FYS 3610

EXERCISES WEEK 46

Descriptive questions:

i) Why does ionospheric conductivity anisotropic by nature?
ii) Describe Hall-, Pedersen- and Birkeland currents with respect to the direction of the electric and the magnetic fields.
iii) What is the underlying physical mechanism for ionospheric conductivity to occur?
iv) Why are there no horizontal ionospheric currents above 200 km?
v) Why can the horizontal ionospheric currents be neglected below 90-200?
vi) What is the definition of height integrated ionospheric concuticvity?
vii) Why has night time auroral precipitation greater impact on the height integrated ionospheric conductivity than the daytime auroral precipotation

Exercise 1

a) Sketch a typical electron density (m^{-3}) versus altitude profile for daytime sunlit conditions. Mark out the altitude ranges for the D-, E-, and F-layers.

The ion and electron momentum equations are given as:

$$n_i m_i \frac{d\vec{v}_i}{dt} = n_i e(\vec{E} + \vec{v}_i \times \vec{B}) - n_i m_i \nu_{in} \vec{v}_i \qquad (1.1)$$

$$n_e m_e \frac{d\vec{v}_e}{dt} = -n_e e(\vec{E} + \vec{v}_e \times \vec{B}) - n_e m_e \nu_{en} \vec{v}_e \qquad (1.2)$$

b) Describe the different terms in Eq. 1.1. Derive the following expressions for $\vec{v}_e$ and $\vec{v}_i$:

$$\vec{v}_i = \frac{\omega_i \nu_{in}}{\omega_i^2 + \nu_{in}^2} \frac{\vec{E}_\perp}{B} + \frac{\omega_i^2}{\omega_i^2 + \nu_{in}^2} \frac{\vec{E}_\perp \times \vec{B}}{B^2} \qquad (1.3)$$

$$\vec{v}_e = -\frac{\omega_e \nu_{en}}{\omega_e^2 + \nu_{en}^2} \frac{\vec{E}_\perp}{B} + \frac{\omega_e^2}{\omega_e^2 + \nu_{en}^2} \frac{\vec{E}_\perp \times \vec{B}}{B^2} \qquad (1.4)$$

c) Explain Figure 1.1.

d) Apply Figure 1.1, Eq. 1.3 and Eq. 1.4 to describe rotation of the velocity vectors $\vec{v}_i$ and $\vec{v}_e$ by altitude. (Hint: Derive expressions for the angle between the velocity vectors and $\vec{E}_\perp$ and draw an illustration). Derive expressions for the electron and the ion speeds and comment on the altitude variation. What is the maximal speed?

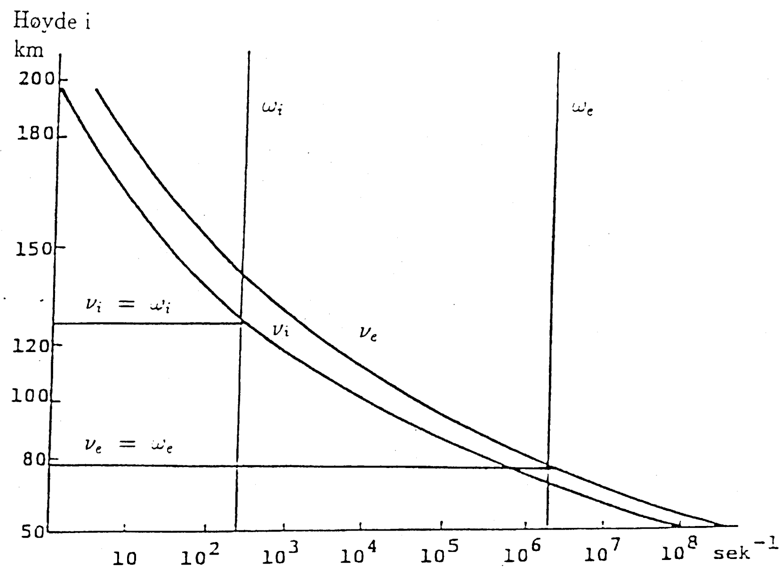

Figure 1.1

e) Find an expression for the current density $\vec{j}$. Point out the Hall and Pedersen terms and discuss j versus altitude. What controls the upper and the lower limits of the conductive layer?

EXERCISE 2

Assume an Earth-fixed Cartesian coordinate system (*x*,*y*,*z*) where *x* is pointing magnetic northward, *y* magnetic eastward, and *z* downwards towards the Earth's center. In this coordinate system the magnetic field is given by

$$\vec{B} = B(\cos I \ \hat{x} + \sin I \ \hat{z})$$

and the electric field is given by

$$\vec{E} = E_x \hat{x} + E_y \hat{y} + \vec{E}_z \hat{z}$$

For this coordinate system it is assumed that the magnetic dipole axis is antiparallel to the Earth's rotation axis and that the magnetic field is symmetric around this axis.

The height integrated current is given by:

$$\vec{J} = \Sigma_P \vec{E}_\perp - \Sigma_H \vec{E} \times \hat{B} + \Sigma_\parallel (\vec{E} \cdot \hat{B}) \hat{B}$$

Show that in the above coordinate system the height-integrated current can be expressed on tensor form as:

$$\begin{bmatrix} J_x \\ J_y \\ J_z \end{bmatrix} = \begin{bmatrix} \Sigma_P \sin^2 I + \Sigma_\parallel \cos^2 I & -\Sigma_H \sin I & (\Sigma_\parallel - \Sigma_P) \sin I \cos I \\ \Sigma_H \sin I & \Sigma_P & -\Sigma_H \cos I \\ (\Sigma_\parallel - \Sigma_P) \sin I \cos I & \Sigma_H \cos I & \Sigma_P \cos^2 I + \Sigma_\parallel \sin^2 I \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

Note that $\vec{E} = \vec{E}_\perp + \vec{E}_\parallel$