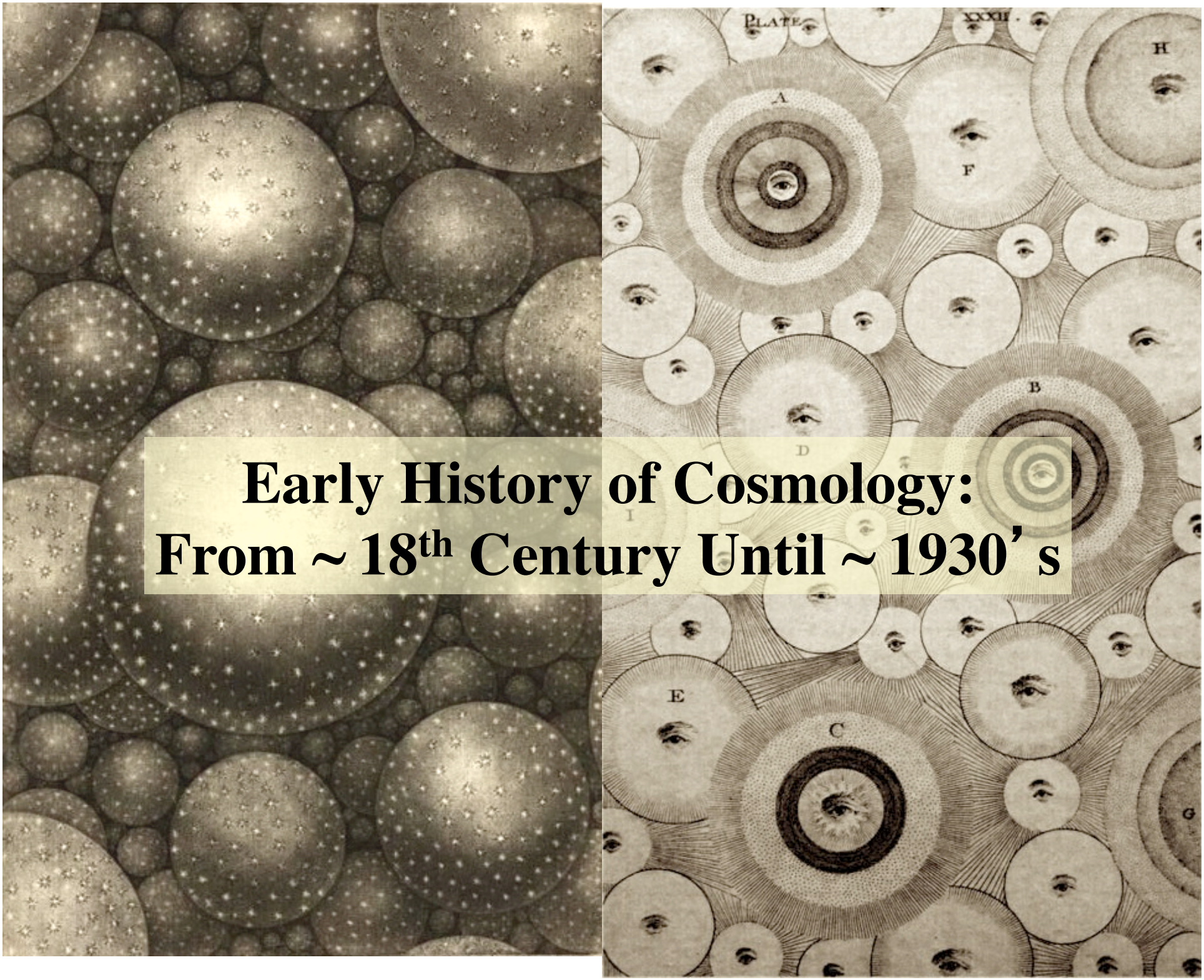
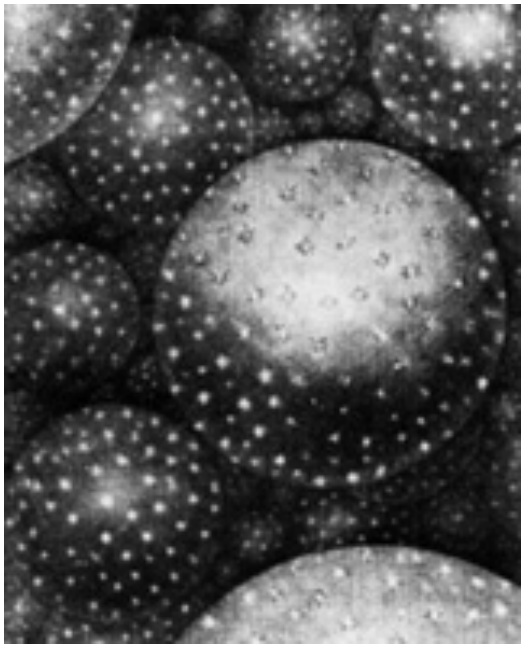


