Introductory Astronomy

Week 6: Relativity and Black Holes

Clip 7: Conservation Laws

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Conservation Laws

- Newtonian conservation laws are not Lorentz-invariant
- Find relativistic conserved quantities

$$\vec{p} = \frac{m\vec{v}}{\sqrt{1-v^2/c^2}} \sim m\vec{v}(1+v^2/2c^2)$$

$$E = \frac{mc^2}{\sqrt{1-v^2/c^2}} \sim mc^2(1+v^2/2c^2) = mc^2 + mv^2/2$$

Remarks

- $E^2 - \vec{p}^2 c^2 = m^2 c^4$ invariant mass
- $(E, c^2\vec{p})$ transform under Lorentz like $(t, \vec{x})$
- These conservation laws hold always. Lavoisier 1777 would find that energy lost to radiation reduced mass slightly
- Decay of a particle that does not conserve mass is consistent with these – and happens
- Other conserved quantities Q, L are invariant

Relativistic Laws

- Electromagnetism (Maxwell) is Lorentz-invariant
- Nuclear interactions have Lorentz-invariant form
- Quantum relativistic version (Quantum Field Theory 1940/1972.
- Gravity????