Extragalactic Astrophysics: Question Sheet 2

1. **Density of the Universe.** Suppose that the Milky Way is a typical galaxy, containing say 10^{11} stars, and that galaxies are typically separated by a distance of 1 Mpc. Estimate the density of the Universe in SI units. How does this compare with the density of the Earth? (Problem 2.1 Liddle)

2. **Distribution of standard candles.** Suppose that stars are standard candles with some fixed luminosity L (this unrealistic assumption is not necessary, but it simplifies things), and a number density in the Solar neighborhood n that is independent of position. Show that the number of stars that have a flux at Earth greater than some value f_0 scales as:

$$N(f > f_0) \propto f_0^{-3/2} \tag{1}$$

Suppose that instead of being uniformly distributed throughout space, the stars are instead distributed uniformly in a very thin disk. Find the distribution of N in this case.

3. **Rotation curves.** A galaxy has a flat rotation curve, $v(r) = v_c$, with v_c a constant, out to some radius R. Interior to R the dominant contribution to the potential is dark matter, with a spherically symmetric distribution. Outside R, the mass density is zero. Show that the escape velocity from the galaxy for $r < R$ is given by,

$$v_e^2 = 2v_c^2(1 + \ln(R/r)) \tag{2}$$

4. **Dark Matter.** The most popular candidate for Dark Matter is a supersymmetric particle, with a mass-energy of around 100 GeV. Supposing that the typical velocity of these particles relative to the Earth's motion is 300 km s^{-1}, and that they are uniformly distributed throughout the Universe, estimate how many pass through your body each second. Take the energy density of the Universe = 10.5 GeV m^{-3}. (Problem 1.5 in Rowan-Robinson)

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