Problem set 3. Due Feb 10 in class

February 10, 2011

• For particles at the edge of the Earth magnetosphere, located at 10 Earth radii, estimate drift velocity due to (i) gravitational attraction of the Earth; (ii) inhomogeneity of magnetic field. Assume that the particle is electron of energy 1 keV, magnetic field on the Earth surface is 1 Gauss, magnetic field of the Earth is dipole, \( B \propto \frac{1}{r^3} \). Assume that gravity acceleration equals that on the surface of the Earth.

\[
v_{\text{grav}} = \frac{(F/e)}{Bc} = \frac{mgc}{eB}
\]

\[
v_{\text{grav}} = 5 \times 10^{-2} \text{cm/s for eletrons} \tag{1}
\]

\[
v_{\nabla B} = \frac{mc v^2}{eB} \frac{\nabla \ln B}{2} = \frac{mv^2 c}{2 eB 3R} = 5 \times 10^3 \text{cm/s} \tag{2}
\]

• A particle at the edge of the Earth magnetosphere, located at 10 Earth radii, has a pitch angle of 45 degrees. Find a distance at which it will be reflected.

\[
\frac{\sin^2 \alpha_0}{B_0} = \frac{1}{B}
\]

\[
B = B_0 \left(\frac{r}{R_0}\right)^{-3}
\]

\[
r = R_0 \sin \alpha_0^{2/3} = 5 \times 2^{2/3} R_E \tag{3}
\]

• For a particle at the edge of the Earth magnetosphere, located at 10 Earth radii, find the frequency of the cyclotron emission (corresponding to a transition by one Landau level).

\[
\omega = \omega_B = \frac{eB}{m_e c} = \frac{eB}{m_e c} \left(\frac{R}{R_E}\right)^3 = 1.8 \times 10^4 \text{rad/s} \tag{4}
\]