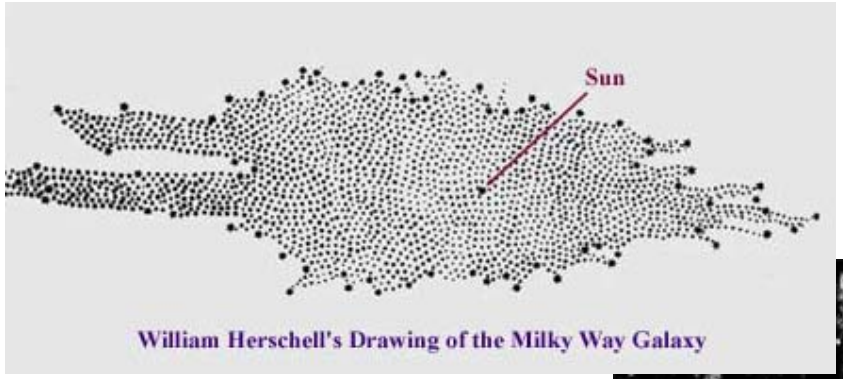
Early History of Cosmology: From ~ 18th Century Until ~ 1930's

The Discovery of Galaxies

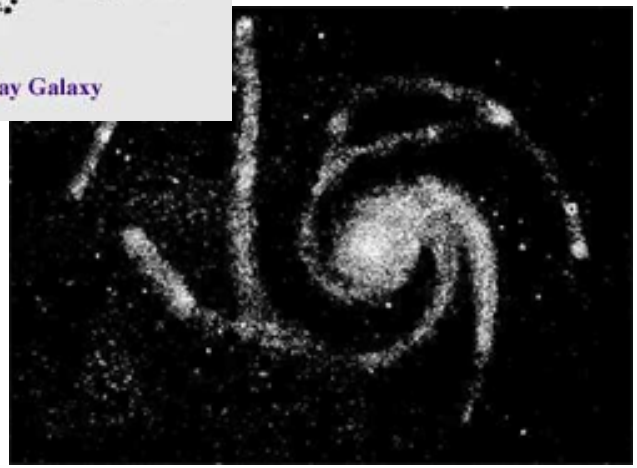
18th Century:

- The first catalogs of "nebulae": Charles Messier, William Herschel
- The pioneers of "island universes": Thomas Wright, Immanuel Kant





William Herschell's Drawing of the Milky Way Galaxy



19th and Early 20th Centuries:

- More catalogs, first spectra, but no physical understanding

The Shapley-Curtis Debate
on the nature of faint nebulae (= galaxies)

At the meeting of the National Academy of Sciences in Washington on 26 April 1920, Harlow Shapley of Mount Wilson and Heber D. Curtis of Lick Observatory gave talks under the title "The Scale of the Universe"

