Problems, Tutorial 3

Space physics EF2240, 2014

1. 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?

2. A satellite is moving with velocity 7 km/s straight above one of the magnetic poles at an altitude of 1000 km. What is the induced electric field measured by the satellite?

3. 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.

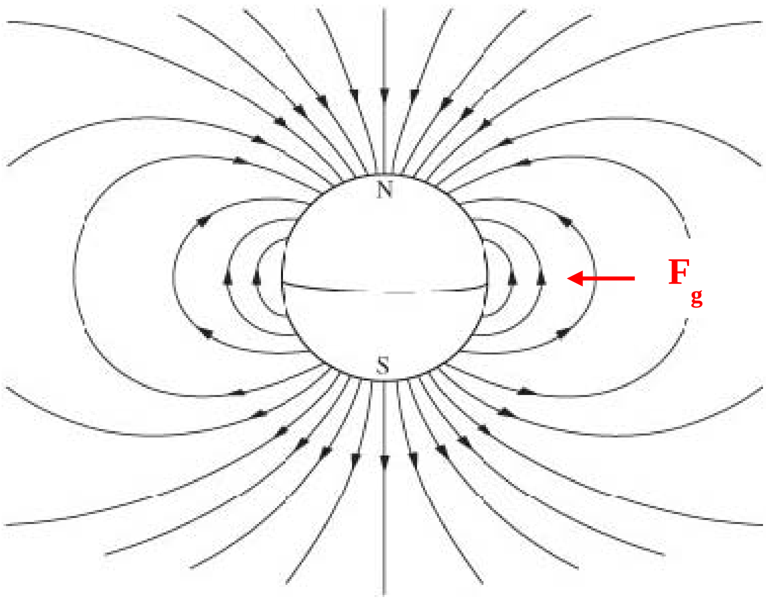


Figure 3

4. Figures 4a) and 4b) 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

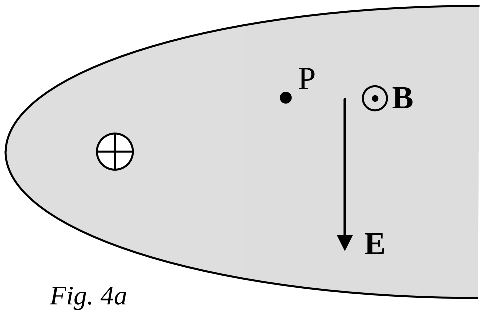


Fig. 4a

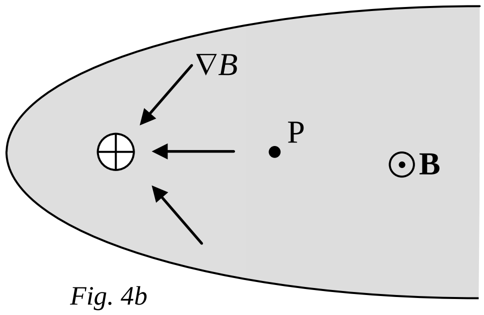
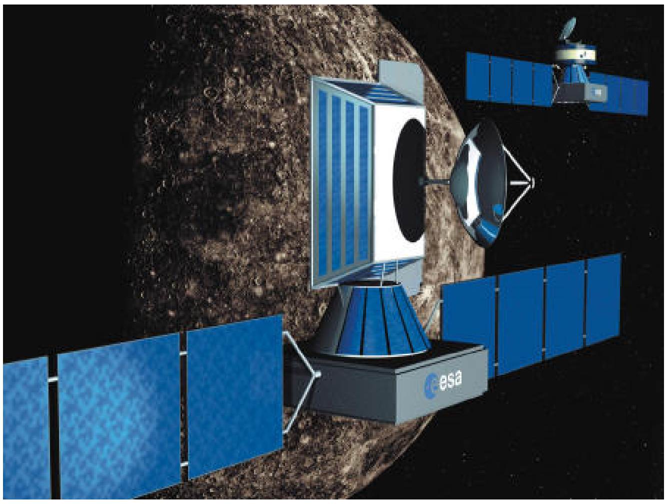


Fig. 4b

5. 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?

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

7. In 2015 the European Space Agency (ESA) will send the spacecraft Bepi-Colombo to orbit Mercury, and study the dynamics of the Mercury magnetosphere.



The Bepi-Colombo spacecraft

a) One of the phenomena expected to be studied is periods when the solar wind pressure is high enough to push the Mercury magnetosphere so far back that the solar wind will penetrate all the way to the planetary surface. Suppose that the solar wind plasma number density at Mercury orbit is n_e = 40 cm^{-3}. Estimate the minimum solar wind velocity for this to occur! The planetary radius R_M is 2440 km and Mercury's magnetic dipole moment is 3.0×10^{19} Am^2.

b) Can a similar phenomenon happen at Earth? Motivate your answer with numbers.

(From Exam, October 2007)