PLASMA ASTROPHYSICS: SMALL RESEARCH PROJECTS

The project may be original work or a critical review of the literature, with the results written up as a paper and presented to the class. The papers are due December 9, and the presentations will take place that week. You may work in common with up to 2 other people. Please set up a meeting with me before you start work to discuss the topic and scope of the project.

Here are several possible topics. You may propose your own, in which case it is even more important that we discuss it beforehand.

- **Activity in brown dwarfs:** The atmospheres of so-called brown dwarf stars are so cool that they are almost entirely neutral, and have relatively low electrical conductivity. Yet, brown dwarfs are observed to have radio and x-ray flares which are thought to be powered by magnetic fields. Investigate the dynamics of magnetic fields in a brown dwarf envelope.

- **Shock acceleration:** Galactic cosmic rays are thought to be accelerated by turbulence in the vicinity of shocks driven by supernova explosions. Write a Monte Carlo code to simulate this process. Try to reproduce the power law spectrum predicted by theory and study its evolution over time.

- **Escape of galactic magnetic fields:** Escape of galactic magnetic fields plays a crucial role in their evolution, including operation of a galactic dynamo. Evaluate the various mechanisms that have been proposed for the vertical escape of magnetic fields from disk galaxies. Estimate their efficiency as a function of field strength and other properties of the galaxy.

- **Collisionless magnetic reconnection:** Magnetic reconnection beyond MHD. As we discussed in class, theories of magnetic reconnection based on MHD predict that reconnection is very slow. Alternative theories have been proposed based on enhancement of the resistivity by instabilities or separating electron and ion dynamics through the Hall effect. Survey at least one of these theories and discuss astrophysical applications.

- **Ultrathin galaxies:** We have seen (Problem Set 2) that magnetic fields and cosmic rays thicken the disk of our galaxy by a factor of 2 - 3. As their name implies, ultrathin galaxies are unusually thin. Does this mean that their magnetic fields are very weak and their cosmic ray populations are
low? If so, why? Discuss the observational bounds that can be placed on the magnetic and cosmic ray energy density in these systems. Note: My Astronomy colleague Jay Gallagher is an expert on these systems.

- **Laboratory experiments:** Magnetic reconnection, particle acceleration, dynamos, and angular momentum transport are all seen in the laboratory. Discuss the evidence for at least one of these phenomena in at least one experiment, and assess its bearing on at least one astrophysical system. Design your own experiment to study an process in plasma astrophysics.

- **Accretion disk dynamos:** Review the evidence for dynamos in accretion disks, and discuss the models. Compare accretion disk dynamos with galactic and stellar dynamos in terms of geometry, plasma parameters, energy sources, and observational evidence.