Overview of the plasma physics course

January 6, 2011

1. Basic Notions
   - Ionization temperature $\ll$ ionization potential. Why?
   - Cross-section for binary collisions, large and small angles scattering, Coulomb logarithm, mean free path, e-e, i-e, i-i scattering frequencies (including ratio of), e-i thermalization times
   - Run-away phenomenon, Dreicer E-field
   - Debye screening
   - Plasma frequency, Langmiur oscillations
   - Charge-neutrality on $r \gg r_D$; potential of a charge in plasma
   - Plasma parameter, ration of thermal to Coulomb energies in plasma
2. Single particle motion
   - Motion in magnetic field
   - Drifts: electric, gradient, in gravitational field
   - Adiabatic invariants (first & second), magnetic moment
   - Magnetic bottling, mirrors
   - Earth ring current
3. MHD: strongly collisional plasma
   - typical times/scales in plasma, applicability of MHD, charge neutrality
   - Ideal condition
   - Equations of MHD
   - Notion of magnetic field line, frozen-in condition
   - Resistivity, two types of E-field in plasma, diffusion of magnetic field line
   - Stationary solutions, magnetic surfaces, plasma beta
   - Force-free configurations, Grad-Shafranov eq.

- MHD waves: Equilibrium, Small perturbations, Linearization, Fourier transform, Dispersion relation
- Alfvén velocity, slow, Alfvén fast waves
- Collisionless plasma, anisotropic pressure

4. Shock waves
   - Which way will magnetic field bend at a shock?
   - Earth-Solar wind interaction
   - Shock thickness
5. MHD stability
   - sausage, kink, R-T, K-H, firehose
6. Plasma normal modes
   - Plasma dielectric tensor
   - Alfvén , whistlers, E-M waves
   - Cut-offs and resonance
   - skin depth
   - Dispersion and Faraday rotation
7. Plasma instabilities
   - Two-stream, bump-in-tail instability, current (Bunemann) instabilities, loss cone
   - Resonances, Landau rule, Collisionless damping
   - Plasma maser
8. Reconnection
   - tearing mode
   - Sweet-Parker model, Lundquist number, reconnection rate
   - anomalous resistivity
9. Dynamo
   - anti-dynamo theorems, necessary conditions for dynamo
   - Faradey wheel
   - streatch-twist-fold
10. Particle acceleration
    - Shock acceleration, Fermi I and II
11. Non-linear effects in plasma

- non-linearity parameter
- Self focusing, induced transparency
- Ponderomotive force, Wakefield acceleration.