FYS 3610

EXERCISES WEEK 43

EXERCISE 1

a) Sketch a vertical profile of electron density versus altitude for noon sunlit conditions, and also for midnight non-auroral conditions. Indicate D, E, and F-regions on your sketch.

The ion and electron drifts perpendicular to the magnetic field can be written as:

$$\vec{v}_{i\perp} = \frac{k_i}{1+k_i^2}\frac{\vec{E}_\perp}{B} + \frac{k_i^2}{1+k_i^2}\frac{\vec{E}_\perp \times \vec{B}}{B^2} \qquad \text{Eq. 1.1}$$

$$\vec{v}_{e\perp} = -\frac{k_e}{1+k_e^2}\frac{\vec{E}_\perp}{B} + \frac{k_e^2}{1+k_e^2}\frac{\vec{E}_\perp \times \vec{B}}{B^2} \qquad \text{Eq. 1.2}$$

where $k_i = \frac{\Omega_i}{\nu_{in}}$ and $k_e = \frac{\Omega_e}{\nu_{en}}$. (The neutral wind has been neglected).

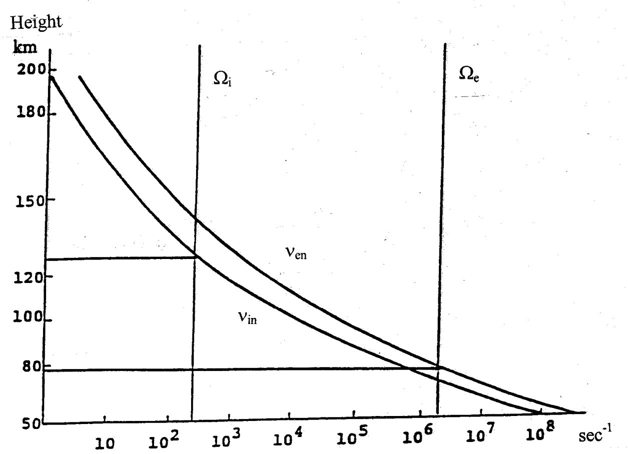

Figure 2.1

b) Given Figure 1.1 discuss the rotation of $\vec{v}_i$ and $\vec{v}_e$ by height as well as their variation in amplitude by height from 50 to 200 km.

c) Based on Eqs. 1.1 and 1.2 derive expressions for the height-integrated Hall and Pedersen currents.

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

$$\vec{B} = B(\cos I \ \hat{x} + \sin I \ \hat{z}) \qquad \text{Eq. 1.3}$$

and the electric field is given by

$$\vec{E} = E_x \hat{x} + E_y \hat{y} + \vec{E}_z \hat{z} \qquad \text{Eq. 1.4}$$

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. In this coordinate system the height-integrated current can be expressed on tensor form as:

$$\begin{bmatrix} J_x \\ J_y \\ J_z \end{bmatrix} = \begin{bmatrix} \Sigma_P \sin^2 I + \Sigma_{\parallel} \cos^2 I & -\Sigma_H \sin I & (\Sigma_{\parallel} - \Sigma_P) \sin I \ \cos I \\ \Sigma_H \sin I & \Sigma_P & -\Sigma_H \cos I \\ (\Sigma_{\parallel} - \Sigma_P) \sin I \ \cos I & \Sigma_H \cos I & \Sigma_P \cos^2 I + \Sigma_{\parallel} \sin^2 I \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix} \qquad \text{Eq.1.5}$$

d) Apply Eq. 2.5 on the equatorial region where the inclination angle is zero and $\vec{B} = B \ \hat{x}$. Assume that the vertical current $J_z = 0$ and show that

$$J_y = \left(\Sigma_P + \frac{\Sigma_H^2}{\Sigma_P} \right) E_y \qquad \text{Eq. 1.6}$$

which is the equatorial electrojet. Comment on the analogy with the auroral electrojet.

EXERCISE 2

The NASA satellite ACE is used for monitoring the solar wind. It is located around 230 Re upstream. Visit the following homepage http://sec.noaa.gov/ace/ and get yourself familiar with it. Concentrate on the Real Time Data and Dynamics plots, and plot data from MAG and SWEPAM (6 hours time scale I find very useful). List up the different parameters that are plotted in the MAG and SWEPAM plots. What is the typical range for each parameter? Estimate a typical time delay from plasma is being probed by the satellite until the same plasma impinge on the magnetopause.

EXERCISE 3

Investigate the home page for SuperDARN radars: http://superdarn.jhuapl.edu. In particular look at Real-Time data, Covection maps. Notice that the solar wind Theta angle in the XZ plane is given in the upper right. It would be good if you could take a frequent look at convection maps under varying solar wind conditions to hopefully reveal a systematic pattern. Then you get an experimental approach to ionospheric convection before we lecture it.