Peebles 1982

Large Scale Background Temperature and Mass Fluctuations
Due to Scale-Invariant Primeval Perturbations

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A Cold WIMP Model

$\Omega = 1$, $\Lambda = 0$

& WIMP mass, $m_x >\sim 1$ keV

On top of primeval pertubation spectrum

$\Downarrow$

Density Fluctuation Power Spectrum, *P(k)*

RMS Mass Fluctuation, $\delta M/M$

Autocorrelation Length, ξ

Size of Temperature Fluctuation, $\delta T/T$

Overview

- Important Model Features and Motivations
- Calculations
- Discussion of Findings

Basic Assumption 1

- Adiabatic Perturbations with Scale-Invariant Power Spectrum:
  - $P(k) \propto k$
- Equal amount of density fluctuation at any length scale (scale invariant)
- Primeval spectrum
- Spectrum at small *k* or large scale

Basic Assumption 2

- m_x Dominates ($\Omega = 1$)
- Needed to make small scale (smaller than Jean's length) perturbations grow before decoupling
- Baryon-only universe, inconsistent with
  - $P(k) \propto k$
  - linear growth factor off by 8 orders of magnitude

How Heavy? Limit on m_x:

- Particle Velocity Distribution:
  - [exp($m_x vc/kT_x$) ± 1] $^{-1}$
- distribution → rms peculiar velocity → rms displacement, *r*

$$r \sim (0.8 + 0.3 \ln m_x) m_x^{-4/3} Mpc$$

Power Spectrum

- Small k: $P(k) \propto k$
- Large k: $P(k) \propto k^{-3}$

$$P(k) = Ak(1 + \alpha k + \beta k^2)^{-2}$$

$$\alpha = 6(\tau / h)^2 \, Mpc$$

$$\beta = 2.65(\tau / h)^4$$

$$h \leftarrow Ho = 100 * h \ \ km / s$$

$$\tau \leftarrow T = 2.7 * \tau \ \ K$$

Background Temperature

$$T(\theta,\phi)/T_b - 1 = \sum a_l{}^m Y_l{}^m = -\frac{1}{2}H^2 \sum k^{-2}\delta_k \exp(ik \bullet x)$$

$$\Rightarrow a_l : (a_l)^2 = 6(a_2)^2/[l(l+1)]$$

$$\xi(\theta_{12}) = \sum_{l>1}(a_l)^2(2l+1)P_l(\cos\theta_{12})/4\pi$$

$\xi(\theta) = (3/\pi)(a_2)^2 \log(\Theta/\theta)$, for $\theta << 1$ radian

RMS Mass Fluctuation

- From:

