

$$E_\gamma = h\nu$$

$$= \frac{hc}{\lambda}$$

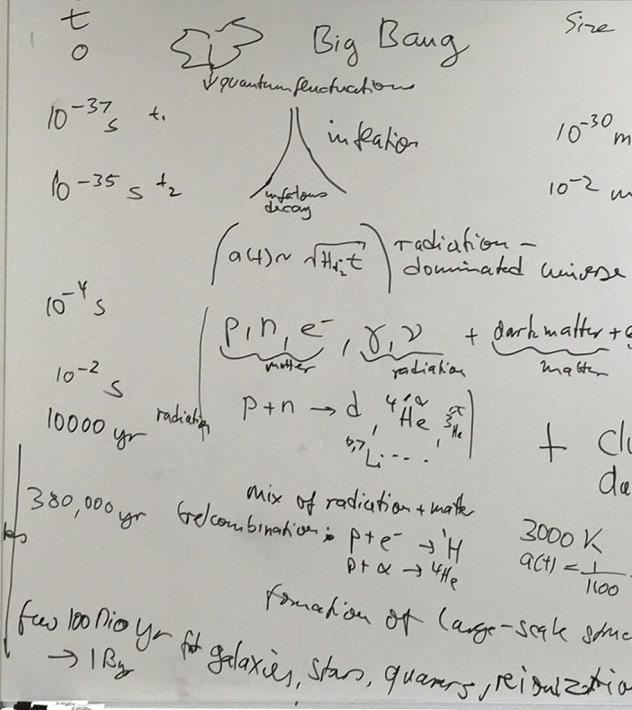
Radiation:
anything that
has $p \approx mc$

$$E_{rel} = \sqrt{m^2c^2 + \vec{p}^2} \cdot c$$

red shift $z = \frac{a_0}{a(t)} - 1$

$$n \rightarrow p + e^- + \bar{\nu}_e$$

Matter
dominates
 $a(t)^3$



net energy = 0 $\Leftrightarrow K = 0$

inflatous ($\rho = \text{const} \rightarrow a(t) = a(t_0) \cdot e^{H(t_0) \cdot t}$)

inflatous \rightarrow quarks (u, d), leptons ($e^-, \mu^-, \tau^-, \nu_e, \nu_\mu, \nu_\tau$), γ, W^\pm, Z, g, H + antiparticles + dark matter (supersymmetric partners to all) + ? ? ? , dark energy

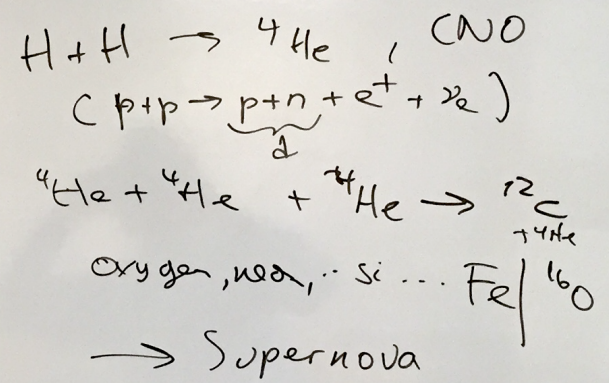
+ Clumping of dark matter

10 Byr: $\Omega_\Lambda > \Omega_M$ 70% 30% today
 $a(t) \propto e^{H_0 t}$
 14 Byr: today $T \sim 2.7 K$
 1000 Byr: Big RIP + darkness

4 since Big Bang
4 Byr Milky Way!

Star formation (in arms)
Hot, big stars (blue) →

9.5 Byr → solar system



- ↳ heavier elements
- ↳ dispersion

$r_c \rightarrow$ distance?

$a(t)$
 r "radius of the universe"

$$\text{distance} = r_c \cdot a(t)$$