Pls hand in PS #6

Bondi & Gold 1950s

UNIVERSE EXPANDS

"Big Bang"

in the past: denser
hotter

in the future: sparser
cooler

things change in time
→ implication
"initial singularity"

past is different
from present

observable through
"look back time"

"Steady State"

new matter/energy
is created to
fill in the voids

past future
→ density same
other clocks same

→ eternal
infinite

exists
matter/energy
creation

1960s:

* Discovery of "quasars"
(accretion supermassive black holes)

HUGE energy source

high redshifts → large distances

⇒ MANY MORE QUASARS IN THE PAST

⇒ a change in the composition of universe

* "cosmic microwave background" radiation generated when universe was MUCH DENSER HOTTER → 10^4 °K SMOOTHER

strong support for B.B.

* 3/4 H, 1/4 He ⇒ when early universe [illegible] was H fusion → He

in first three minutes
1/4 of H fuses → He
afterwards no more (too cool)

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by now: galaxies evolve significantly

⇒ Big Bang

FABLE: demise of steady state

MORAL: some science is anti-atheistic not anti-religious

"Big Bang"

in past: denser, hotter, smoother

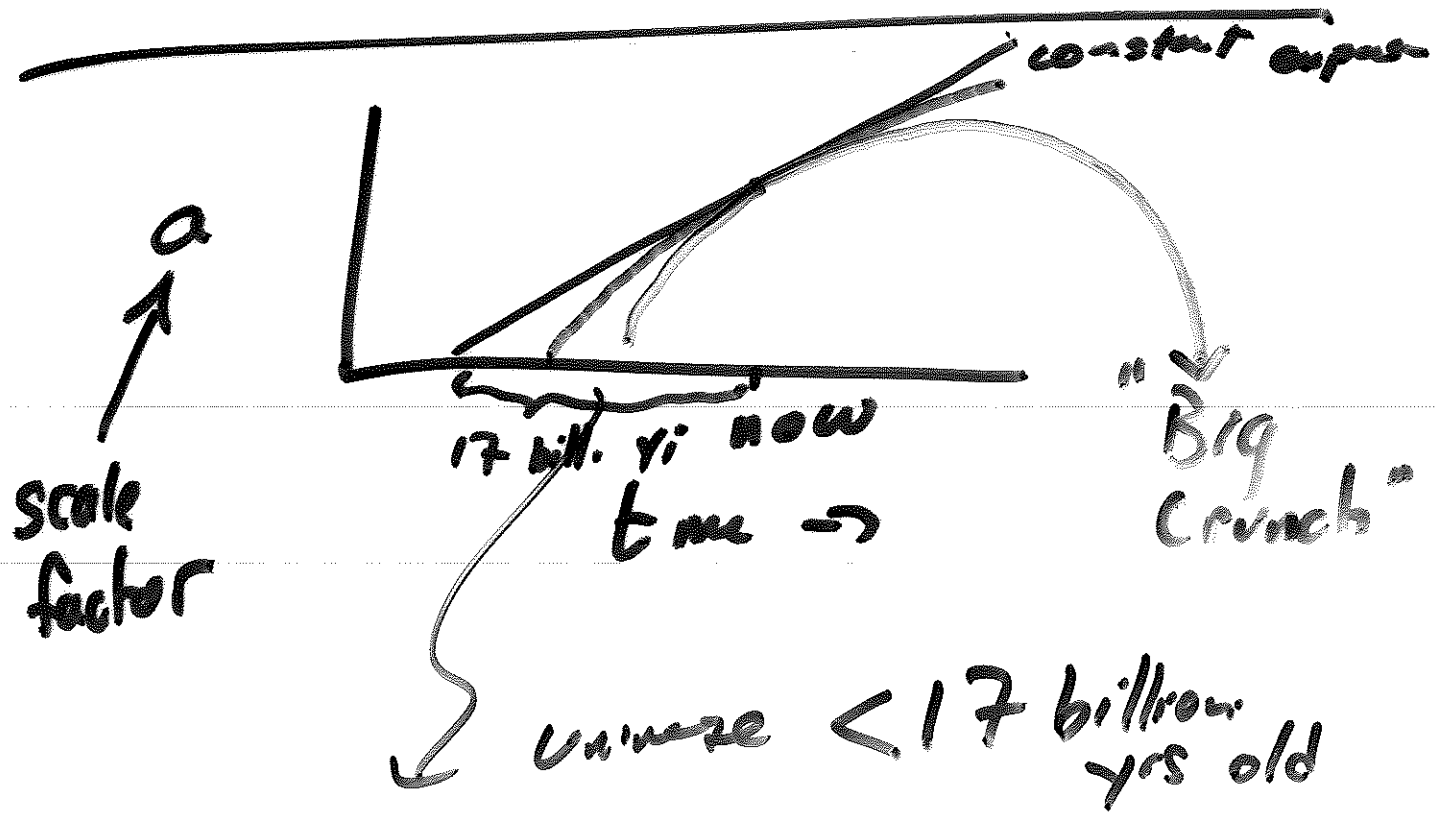
extrapolate to initial singularity

1 yr = 3×10^7 s

age of Universe is

$$\frac{5 \times 10^{17}}{3 \times 10^7} = 1.7 \times 10^{10}$$

17 billion yrs



$V = HD$

↳ "Big Bang"

