Heliophysics Summer School, 2012

Homework, Radiation Belts

Problem 1.

a) Write an equation of motion in the form $(x = x(t), y = y(t), z = z(t))$ for a relativistic particle, in a uniform magnetic field. Assume that the electric field is zero.

b) Estimate the gyrofrequency of 1 MeV electrons and protons at a radial distance of 4 Earth radii, and in the equatorial plane. Will relativistic effects play an important role for these particles?

Problem 2.

a) Estimate the value of the loss cone in the equatorial plane at radial distances of 4 Earth radii and 9 Earth radii.

Hint: Use conservation of the first adiabatic invariant and equation for the dipole magnetic field.

$$r = R_E \; L \; cos^2\lambda \tag{1}$$

$$B = \frac{B_0}{L^3} \frac{(1 + 3sin^2\lambda)^{1/2}}{cos^6\lambda} \tag{2}$$

b) Explain why it is important to measure radiation belt particles close to the equatorial plane.

c) Explain how measurements at LEO orbit can help us to understand precipitation from the radiation belts. Explain why it is difficult to infer precipitation of fluxes into the atmosphere from equatorial spacecraft measurements.

Problem 3.

a) List acceleration and loss mechanisms for relativistic electrons in the Earth's radiation belts.

Problem 4.

Show that phase space density f can be related to the directional differential flux J as $f = J/p^2$, where p is the particle's momentum.

Hint: Write an expression for the number of particles going through a particle detector measuring the differential flux. Write an expression for the volume in phase space occupied by these particles.