☛ Shapley argued that the nebulae are parts of our own Galaxy, the only one

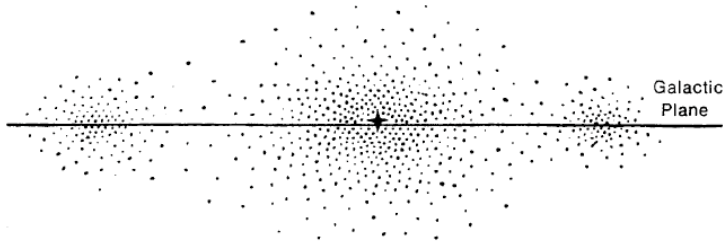
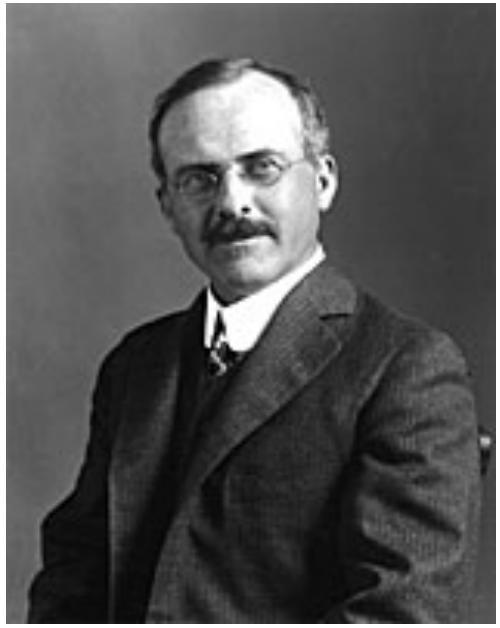


FIG. 3—Arthur Eddington's (1912) galaxy placed the Sun's position 60 LY above the center of the galactic plane.

