

* w. class reached. (?)

* outline of next 4 classes

Today: • consensus model ~~the~~

+ next

- how we know each one

- implications (e.g. time frame over which a given component dominates)

i: what that looks like -

• $\Omega_m \approx 0.27$ i: comparison to / interp of

Figs 24.3, 24.4

... proper distance, horizon distance...

↳ constraints on model parameters

from Hubble Law measurements

⇒ Accelerating Univ.

• dark matter

so... we did, briefly

$$\Omega_b \approx 0.04$$

$$\text{but } \Omega_m \approx 0.3$$

based on gravitational effects

$$\therefore \Omega \approx 0.26$$

is non-baryonic dark matter

based on counting galaxies
(really, measuring brightnesses of galaxies, assuming all light comes from stars ... i: knowing how luminous stars of a given mass are...)

↳ let's explore these gravitational effects: ~~the~~

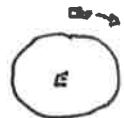
i) already mentioned grav. lensing

(nothing quantitative, just: more mass \rightarrow more distortion/lensing ... but realize that w/ lots of technical analysis you can both "weigh" the mass & map out its distribution)

ii) using orbital motion to weigh dark matter

Dark Matter in gravitational dynamics

Kepler's 3rd law:



$$P^2 = \frac{4\pi^2 r^3}{GM}$$

↳ comes from $F_c = F_g$

measure rel. ratios then period

Galaxy cluster

stirr galaxy rotation curves

"agreement"

Consensus Model

(Tab. 24.1)
* all are current values
density (rel. to ρ_{crit})

component

radiation

$$\Omega_r = 8.4 \times 10^{-5}$$

notes

mostly CMB photons
(but also starlight, neutrinos)

T_CMB gives Flux via
 $\propto T^4$ divid F/c
 $\text{ph/m}^2/\text{s} \rightarrow \text{ph/m}^3$

matter

$$\Omega_m \approx 0.30$$

→ from gravitational effects (lensing, orbits)

$$\Omega_b \approx 0.04$$

→ from brightness measurements

$$\Omega_{DM} \approx 0.26$$

→ from subtracting the 2

* but more confirmation from the spatially distinct distrib. of baryonic & dark matter

cosmological constant

$$\Omega_\Lambda \approx 0.7$$

→ from the acceleration of the expansion of the Universe

$H(t)$ at early t

i.e. indirectly by combining geom. measurements

w/ $\Omega_m + \Omega_r$, measurements & knowing

$$\Omega = \Omega_m + \Omega_r + \Omega_\Lambda$$

Independent, additional measurements/constraints

- $S_L \approx 1.0$ from geometry
- semi-quantitative galaxy size distribution analysis
 - also - more detailed analysis of the CMB anisotropies
(same idea - angles rel. to surface; size depends on geometry)

$S_{L_b} \approx 0.04$ from "Big Bang Nucleosynthesis"
in the early universe

→ constraints from large scale structure

- start w/ consensus model ingredients
- : model the grav. collapse $\stackrel{\text{of mat+gas}}{\rightarrow}$ & subseq. formation of galaxies →
- can the observed distribution be reproduced by the models

p. 551

Note: at we already know

$$V_m \propto a(t)^{-3}$$

volume increases at univ. expands
density of particles decreases inversely
w/ volume

$$U_r \propto a(t)^{-4}$$

some effect for photons, but
they also redshift; lose
energy at $a(t)^{-1}$

∴ The relative effects of ρ & Γ will vary
in time w/ radiation being
relatively more important when
The universe was smaller

∴ since $U_\Lambda = \text{constant}$

Λ will eventually dominate rad. & matter
in the future

Fig. 24.2

