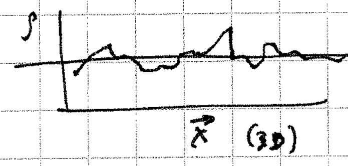
Growth of density perturbations δ

$$1+\delta(\vec{x}) = \frac{\rho(\vec{x})}{\langle\rho\rangle}$$



adiabatic perturbations
grow like the expansion $\delta \sim a(t)$
at early times when $\Omega_m \rightarrow 1$ is a good approximation

The perturbed Friedmann eqn becomes

$$\ddot{\delta} + 2\frac{\dot{a}}{a}\dot{\delta} = \delta\left(4\pi G\rho - \frac{c_s k^2}{a^2}\right)$$

remember : $a = (1+z)^{-1}$ $\quad H(z) = \frac{\dot{a}}{a}$

k is the wavenumber $(\sim 2\pi/\ell)$

c_s is the sound speed, $c_s^2 = \frac{\partial P}{\partial\rho}$

In the very early, radiation-dominated universe,

$$c_s = \frac{c}{\sqrt{3}}$$

The corresponding Jeans length is

$$\lambda_J = c_s\sqrt{\frac{\pi}{G\rho}}$$

Powerspectrum is
$P = |\delta|^2 \sim k^n$

Sets over/under scale for growth vs. standing waves.

The periodicity of peaks in the acoustic power spectrum corresponds to standing waves with modes in integral devisors of the sound horizon at the time of recombination. We know c_s, so the location of the CMB peaks makes an excellent standard ruler.