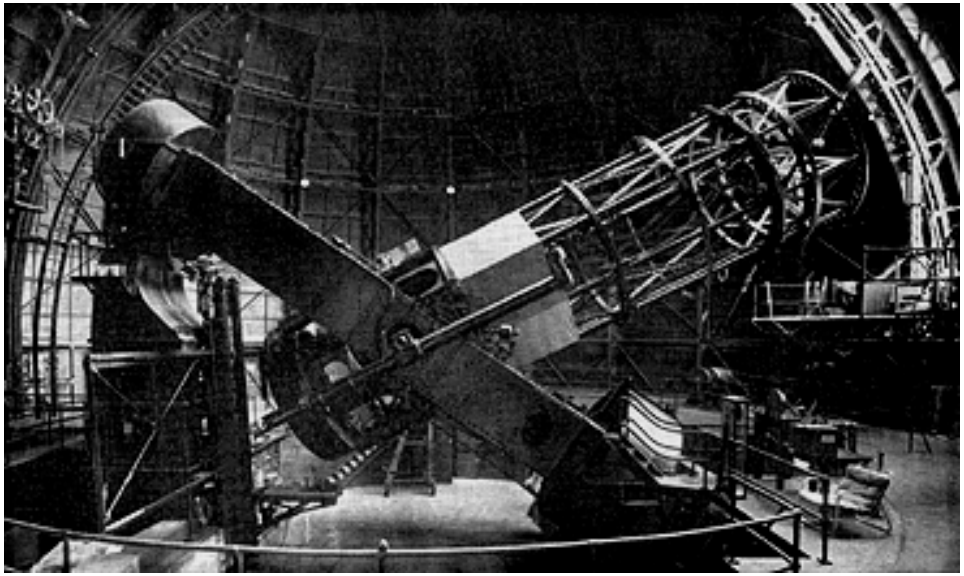


Curtis ☛ thought that these are other galaxies, just like ours

The Resolution: Nebulae are Extragalactic

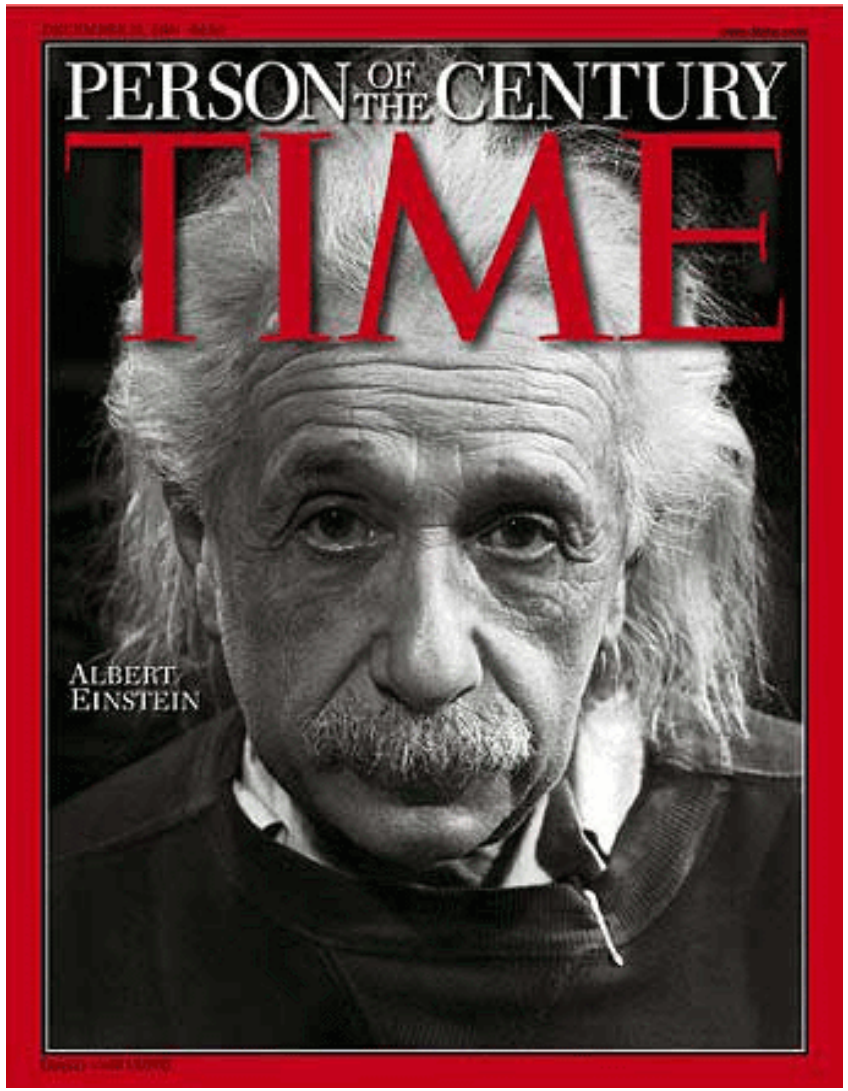
- In 1923 Hubble resolved Cepheids in M31 (Andromeda)
- A profound shift in the understanding of the scale of the universe

