Exercises in Space Physics

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1 Radar and optical problems on ionospheric phenomena

1. Consider a charged particle in a magnetic field $\mathbf{B} = \mathrm{B}_z$. Calculate and show in a coordinate system its motion a) if there is no electric field, b) if there is an electric field $\mathbf{E} = \mathrm{E}_y$. c) Describe also the motion of a charged particle in the auroral zone, where the magnetic field is close to vertical and the magnetic field strenght increases as approaching the Earth.

2. Assume an ionosphere consisting of a majority of oxygen ions O^+ and a minority of carbon dioxide ions $\mathrm{CO_2}^+$. a) Estimate the scale heights for these ions by assuming that the temperature is the same and that the variation in temperature and gravitation can be neglected. b) What are the scale heights for the corresponding neutral constituents, oxygen atoms and carbondioxide molecules?

3. Estimate the electron density for the E, F_1 and F_2 layers in the ionogram in Figure 1. At which altitudes are the tops of the layers?

4. The directions of the geomagnetic field components are defined as following B_x (northward), B_y (easward) and B_z (down). At the lower edge of an auroral arc there can appear strong electric currents flowing eastward (eastward electrojet) or westward (westward electrojet). Figure out how they affect the B_x component straight below the arc and how they affect the B_z components north and south of the arc.

5. Assume a 32-m parabolic radar transmitter at 930 MHz. Estimate how much of the transmitted power will return back from the ionospheric E layer, as transmitting a 30 microsecond pulse with 1 MW power. What kind of various parameters affect the returned signal?

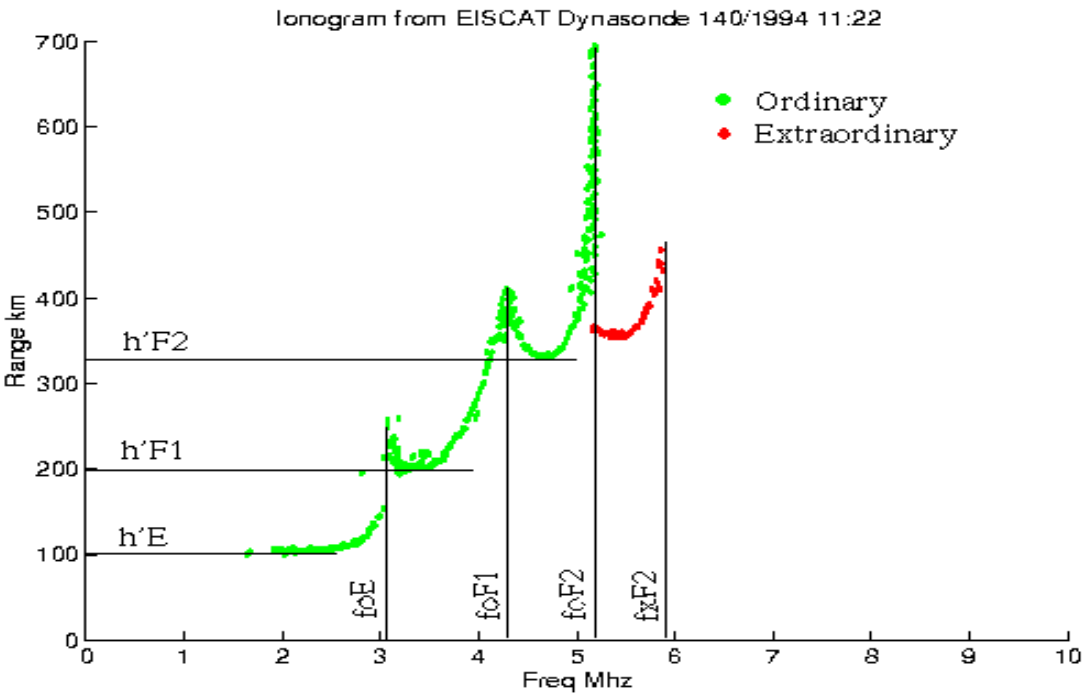

Figure 1: An ionogram.