Galaxies

Lecture 1

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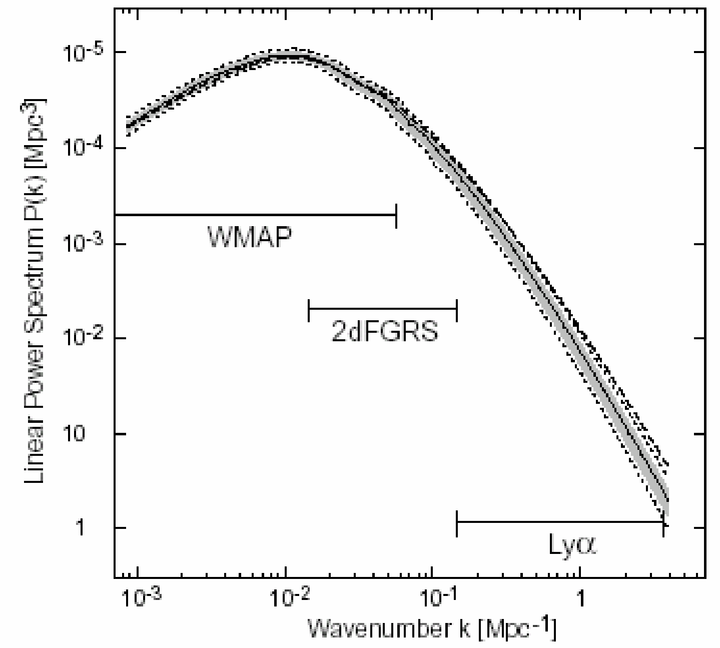
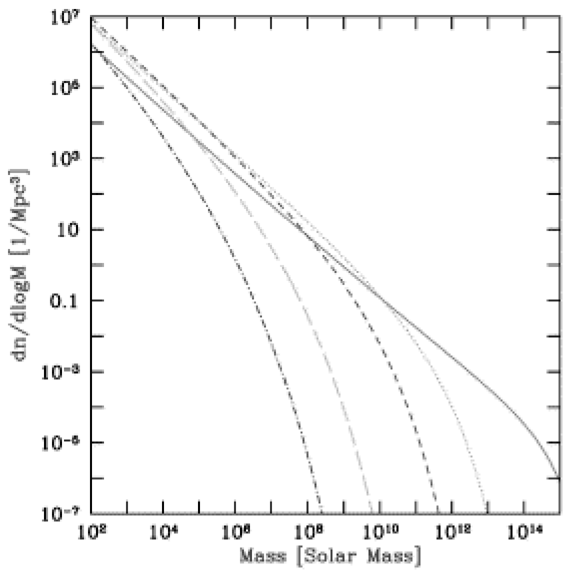
http://wise-obs.tau.ac.il/~barkana/galaxies.html

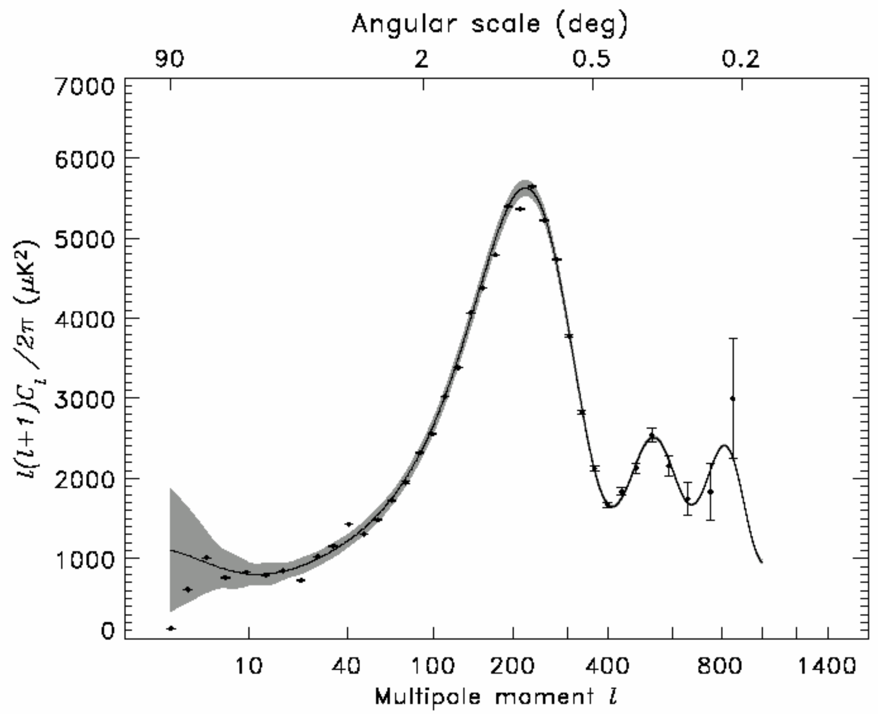
Goal



Linear Power Spectrum P(k) [Mpc3]
Wavenumber k [Mpc-1]
WMAP
2dFGRS
Lyα



dn/dlogM [1/Mpc3]
Mass [Solar Mass]