Edwin Hubble

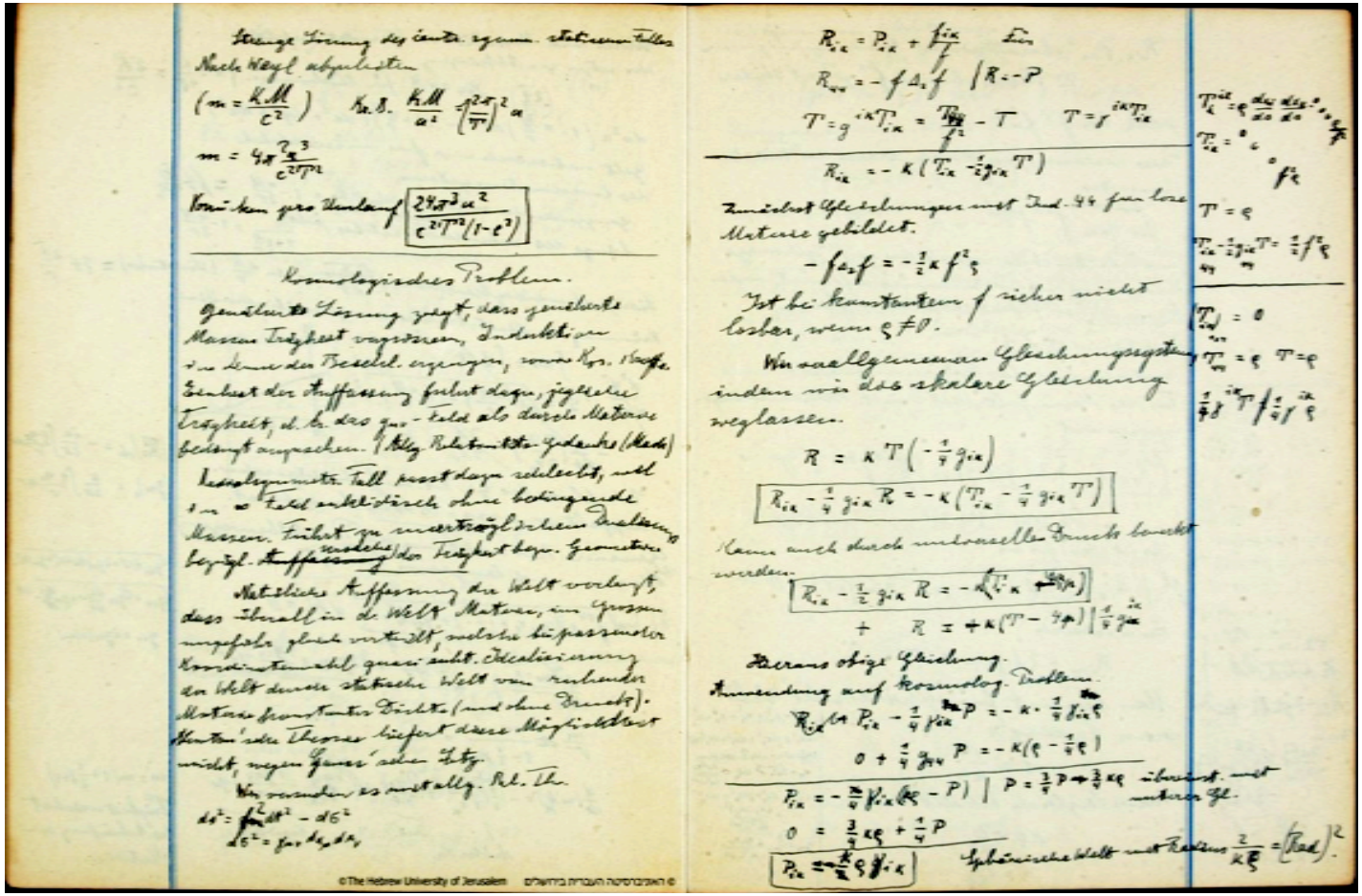


The Mt. Wilson 100-inch

Theoretical Basis of Modern Cosmology: The General Theory of Relativity (1915)



Einstein's lecture notes for a course he taught on GR in 1919. The final topic of the course was cosmology, which he had begun to investigate only two years earlier. Here he describes his methods in constructing the first mathematical model of cosmology in GR. This universe contains non-relativistic matter, stars and nebulae in agreement with the contemporary observations, but is spatially finite.

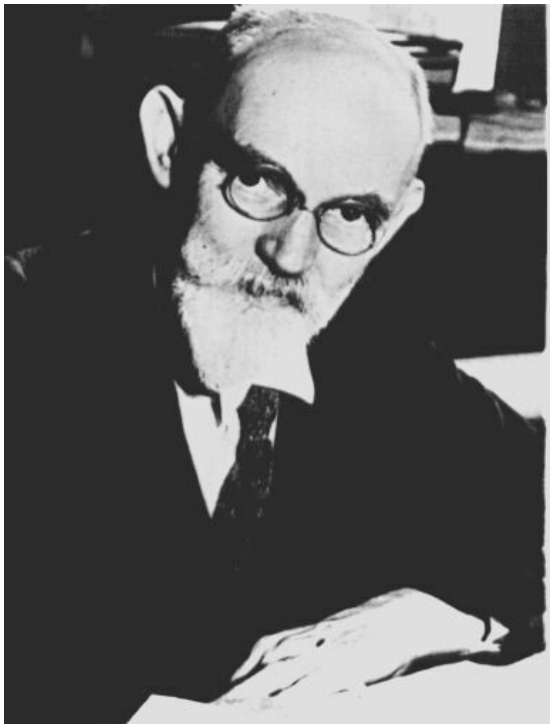


(From R. Caldwell)

The Early Cosmological Models

Einstein in 1917 constructed the first relativistic cosmological models. Thinking that the universe is static, he introduced the cosmological constant term to balance the force of gravity. This model was unstable.

