Problems, Tutorial 3

Space physics EF2240, 2011

1. Near the equator, the geomagnetic field is perpendicular to the gravitational force $F_g = mg$ (see Figure 1).

   a) Calculate the plasma drift velocity due to the gravitational force at an altitude of 1000 km for an electron and for an Oxygen ion. (*Hints: The atomic weight of Oxygen is 16 amu. The gravitational acceleration g at 1000 km altitude is 7.3 ms^{-2}.)*

   b) What is the ratio of the gravitational drift of the Oxygen ion in a) to the E×B drift due to an electric field of 10 mV/m, in the same direction as the gravitational force, at the same altitude in the equatorial plane.

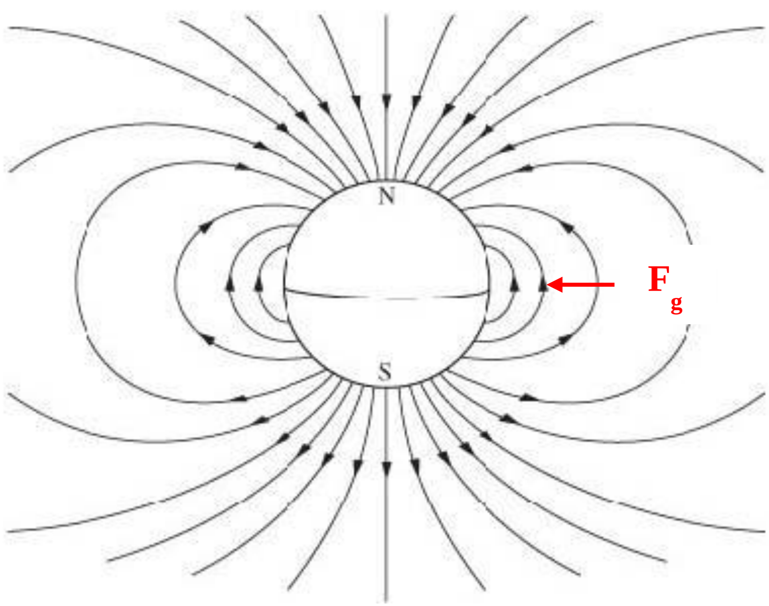

Figure 1

2. Figures 2a) and 2b) represent the equatorial plane in Earth's magnetosphere viewed from "above", with Earth marked as $\oplus$.

   a) With an electric field **E** and a magnetic field **B** as in Figure 2a, show what direction an electron and an ion, respectively, will drift from the starting point P. Calculate the drift velocity if |**E**| = 2.5 mV/m and |**B**| = 120 nT.

   b) With a magnetic field B as in Figure 2b, and a gradient of B as indicated by the arrows, show what direction an electron and an ion, respectively, will drift from the starting point P

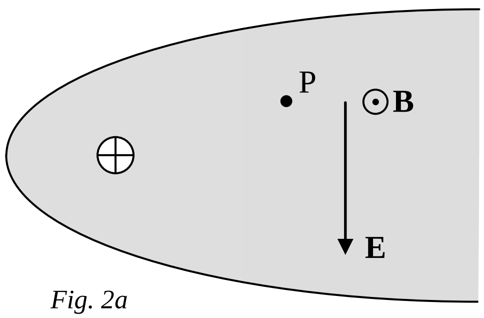

Fig. 2a

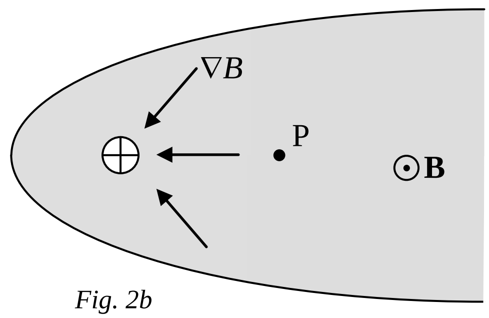

Fig. 2b

3. In a plasma a magnetic field is directed along the z-axis, and an electric field is given by $\mathbf{E} = E_x \hat{x}$ where E_x = 0,1 V/m. The plasma conductivities are given by $\sigma_{//}$ = 11 S/m, σ_P = 0,8 S/m and σ_H = 1,2 S/m. What is the resulting angle between the electric field and the current density vector?

4. What is the weight of the magnetosphere? Make an estimate using very simplified approximations of form, size and density.

5. With measurements made by the Mariner 10 space probe the magnetic moment of Mercury has been determined to be $a = 3.0 \times 10^{19}$ Am^2. Use this value to estimate the distance from Mercury's magnetopause to the dayside surface of the planet. As typical values for the solar wind speed and particle density at Mercury orbit, use $v = 200\,\text{kms}^{-1}$ and n_e = 50 cm^{-3}. Give the answer in km and in Mercury radii. (Mercury's radius is 2424 km)