PHY 525 Homework 2 Due: Tue, Sept. 24, 2019

1. Earth's magnetic field

Suppose that the earth's magnetic field is $3x10^{-5}$T at the equator and it falls off as $1/r^3$, as for a perfect dipole. Let there be an isotropic population of 1eV protons and 30keV electrons, each with density $n=10^7\ m^{-3}$ at r=5 earth radii in the equatorial plane.

(a) Compute the ion and electron ∇B-drift velocities.
(b) Does an electron drift eastward or westward?
(c) How long does it take an electron to encircle the earth?
(d) Compute the ring current density in A/m^2.

Note: the curvature drift is not negligible and will affect the numerical answer, but neglect it anyway.

2. Magnetic mirror

Consider a mirror machine of length 2L with a mirror ratio of Rm, so that B(-L) = B(L) = Rm B_0. A plasma with an isotropic velocity distribution is placed at the center of the machine. Ignoring collisions, what is the fraction of trapped particles?

3. Second adiabatic invariant

A particle is trapped in a magnetic mirror field given by

$$B_z = B_0 [1+(z/L)^2].$$

Initially, the mirror points of the particle are located at $z=\pm L$.

(a) B_0 is now slowly increased to $2B_0$. Using the second adiabatic invariant, find the new mirror point locations and the new mirror field B_m.
(b) L is then slowly decreased to L/2, while holding $2B_0$ constant. Using the second adiabatic invariant, find the new mirror point locations and the new mirror field B_m.