Willem De Sitter in 1917 also developed a similar model, but also obtained solutions of Einstein equations for a nearly empty, ***expanding*** universe.



In 1932, Einstein & De Sitter jointly developed another, simple cosmological model which bears their names.

Discovery of the Expanding Universe

Vesto Melvin Slipher
(1917)

Knut Lundmark
(1924)

And also Carl Wirtz (1923)

TABLE I.

RADIAL VELOCITIES OF TWENTY-FIVE SPIRAL NEBULÆ.

Nebula.	Vel.	Nebula.	Vel.
N.G.C. 221	− 300 km.	N.G.C. 4526	+ 580 km.
224	− 300	4565	+1100
598	− 260	4594	+1100
1023	+ 300	4649	+1090
1068	+1100	4736	+ 290
2683	+ 400	4826	+ 150
3031	− 30	5005	+ 900
3115	+ 600	5055	+ 450
3379	+ 780	5194	+ 270
3521	+ 730	5236	+ 500
3623	+ 800	5866	+ 650
3627	+ 650	7331	+ 500
4258	+ 500		

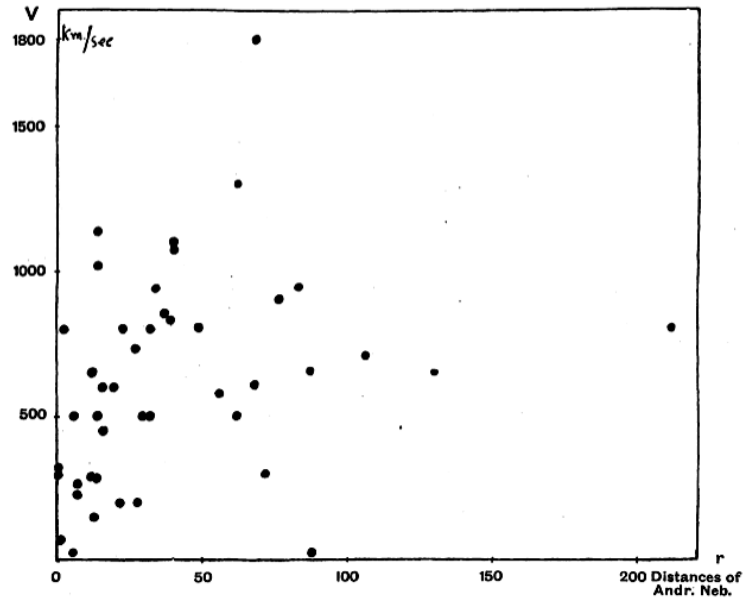
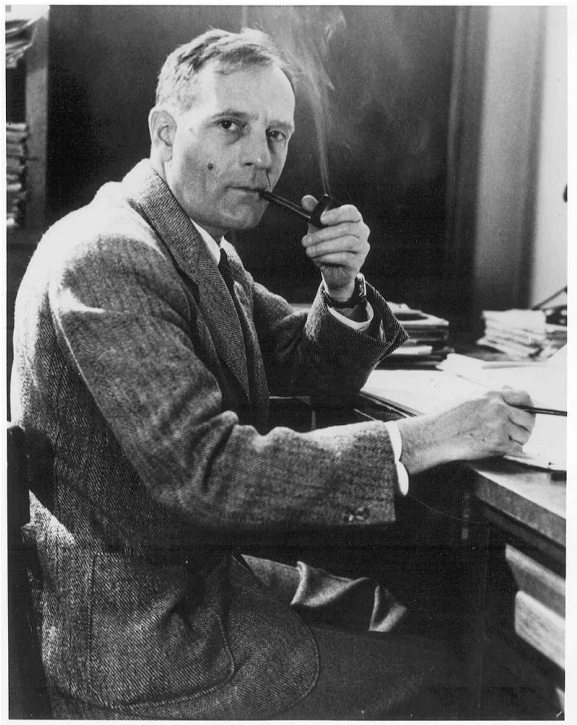
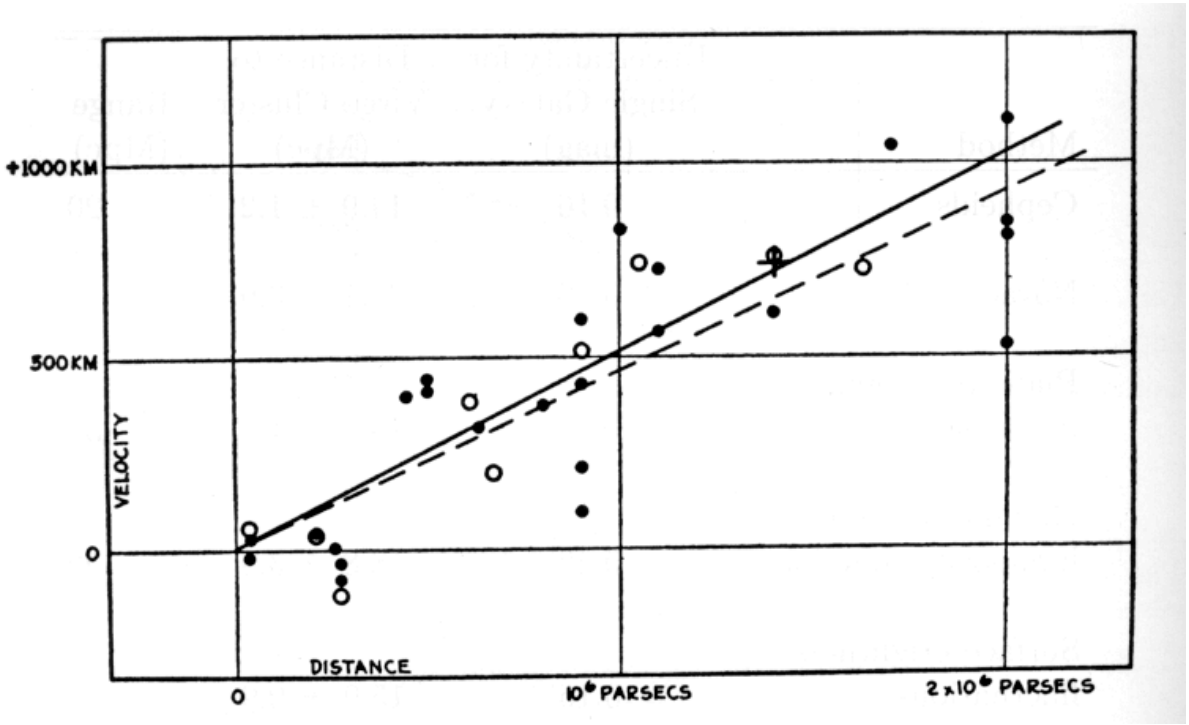


