ASTR2013 Problem Set 5 - due **11 Oct 2019**

A/Prof Mike Ireland

September 29, 2019

1. In spite of low luminosity irregular galaxies being the most common galaxy in the Universe, they do not appear in Hubble's original "tuning fork" classification. Maybe this is because when only looking at the brightest galaxies, fainter irregular galaxies usually aren't detected.

   (a) For a galaxy of luminosity L and a telescope flux limit F, find the maximum distance r at which the galaxy can be detected.

   (b) For a galaxy luminosity function $\phi(L)$ following the Schechter function and a telescope flux limit F, find the number of galaxies of luminosity between L and $L + dL$ that can be detected.

   (c) What is the most likely Galaxy luminosity that is detected? [Hint - the answer to (b) can be written as a function g(L), which is the probability density function of galaxy luminosity for a flux-limited survey. You want to find the maximum of this function]

2. (Based on Textbook Q7.1) For any group of stars of Galaxies, we can learn something about their spatial distribution (or the geometry of the Universe) by simply counting objects as a function of limiting flux. Assume there is a population of objects that are uniformly distributed in space, with a spatially constant luminosity function. [For this question, assume a standard Euclidean geometry of flat spacetime - we only learn about an alternative to this in Week 10].

   (a) Show that if these objects all have a the same luminosity L (i.e. a luminosity function represented by a dirac delta-function), then the number of objects observed to have a flux greater than some value f_0 obeys $N(f > f_0) \propto f_0^{-3/2}$

   (b) Explain why this relationship still holds if instead of a single luminosity, the objects have a distribution of luminosities (which is spatially constant).

   (c) Based on this relationship, if the number of uniformly distributed objects per square degree is N between a magnitude of 15 and 16, how many objects are there between a magnitude of 16 and 17?

   (d) If you observe fewer objects than this between magnitudes 16 and 17 than predicted in (c), what does this mean?

3. Assume that a $10\,M_\odot$ black hole is formed from a supernova explosion, and this black hole is subsequently fed by an endless supply of gas. Assume that the black hole's growth is Eddington-limited.

   (a) Equate the luminosity of the black hole to the Eddington luminosity, to relate the black hole mass to its accretion rate.

   (b) Solve this differential equation, and find the mass of the black hole after 100 million years.