Terry Onsager - Fundamentals of Single-Particle Motion in a Collisionless Plasma

- Single-particle motion in uniform electric and magnetic fields
- Guiding center approximation
- Data example of ExB drift comet tails
- Data examples of non-guiding center motion:
  1) the foot of a collisionless shock;
  2) the spatial gradient of energetic particles
- Guiding center motion in inhomogeneous magnetic fields
  (gradient and curvature drifts and magnetic mirroring)
- Adiabatic invariants in time-varying magnetic fields
- Data example of the gradient drift of magnetospheric particles
  Comparing the observed and the calculated period of drift echos.
- Fun activity: Magnetospheric Golf by Jamie Harold

Tom Holzer – Magnetized Fluid Descriptions of Space Plasmas

In the lecture (which will be designed to foster interaction between the students and the speaker), we will begin by briefly discussing some of the properties that make a plasma different from a gas composed of neutral atoms and molecules. After this we will consider briefly the relationships between three different descriptions of physical phenomena in space plasmas: (1) single particle motion in electromagnetic fields; (2) kinetic theory of plasmas that are not collision dominated; (3) fluid theory of plasmas that either are collision dominated or can be satisfactorily treated as such. This discussion will involve the introduction of the concept of conservation laws. Next, taking the fluid perspective, we will consider the acceleration and heating of fully and partially ionized plasmas by transfer of electromagnetic energy to the plasma, and we will briefly touch on an example of the inverse of this process—viz., the growth of electromagnetic waves at the expense of the plasma energy. Specific examples of heating and acceleration processes will be given in the following contexts: the quasi-steady solar corona and solar wind; magnetic field line reconnection in solar flares, at the dayside magnetopause, and in the magnetotail; and current dissipation in the E region of the ionosphere.

In the follow-on problem and interactive discussion session, a small number of problems (based on the material discussed in the lecture) will be provided for selected groups to work on, with the goal of stimulating further interaction between the students and the speaker. Each small group will be made up of students with varying degrees of familiarity with the material considered.

Rod Heelis - Current Systems in the Terrestrial Space Environment.

Basic Properties of Electric Currents

- Support the Magnetic Field Configuration
  curl H = J
- Electrically connect resistive loads to source of electric potential
  Electric light bulb and Battery Analogy.
- Must flow continuously in closed loops

Generalized Ohm's Law

- Application in the magnetosphere
    Effective conductivity of the magnetosphere
- Application in the ionosphere
    Effective conductivity of the ionosphere

Currents connecting the magnetosphere and ionosphere.

- Region 1 and Region 2 currents
- Potentials at the Polar Cap and the Auroral Zone

Currents in the Ionosphere

- E-region wind drivers
- F-region wind drivers
- Storm perturbations

Evolution of currents during a storm

Marty Lee - Particle Acceleration from the Sun to the Earth and Beyond

In the lecture, the basic physics of particle acceleration by electric fields in space is described. The early history of attempts to understand the acceleration of galactic cosmic rays by the Fermi-I and Fermi-II mechanisms is presented. Then the exciting new realm of energetic particles discovered in the Space Age beyond the protective cocoon of our magnetosphere is described, including solar energetic particles from the Sun, energetic storm particles associated with geomagnetic storms and interplanetary shock waves, the corotating ion events at interaction regions in the solar wind, and the anomalous cosmic ray component accelerated at the boundary region of the heliosphere. The mechanism of shock acceleration is then analyzed in detail to describe the evolution of the particle distribution function in space and time, the growth of the excited hydromagnetic waves adjacent to the shock, and the prediction of energetic ions and electrons at Earth orbit.

In the problem and interactive discussion session a number of problems relating to particle acceleration will be posed for groups of students to work on. Possible problems are:

1. Particle acceleration in a constant electric field in the presence of Coulomb collisions.
2. Stochastic acceleration in a flare environment.
3. Particle scattering by small-amplitude magnetic fluctuations.
4. Particle interaction with Earth’s dipole magnetic field.
5. Magnetohydrodynamic shock structure.
6. Particle interaction with a laminar shock with no scattering (“shock drift” acceleration).
7. Diffusive shock acceleration with a “free-escape” boundary.

Groups will present their work to all participants and discuss its impact on particle acceleration in the heliosphere.