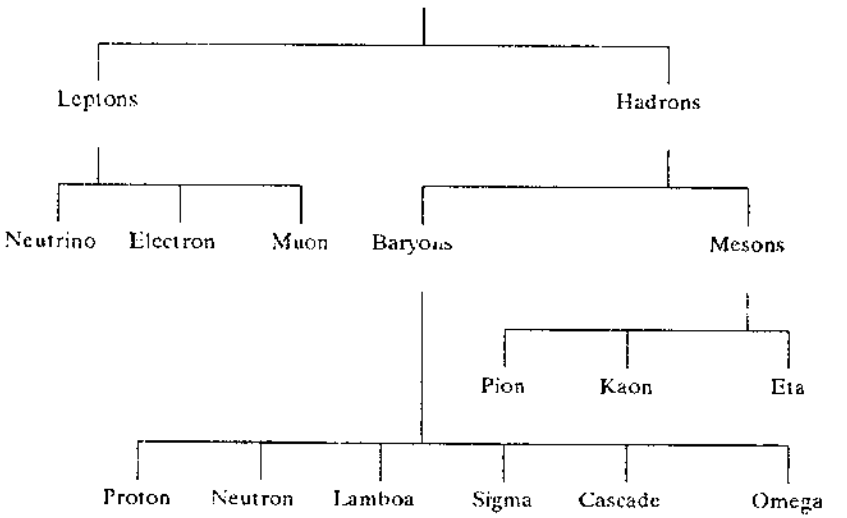
ATOMIC No.	NAME	SYMBOL	AWEIGHT	GROUP or FAMILY	Number of Electrons in Each Shell	Special characteristics
74.	(Wolfram) Tungsten	W	183.85	VIB	2 8 18 32 12 2	Metals
75.	Rhenium	Re	186.2	VIIB	2 8 18 32 13 2	
76.	Osmium	Os	190.2	VIIIB	2 8 18 32 15 2	The Triads
77.	Iridium	Ir	192.2	VIIIB	2 8 18 32 15 2	Second
78.	Platinum	Pt	195.09	VIIIB	2 8 18 32 17 1	Tr. Metals
79.	(Aurum) Gold	Au	196.97	IB	2 8 18 32 18 1	Third Tr.
80.	(Hydragyrum) Mercury	Hg	200.59	IIB	2 8 18 32 18 2	Metals
81.	Thallium	Ti	204.37	IIIA	2 8 18 32 18 3	B & C Fam.
82.	(Plumbum) Lead	Pb	207.19	IVA	2 8 18 32 18 4	
83.	Bismuth	Bi	208.98	VA	2 8 18 32 18 5	N & O
84.	Polonium	Po	210	VIA	2 8 18 32 18 6	Families
85.	Astatine	At	210	VIIA	2 8 18 32 18 7	Halogen
86.	Radon	Rn	222	VIIIA	2 8 18 32 18 8	Inert gas
87.	Francium	Fr	223	IA	2 8 18 32 18 8 1	A & A.M.
88.	Radium	Ra	226	IIA	2 8 18 32 18 8 2	A & A.M.
89.	Actinium	Ac	227		2 8 18 32 18 8 2	
90.	Thorium	Th	232.04		2 8 18 32 18 10 2	
91.	Protactinium	Pr	231		2 8 18 32 20 9 2	89 – 103
92.	Uranium	U	238.03		2 8 18 32 21 9 2	Actinide metals
93.	Neptunium	Np	237		2 8 18 32 22 9 2	
94.	Plutonium	Pu	242		2 8 18 32 24 8 2	
95.	Americium	Am	243		2 8 18 32 25 8 2	
96.	Curium	Cm	247		2 8 18 32 25 9 2	
97.	Berkelium	Bk	247		2 8 18 32 27 8 2	93 to 103
98.	Californium	Cf	249		2 8 18 32 28 8 2	Man made
99.	Einseinium	Es	254		2 8 18 32 29 8 2	elements
100.	Fermium	Fm	253		2 8 18 32 30 8 2	
101.	Mendelevium	Md	256		2 8 18 32 31 8 2	
102.	Nobelium	No	254		2 8 18 32 32 8 2	
103.	Lawrencium	Lw	257		2 8 18 32 32 9 2	