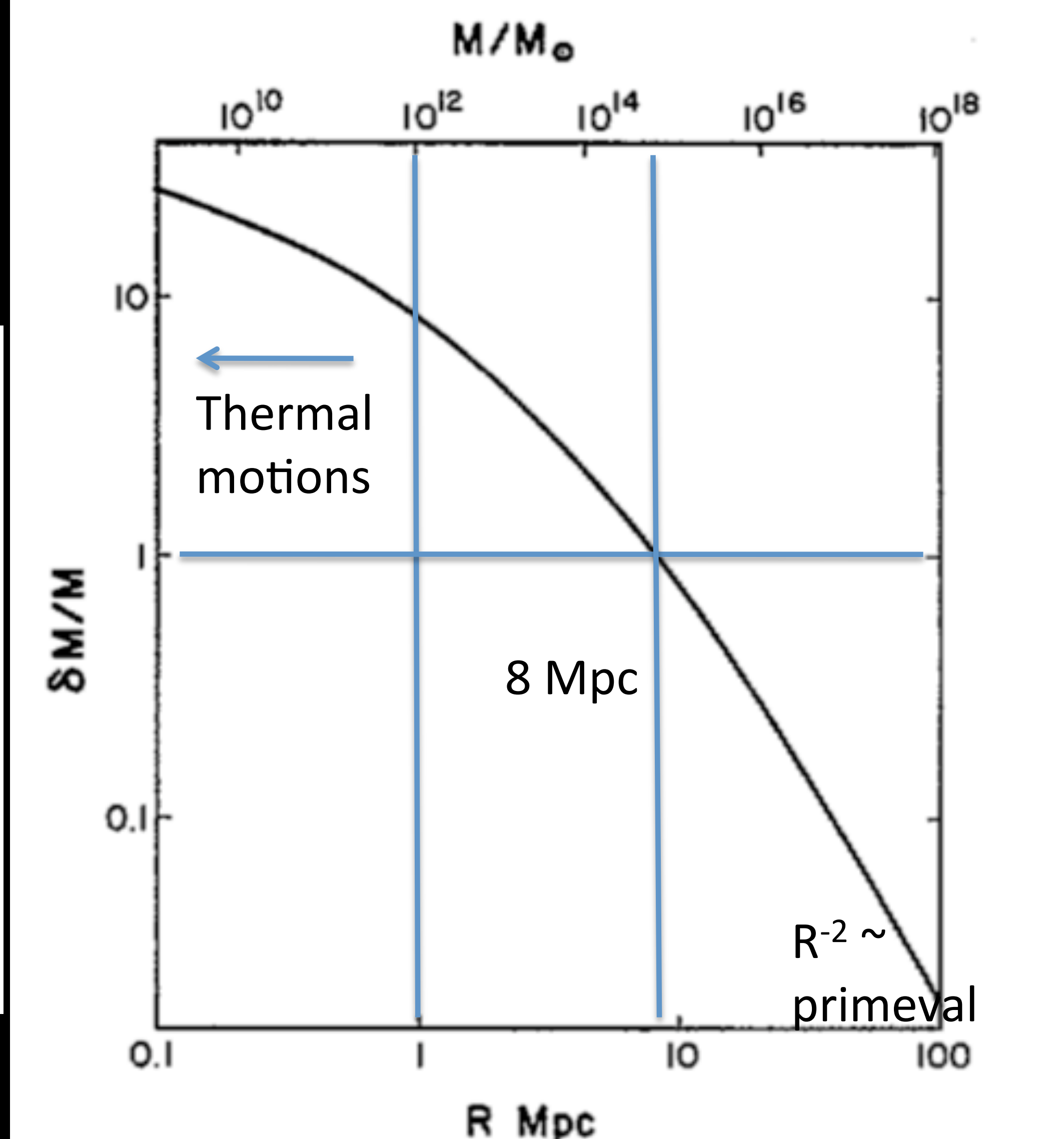
$$\rho = \rho_b\left(1 + \sum \delta_k \exp(ik \bullet r)\right)$$

- Get:

$$\frac{\delta M}{M} = \left(\frac{108}{\pi}\right)^{1/2} a_2 \left(\frac{c}{H}\right)^2 \left(\frac{h}{\tau}\right)^4 \times I\left(Rh^2/\tau^2\right)$$

$$[I(R)]^2 = \int_0^\infty \frac{k^3 dk}{\left(1 + 6k + 2.65k^2\right)^2} \times \frac{\left(\sin kR - kR\cos kR\right)^2}{(kR)^6}$$

- $a_2 = 3.5\text{x}10^{-6}$



Summary of Results / Implications

- $$r \sim (0.8 + 0.3 \ln m_x) m_x^{-4/3} \Rightarrow m_x >\approx 1 keV$$
- $$\xi(\theta) = (3/\pi)(a_2)^2 \log(\Theta/\theta) \Leftarrow \delta T/T$$
- $$\frac{\delta M}{M} = \left(\frac{108}{\pi}\right)^{1/2} a_2 \left(\frac{c}{H}\right)^2 \left(\frac{h}{\tau}\right)^4 I\left(Rh^2/\tau^2\right)$$

- $a_2 = 3.5\text{x}10^{-6}$
- $\delta T/T \sim 5\text{x}10^{-6}$

Conclusions

- Adding a dominant, massive, weakly interactive component to the universe allows perturbations to grow sufficiently, to explain to the distribution of galaxies seen today.