

Astro 321

Set 3: Inhomogeneous Fields

Wayne Hu

Inhomogeneous Universe

- Inhomogeneities in the matter-energy distribution of the universe grow via gravitational instability
- In expanding universe, growth rate is power law not exponential
- Must be a source in the early universe to explain structure in the universe
- Follow general principles of the FRW/Thermal History discussion but drop homogeneity and isotropy

Matter moves in the perturbed geometry (automatically conserving stress-energy)

Closure requires more than just the relation between average pressure and energy density w

Matter curves the geometry - cosmological Poisson equation generates gravitational potential from density perturbations

Inhomogeneous Fields

- Like homogeneous cosmology, a full description of the matter fields is given through their phase space distribution function

$$f(\mathbf{x}, \mathbf{q}, t)$$

where the momentum dependence \mathbf{q} describes the bulk motion of the particles

- Energy density and pressure are functions of position

$$\rho(\mathbf{x}, t) = g \int \frac{d^3q}{(2\pi)^3} f(\mathbf{x}, \mathbf{q}, t) E$$

$$p(\mathbf{x}, t) = g \int \frac{d^3q}{(2\pi)^3} f(\mathbf{x}, \mathbf{q}, t) \frac{|\mathbf{q}|^2}{3E}$$

and can be considered as low order moments of the distribution function