1. Particle dynamics

Assume a plasma density of 1 cm^{-3}, temperature equivalent to 1 keV, and a magnetic field of 20 nT which are typical for the near Earth magnetotail.

Determine the temperature in degrees Kelvin. Determine the energy density in kW hours/m^3 and kW hours /R_E^3 (1 R_E=6400 km). For the sake of simplicity assume that the plasma sheet of the magnetosphere is represented by a cylinder with 15 R_E radius and 100 R_E length. How long could a power plant with an output of 1000 MW operate on the thermal energy stored in the plasma? How many power plants could operate on the respective power if the plasma sheet energy were restored every 30 minutes ?

2. Magnetic gradient drift:

Geosynchronous (6 R_E geocentric radial distance) satellites observe frequently sudden increases in energetic particle fluxes in the Magnetosphere. This observation is called energetic particle injection. Typically this increase is seen first in the most energetic particles and subsequently at lower energies. This property is called energy dispersion in the particle fluxes. At the satellite location the magnetic field is reasonably approximated by a dipole field.

(a) Assuming a point source for the energetic particles, why is it that more energetic particle fluxes increase first?

(b) Consider that 0.5 MeV flux increases about a minute after the 1 MeV particle flux increase. What is the distance to the origin of the energetic particles?

(c) At what times after the increase of the 1 MeV particles do you expect that the 100 keV and the 10 keV fluxes increase?

(Help: Although particles are generally conducting a gradient and curvature drift assume for this problem that particles have only a perpendicular velocity and are drifting in the equatorial plane of the dipole field.

3. Normalization

a) Following the example presented in class, determine typical values for the electric field E_0 and the pressure p_0 from the MHD momentum equation in terms of L_0, ρ_0, B_0.

b) Using the normalization procedure, derive the coefficients of the inertial term and of the Hall term in generalized Ohm's law. Show that these coefficients are $(c/\omega_{pe})^2 / L_0^2$ and $c/(\omega_{pi} L_0)$ respectively.

Please turn in the solutions to the exam on Friday, 03/30/12