Angular scale (deg)
$l(l+1)C_l/2\pi$ (μK^2)
Multipole moment l

Today: Cosmology

FRW Metric, Hubble's Law, Redshift (λ)

Friedmann Eq., Expansion History

Redshift (momentum, temperature)

Friedmann-Robertson-Walker (FRW) Metric

$$ds^2 = dt^2 - R^2(t)\left\{\frac{dr^2}{1-kr^2} + r^2 d\Omega^2\right\}$$

$$d\Omega^2 = d\theta^2 + \sin^2\theta\, d\phi^2$$

$$\boxed{c = 1}$$

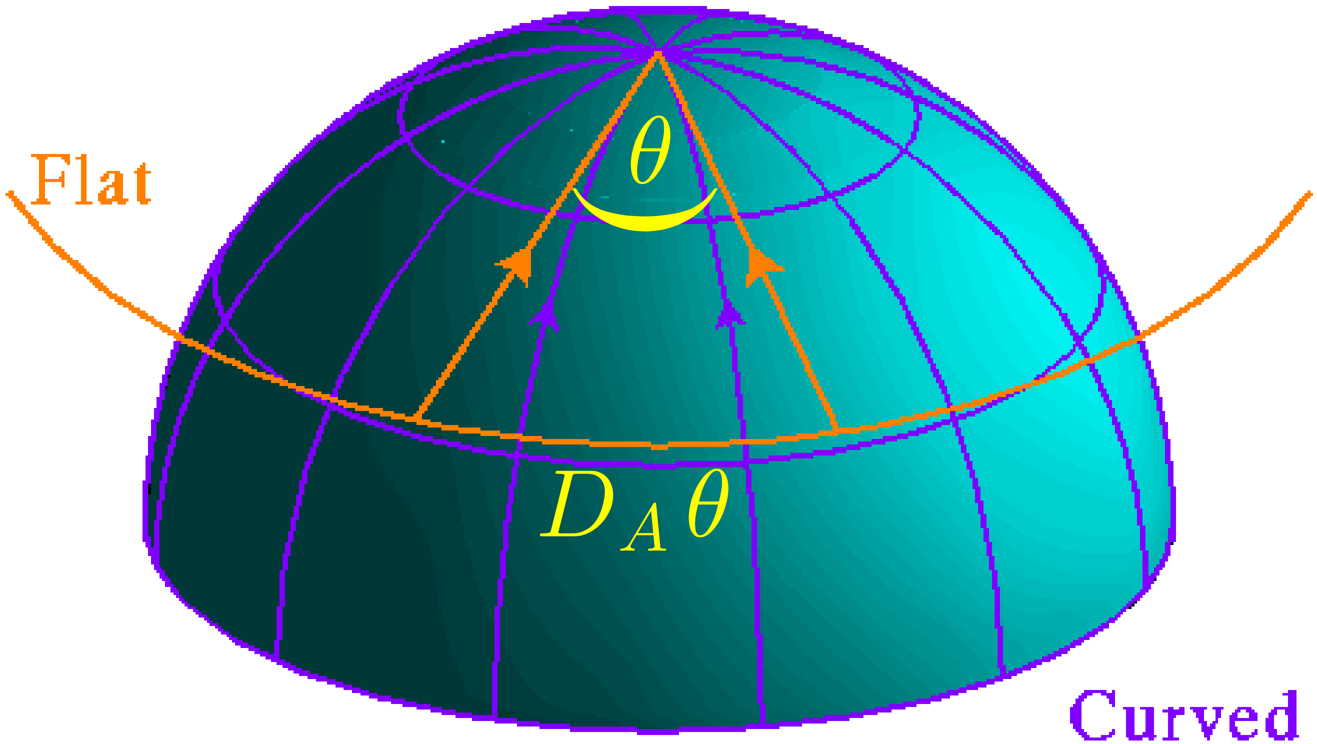
$$k = +1,\ 0, -1$$

$$ds^2 = a^2(\tau)\left\{d\tau^2 - \left[d\chi^2 + \sin_K^2\chi\, d\Omega^2\right]\right\}$$