TABLE OF PARTICLES

	Particle Name	Mass	Spin	Charge	Anti-Particle	Typical Mode of Delay/Average Life-Time
	Photon	0	1	Neutral	Same Particle	Stable/Infinite
	Graviton[3]	0	2	Neutral	Same Particle	Stable/Infinite
LEPTONS	Electron Neutrino	0	1/2	Neutral	–	Stable/Infinite
	Elecctron	1	1/2	Negative	–	Stable/Infinite
	Muon Neutrino	0	1/2	Neutral	–	Stable/Infinite
	Muon	207	1/2	Negative	–	Unstable/2.2 Millionths of a Second (2.2×10^{-6})
	Tau Neutron[3]	–	1/2	Nutral	–	–
	Tau	3536	1/2	Negative	–	Unstable/–
MESONS	Pion-	273	0	Positive	–	Unstable/26 Billionths of a second (26×10^{-9})
	Pion	273	0	Negative	–	Unstable/26 Billionths of a second (26×10^{-9})
	Pion°	264	0	Neutral	Same-Particle	Unstable/80 Quintillionths of a second (80×80^{-18})
	Kaon	996	0	Positive	–	Unstable/12 Billionths of a second (12×10^{-9})
	Kaon°	974	0	Neutral	–	Kaon° (Short) – Unstable/90 Trillionths of a Second (90×10^{-12})
	Eta	1074	0	Neutral	–	Kaono (Long) – Unstable/52 Billionths of a Second (52×10^{-9})
	D	3656	0	Positive	Same-Particle	Unstable/0.8 Quillionth of a Second (0.8×10^{-16})
	D	3646	0	N	–	Unstable/–
	F[3]	–	0	Positive	–	Unstable/–

BARYONS	Proton	1836	1/2	Positive	–	Stable/Infinite
	Neutron	1837	1/2	Neutral	–	Unstable/9/8 Seconds
	Lambda	2183	1/2	Neutral	–	Unstable/0.3 Billionths of a second ($0.3x10^{-9}$)
	Sigma	2328	1/2	Positive	–	Unstable/80 Trillimonths of a second ($80x10^{-12}$)
	Sigma[c]	2334	1/2	Neutral	–	Unstable/58 Sextillionths of a second ($58x10^{-21}$)
	Sigma	2343	1/2	Negative	–	Unstable/0.2 Billionth of a second ($0.2x10^{-9}$)
	Xi[c]	2573	1/2	Neutral	–	Unstable/0.3 Billionth of a second ($0.3x10^{-9}$)
	Xi-	2586	1/2	Negative	–	Unstable/0.2 Billionth of a second ($0.2x10^{-9}$)
	Omega	3272	3/2	Negative	–	Unstable/0.1 Billionth of a second ($0.2x10^{-9}$)
	Lambda[3]	–	–	Positive	–	–/–

TABLE OF PARTICLES



Glossary

SCIENTIFIC TERMS

absolute zero : The lowest possible temperature, at which a substance contains no heat energy.

acceleration : The rate at which the speed of an object is changing.

antiparticle : Each type of matter particle has a corresponding anti-particle. When a particle collides with its antiparticle, they annihilate, leaving only energy (page 34).

atom : The basic unit of ordinary matter, made up of a tiny nucleus (consisting of protons and neutrons) surrounded by orbiting electrons (page 19).

big bang : The singularity at the beginning of the universe (page 59/60).

black hole : A region of space-time from which nothing, not even light, can escape, because gravity is so strong (page 64).

conservation of energy : The law of science that states that energy (or its equivalent in mass) can be neither created nor destroyed (page37).

coordinates : Numbers that specify the position of a point in space and time.

cosmology : The study of the universe as a whole;

micro cosmology : The study of micro (=small) universe i.e. the atom and the elementary particles.

electric charge : a property of a particle by which it may repel (or attract) other particles that have a charge of similar (or opposite) sign (page 39).

electromagnetic force : The force that arises between particles with electric charge, the second strongest of the four fundamental forces (page 31).

electron : A particle with a negative electric charge that orbits the nucleus of an atom.

electron-volt (eV) : It is a unit of energy of electromagnetic force with which the elementary particles are held together in an atom. (It is energy acquired by any particle with one unit of charge falling through a potential difference of 1 volt.)