In a car driving 50 mph
100 miles away from
starting point.
How long have you been
driving?

$$t = \frac{D}{V} = \frac{100}{50} = 2 \text{ hrs}$$

(provided speed is constant)

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galaxy A is at distance D
moving at velocity V
going for a $t = D/V$

$V = HD$ | $\frac{D}{V} = \frac{1}{H}$

Hubble Law

measured!

Age of Universe $= 1/H$

$H = 70 \text{ km/s/Mpc}$

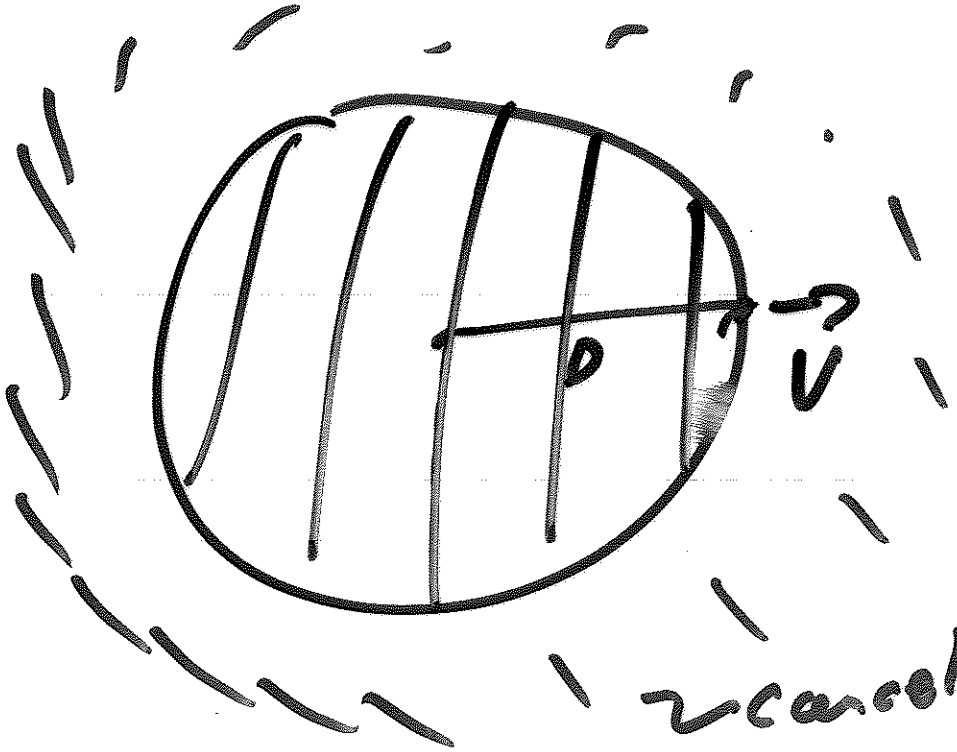
$H = 70 \text{ km/s/Mpc} \left(\frac{\#\text{ of Mpc}}{1 \text{ km}}\right)$

$\hookrightarrow \frac{10^3}{10^6 \, 3 \times 10^{16}}$

$= \frac{1}{3} \times 10^{-19} = 3 \times 10^{-20}$

$H = 2 \times 10^{1} \times 3 \times 10^{-20} = 20 \times 10^{-19} = 2 \times 10^{-18}$ 1/s

$1/H = \frac{1}{2 \times 10^{-18}} = \frac{1}{2} \times 10^{18} = 5 \times 10^{17}$ s



$$V_{esc} = \sqrt{\frac{2GM}{D}}$$

is $V > V_{esc}$?

M = density · volume

$= \rho \frac{4}{3}\pi D^3$ $\quad V = HD$

is $HD > \sqrt{\frac{2G}{\pi}\rho\frac{4}{3}\pi\pi^2 D^2}$

is $H^2 D^2 > 2G\rho \frac{4}{3}\pi D^2$?

is $\rho < \frac{3H^2}{8\pi G}$

$\Downarrow$

ρ_{CRIT}

if $\rho < \rho_{CRIT}$ universe expands forever

if $\rho > \rho_{CRIT}$ universe recollapses

$$\frac{3 \cdot (2 \times 10^{-18})^2}{8\pi \, 7 \cdot 10^{-11}} = 6 \times 10^{-27} \text{ kg/m}^3$$