FIG. 5.—Relation between the relative distances (the unit is the distance of the Andromeda nebula) and the measured radial velocities of spiral nebulæ.

Discovery of the Expanding Universe



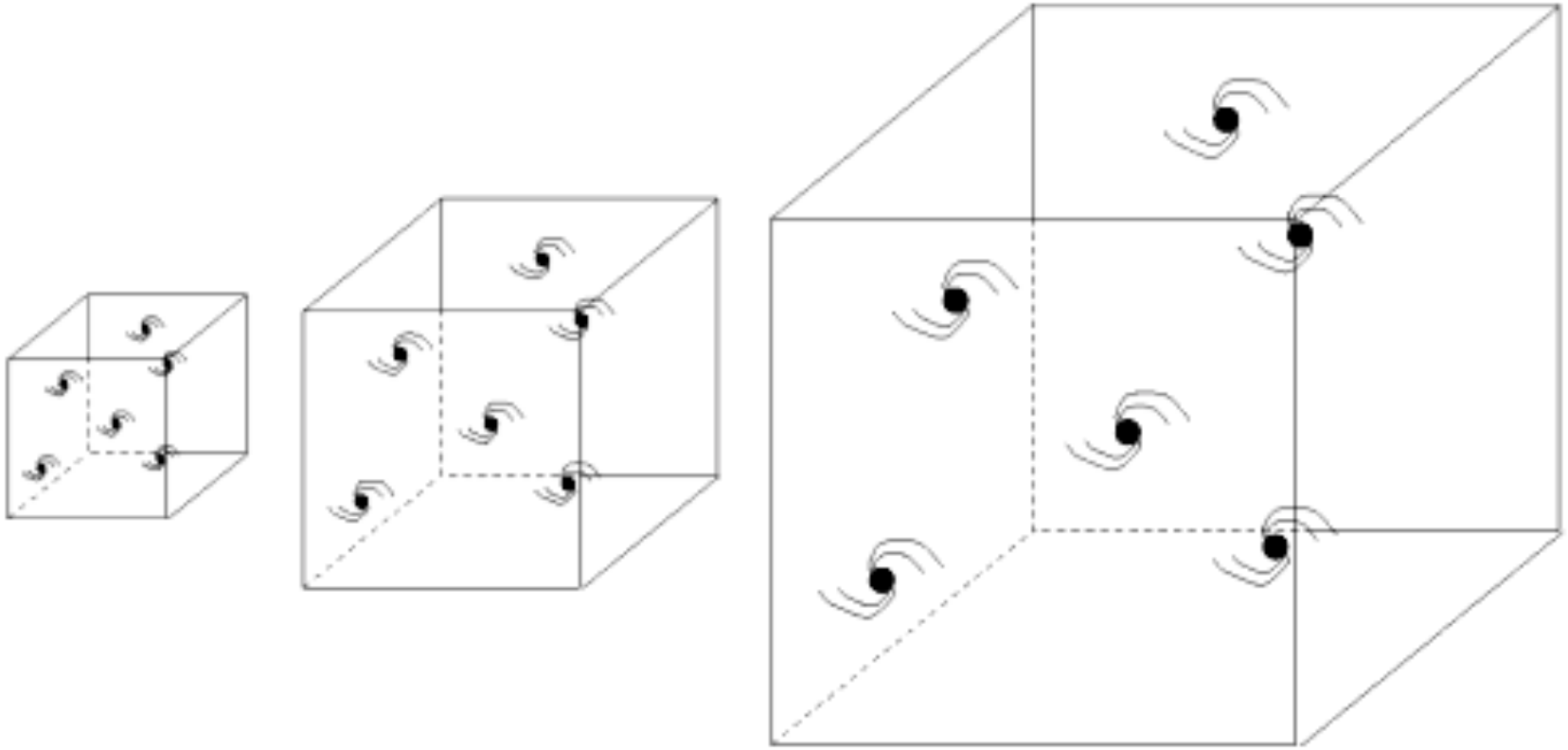
Edwin Hubble (1929)



The Hubble diagram (1936)

The expansion of the universe was then called “the De Sitter effect”

Expansion of the Universe



The space itself expands, and carries galaxies apart

In a homogeneous, isotropic universe, there is no preferred center

Einstein got to see for himself …

Dat vass die biggest mistake of meine kareer …

… by which he probably meant failing to predict the expansion of the universe - not necessarily introducing the cosmological constant to stop it …

Einstein, Hubble, and Walter Adams on Mt. Wilson, 1931

The Friedmann and Lemaitre Models

⇦ **Alexander Friedmann**

In 1922 developed the GR-based, expanding universe model. It was not taken very seriously at the time, since the expansion of the universe has not yet been established.

Georges Lemaitre ⇨

In 1927 independently developed cosmological models like Friedmann's. In 1933, he "ran the film backwards" to a hot, dense, early state of the universe he called "the cosmic egg". This early prediction of the Big Bang was largely ignored.

Development of Relativistic Cosmology

Edward Milne

Arthur Eddington

Howard Robertson

Geoffrey Walker

- E. Milne in 1933 developed "kinematical relativity", and a cosmological model based on the special relativity
- A. S. Eddington promoted and developed relativistic models, and began the interface of quantum theory and cosmology
- H. Robertson and G. Walker in 1930's developed a sounder mathematical basis for GR cosmology and the eponymous metric


Next:
History of Cosmology:
Mid ~ 20th Century