MODELS OF THE UNIVERSE

1. From Static to Expanding Universes
    - 1917: Einstein and a finite static model
      de Sitter and an empty expanding model
    - 1922: Friedmann and a dynamic universe
    - 1929: Hubble and the Expansion
    - 1931: Lemaître and the Primeval Atom

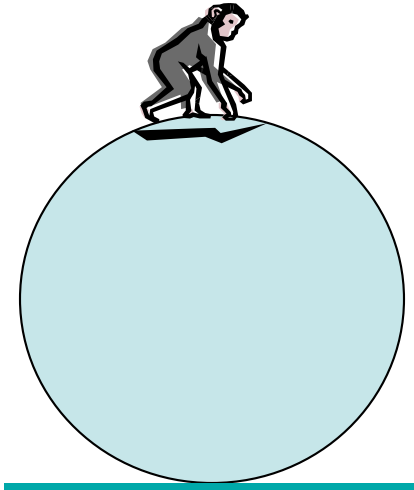
2. The Big Bang Model
    - 1948: Steady-State universe
    - 1948: The BB model
    - 1965: Confirmation of BB model
    - Limitations of the BB model

1917: **Einstein applies GR to universe as a whole**

GEOMETRY = MATTER/ENERGY

cosmological principle: universe same anywhere

Tries static model: unstable, so added "cosmological constant"



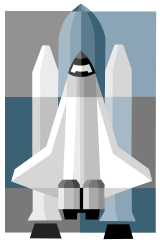
Closed geometry:
Universe is finite without
a boundary

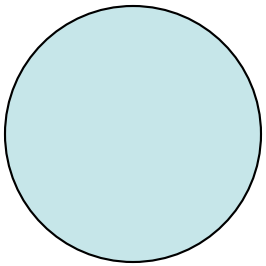
$$\rho = \frac{mass}{volume} = \frac{energy}{volume}$$ = constant

Universe is "same" everywhere: static and homogeneous

1917: de Sitter proposes model only with Λ (cosm. const.)
rapid expansion, but empty cosmos...
a fair approximation
("truth" somewhere in between)

1922: Friedmann -- Universe is dynamic ➡ $\rho(t)$
Universe can change in time (no Λ required)
What is its geometry? Open or closed? And its fate?
➡ it depends on its energy density ρ

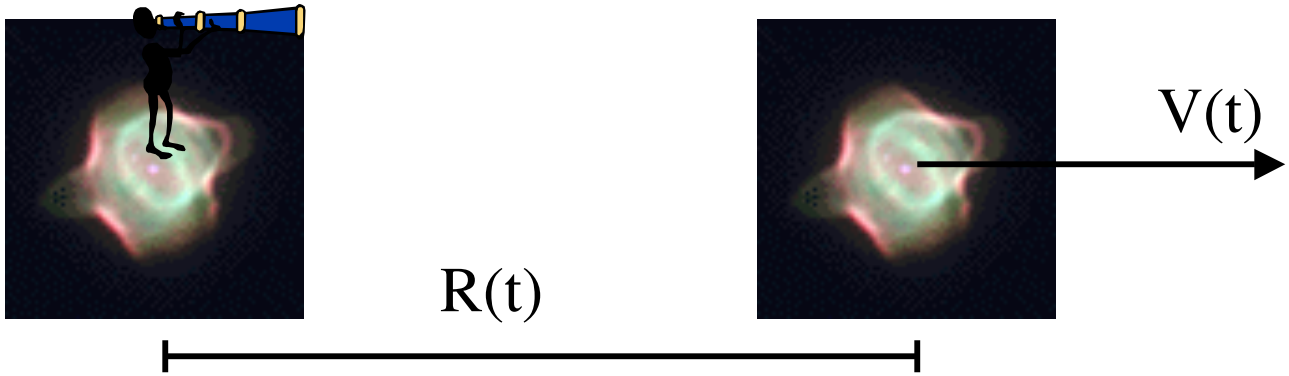


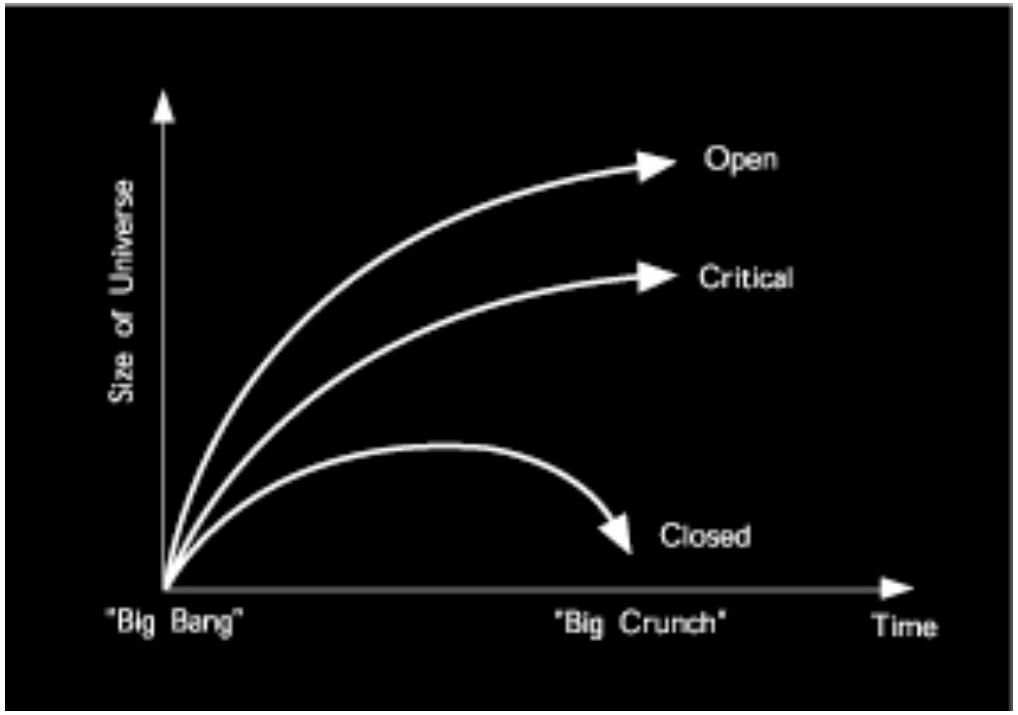


Expansion fights gravitational attraction!!

Geometry and "destiny"

It all depends on "critical density", $\rho_{critical}=10^{-29}g/cm^3$
(about 1 atom of H per cube of 0.5 meter side)





Open: $\rho < \rho_{critical}$

Critical: $\rho = \rho_{critical}$

Closed: $\rho > \rho_{critical}$

Which desktop universe
Corresponds to real one?