The force that binds the electrons to the atomic nuclei is about 10 eV., whereas the force which holds protons and neutrons together in neuclei is about 10 million eV.

1 GeV=1 giga electron-volt.

giga=100 million.

electroweak unification energy : The energy (around 100 GeV) above which the distinction between the electromagnetic force and the weak force disappears (page 32).

elementary particle : A subatomic particle that, it is believed, cannot be subdivided.

event : An event is something that happens at a particular point in sapce and at a particular time, i.e., it is a point in space- time continuum, specified by its time and place.

exclusion principle : Two identical spin-1/2 particles cannot have (within the limits set by the uncertainty principle) both the same position and the same velocity (page 64).

field : Something that extends in space and time, as opposed to a particle that exists at only one point at a time.

frequency : For a wave, the number of complete cycles per second.

gamma ray : Electromagnetic waves of very short wavelength, produced in radioactive decay or by collisions of elementary particles.

grand unification energy : The energy above which, it is believed, the electromagnetic force, weak force and strong force become indistinguishable from each other (page 46).

light-second/light-year : The distance travelled by light in one second/year.

magnetic field : The field responsible for magnetic forces, now incorporated, along with the electric field, into the electromagnetic field.

mass : The quantity of matter in a body; its inertia, or resistance to acceleration.

microcosmology : see, cosmology.

neutrino : An extremely light (possibly massless) elementary particle that is affected only by the weak force and gravity. (page 37).

neutron : An uncharged particle, otherwise very similar to the proton, which accounts for roughly half the particles in the nucleus of most atoms (page 21).

neutron star : A cold star, supported by the exclusion principle repulsion between neutrons (page 64).

nuclear fusion : The process in which two nuclei collide and coalesce to form a single, heavier nucleus (page 54).

nucleus : The central part of an atom, consisting only of protons and neutrons, held together by the strong force.

particle accelerator : a machine that, using electromagets, can accelerate moving charged particles, giving them more energy.

phase : For a wave, the position in its cycle at a specified time : a measure of whether it is at a crest, a trough, or at some point between.

photon : A quantum of light.

Planck's quantum principle : The idea that light (or any other classical waves) can be emitted or absorbed only in discrete quanta, whose energy is proportional to their frequency (page 23).

positron : The (positively charged) antiparticle of the electron.

primordial black hole : a black hole created in the very early universe (page 64).

proton : The positively charged particles that make up roughly half the particles in the nucleus of most atoms.

quantum : The indivisible unit in which waves may be emitted or absorbed.

quantum mechanics : The theory developed from Planck's quantum principle and Heisenberg's uncertainty principle (page 41).

quark : A (charged) elementary particle that feels the strong force. Protons and neutrons are each believed to be composed of three quarks (page 44).

radioactivity : The spontaneous breakdown of one type of atomic nucleus into another (page 17).

space-time-continuum : According to the special theory of relativity, our reality is four-dimensional, in which space has three dimensions and the fourth dimension is time. Thus, there is no such thing as space and time ; but there is only space-time. A continuum is something that cannot be broken down into parts. It flows continuously.

spatial dimensions : Any of the three dimensions of space-time that are spacelike—that is, any except the time dimension.

spectrum : The splitting of, say, an electromagnetic wave into its component frequencies/wave-lengths (page 15).

spin : An internal property of elementary particles, related to, but not identical to, the everyday concept of spin (page 39).

standing wave : Standing waves are patterns of waves confined to a finite region like the waves in a vibrating string such as a clothes-line. Electrons orbiting in an atom are not spherical objects, but patterns of standing waves (page 26).

