AST 250 – Spring 2019
Homework Due: Wednesday April 24

39. The density parameter, Ω_m, is used in cosmology as a measure of the density of matter in the Universe relative to the "critical density", ρ_{crit}, defined as the density for which a mass shell in the Universe is expanding at its escape velocity.

(a) Let's first calculate the critical density by setting the velocity of the Hubble expansion, v = H d, equal to the escape speed for a spherical volume of space with radius d and total enclosed mass M. Convert mass to density and solve for the density – this is defined as the critical density, ρ_{crit}. Ω_m is then defined as the ratio of the observed mass density, ρ_0 , to the critical density: $\Omega_m = \rho_0/\rho_{crit}$. Derive the equation for Ω_m in terms of ρ_0, G, H, and numerical constants.

(b) The latest results from Planck CMB measurements indicate that $\Omega_m = 0.3089$, of which 15% is normal baryonic matter. Calculate the density of H atoms in the visible Universe (give answer in units of number H atoms per m^3 to two decimal places. Assume all baryonic matter is Hydrogen).

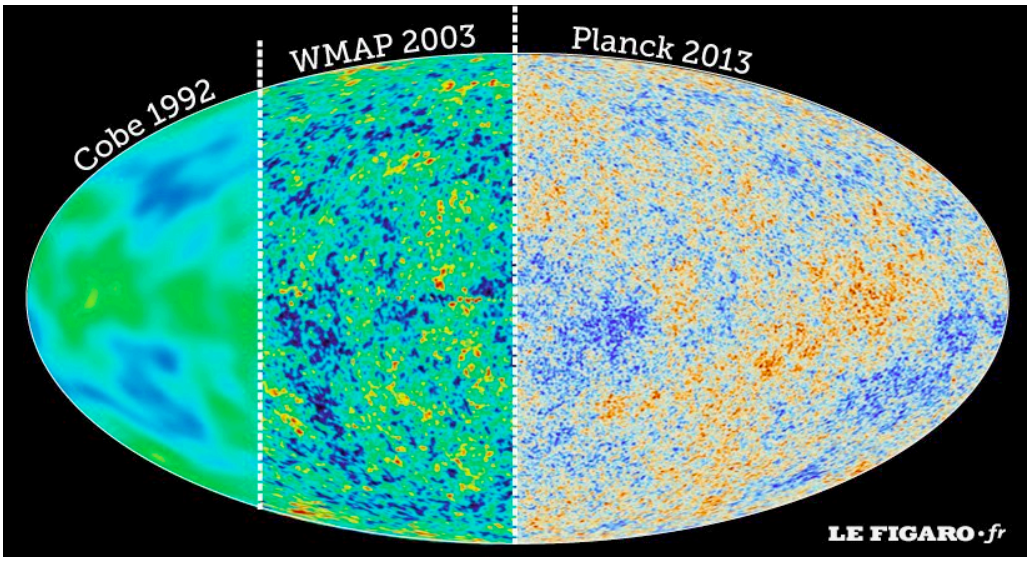

Figure 1: Space missions to measure anisotropy in the CMB. Each mission had progressively better angular resolution.