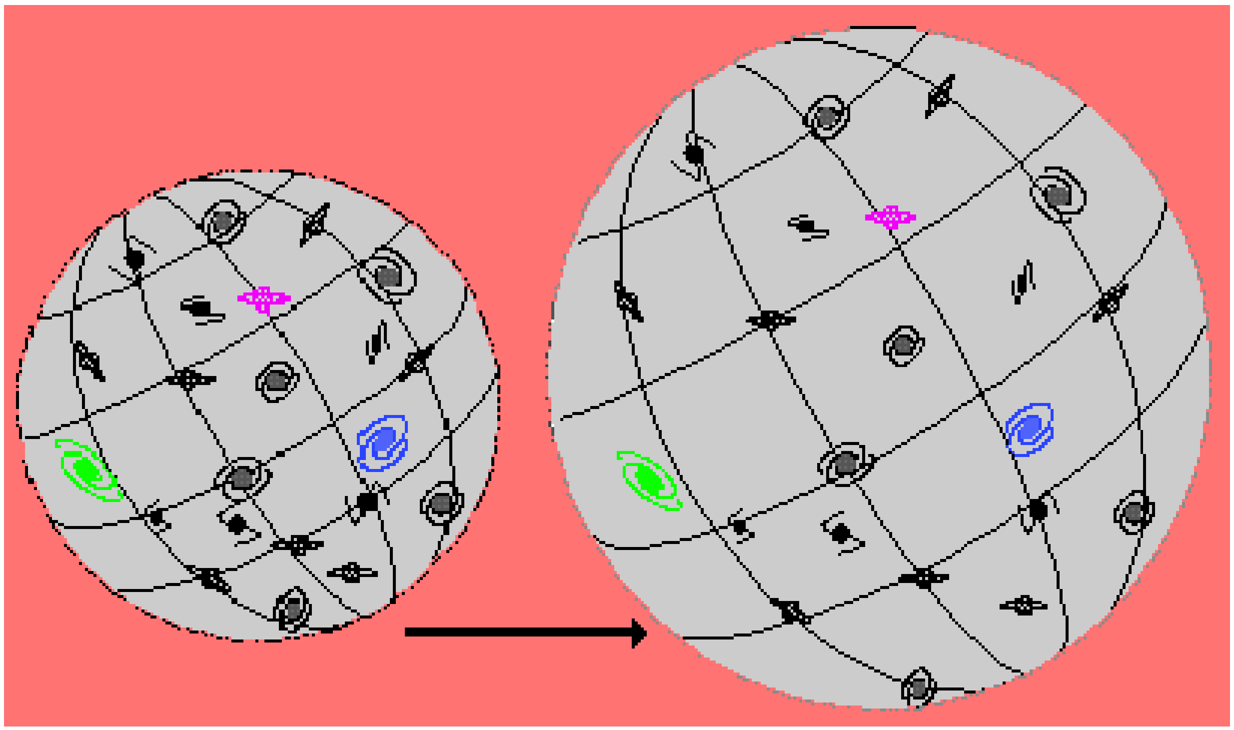
$$\sin_K\chi \equiv \begin{cases} K^{-1/2}\sin K^{1/2}\chi & K>0 \\ \chi & K=0 \\ (-K)^{-1/2}\sinh(-K)^{1/2}\chi & K<0 \end{cases}$$

$$\boxed{a(\tau_0) = 1}$$

Angular Diameter Distance



Expansion



Friedmann Equation

$$G_{\mu\nu} = 8\pi G T_{\mu\nu}$$

$$H^2(t) = \frac{8\pi G}{3}\rho - \frac{k}{a^2} \qquad d(\rho a^3) = -\,p d(a^3)$$

$$\Rightarrow \frac{\ddot{a}}{a} = -\,\frac{4\pi G}{3}(\rho + 3p)$$

$$\rho_c(t) \equiv \frac{3H^2(t)}{8\pi G} \qquad \Omega(t) \equiv \frac{\rho}{\rho_c}$$

$$\frac{k}{a^2} = H^2(t)\big[\Omega(t) - 1\big] \qquad \frac{k}{a_0^2} = H_0^2\big[\Omega_0 - 1\big]$$

$$\text{Geometry} \longleftrightarrow \text{Density}$$