stationary state : One that is not changing with time : a sphere spinning at a constant rate is stationary because it looks identical at any instant, even though it is not static.

strong force : The strongest of the four fundamental forces, with the shortest range of all. It holds the quarks together within protons and neutrons, and holds the protons and neutrons together to form atoms (page 31).

theory of relativity : Einstein's theory based on the idea that the laws of science should be the same for all observers, no matter

how they are moving. It explains the force of gravity in terms of the curvature of a four-dimensional space-time.

uncertainty principle : One can never be exactly sure of both the position and the velocity of a particle, the more accurately one knows the one, the less accurately one can know the other (page 27).

virtual particle : In quantum mechanics, a particle that can never be directly detected, but whose existence does have measurable effects (page 40).

wave/particle duality : The concept in quantum mechanics that there is no distinction between waves and particles, particles may sometimes behave like waves, and waves like particles (page 23).

wave-length : For a wave, the distance between two adjacent troughs or two adjacent crests.

weak force : The second weakest of the four fundamental forces, with a very short range. It affects all matter-particles, but not force-carrying particles (page 31).

weight : The force exerted on a body by a gravitational field. It is proportional to, but not the same as, its mass.

white dwarf : A stable cold star, supported by the exclusion principle repulsion between electrons (page 63).

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Late J. S. Zaveri

He was an Honourary Professor in the Department of 'Science of Living', in the Deemed University of Jain Vishva Bharati Institute, Ladnun. He was also awarded the honour of "Prekshā- pravaktā" i.e., an Exponent of "Prekshā System of Meditation by Ganadhipati Shri Tulsi, the Anushasta of our deemed university. He was equally well-versed in both the modern neuroscience and the ancient science of karma. He had to his credit several books in the field of comparative study of Science and Philosophy/Spirituality. His works "**Microcosmology : Atom in Jain Philosophy & Modern Science**", "**Human Body : Design & Function**", "**Prekshā Dhyana : Health Care**" "**Jain Biology**" speak highly of his deep erudition and lucid style of simplifying the intricate theories.

Born as a Jain devotee and educated in Science and Technology, and being a Professional Electric Engineer and an active exponent of Preksha Meditation, he had developed a rare skill of dealing science and philosophy with equal authenticity.

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As a Jain Monk, he is a ***Padyātri*** having travelled over 25,000 kms. on foot. He has established close contacts with the national leaders including almost all past and present Prime Ministers and Presidents of India. "His demonstration of **avadhana vidya**"—the rare ancient science of memory—at several universities and international conferences has earned him an epithet of "human computer".

His work "***The Enigma of the Universe***" and "***Vishva Praheliká***" (Hindi Version) is a research in the field of cosmology of modern science and ancient Jain Philosophy.

He is an able translator and editor of score of books.

In worldly relation, he is the son of Late Shri J.S. Zaveri. At 20, after passing in first class in B.Sc. (Hons.) from University of Bombay, he was initiated in monkhood.

"Both Indian & Western scholars & researchers have recently become aware of the need of reinterpretation of the classical philosophical thought, because it is precisely amenable to such reinterpretation.

"In every epoch, there is importance and universal relevance of any classical thought, philosophical or otherwise. The present work aims at a critical study of the Jain theory of ultimate atom (Paramāṇu Pudgala), in light of modern scientific theory. The work is certainly important and the author needs to be congratulated. The chapter giving the development of the scientific thought, upto latest development of the high energy physics, is both concise and precise. Coming as it does from a student of science, it has come upto an expectation. The author's efforts is commendable, precisely because it gives to a student of philosophy, in a compact form, the gist of the development of scientific thought upto what is called particle physics, and for this, any student of philosophy should be grateful to him. ...

"..... The book deserves a serious attention of readers because the account of modern scientific thought given in it is good and also because the Jain philosophy that it has explained are indeed praiseworthy. We unhasitatingly recommend it to readers."

– Review in the Annals of Bhandarkar Oriental Research Institute Pune, LVII, (1976), pp. 273, 278