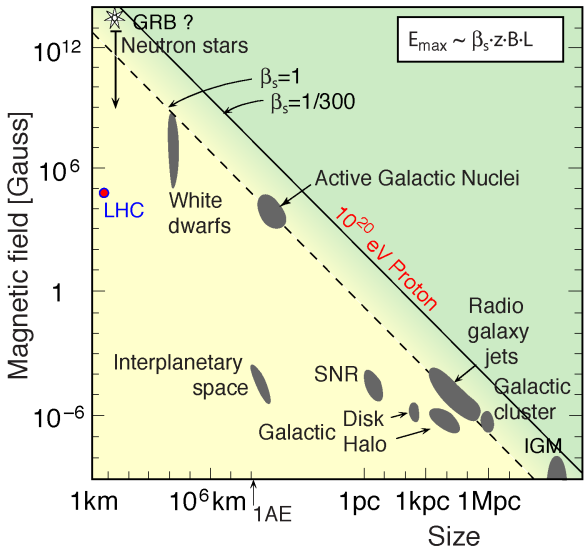

Figure 1:

Fundamentals of Astrophysics, PH 217

Problem Set V: ISM, galaxies

1. **Motion of the ionization front:** Assuming that a star turns ON at $t = 0$ in a neutral medium with H at rest, calculate the radius of the ionization front as a function of time. The volume of the ionization front increases because photoionization eats more and more into the neutral medium, as compared to recombinations in the ionized medium. Express $r_I(t)$ in terms of the Strömgren radius and the recombination time in the ambient density plasma. Note that r_I should asymptotically equal the Strömgren radius.

2. Recall that Kapteyn deduced that the sun was located at the center of our Galaxy (in fact it was thought that ours was the only galaxy in the universe) by looking at the almost uniform distribution of stars. This was of course because dust limited our view. Shapley, by looking at the distribution of globular clusters, deduced that there was an excess density towards the constellation of Sagittarius. Why is do you think that Shapley's observations were not affected by dust attenuation?

3. While cosmic rays with energies less than 10^{15} eV are expected to be accelerated in Galactic supernova remnants. The ultra-high energy cosmic rays (UHECR) sources are essentially unconstrained. A powerful constrain on the plausible sources comes from the Hillas criterion which says that the Larmor radius of the UHECR should be smaller than the size of the system in order for particle to be confined and accelerated to the relevant energy. Interpret Fig. 1 according to Hillas criterion.

4. Problems 1-4 in chapter 5, problems 1, 2, 3, 7 in chapter 6 of Maoz.

5. Problem 6.1, 6.2, 6.4, 6.6, 6.7, 9.1, 9.3 in Arnab's book.