# Problems, Tutorial 5

## Space physics EF2240, 2011

1. For a cosmic ray to be able to penetrate directly into the Earth's atmosphere close to the equator, it has to have a gyro radius at least as great as the size of the magnetosphere itself, otherwise it will begin to gyrate around a field line, and move towards the poles.

   a) Estimate the energy of a cosmic ray particle for this to happen, if the particle is a proton. What about an alpha particle? For the evaluation of the gyro radius use the strongest magnetic field the particle will encounter in the equatorial plane.

   b) How strong a field would you need to use if you wanted to artificially shield a spacecraft from particles of energies less than $10^8$ eV? Assume that the magnetic field is constant within a distance of 100 meters of the spacecraft.

2. What is the electron temperature of the plasma, from which the below Langmuir probe measurement is taken?

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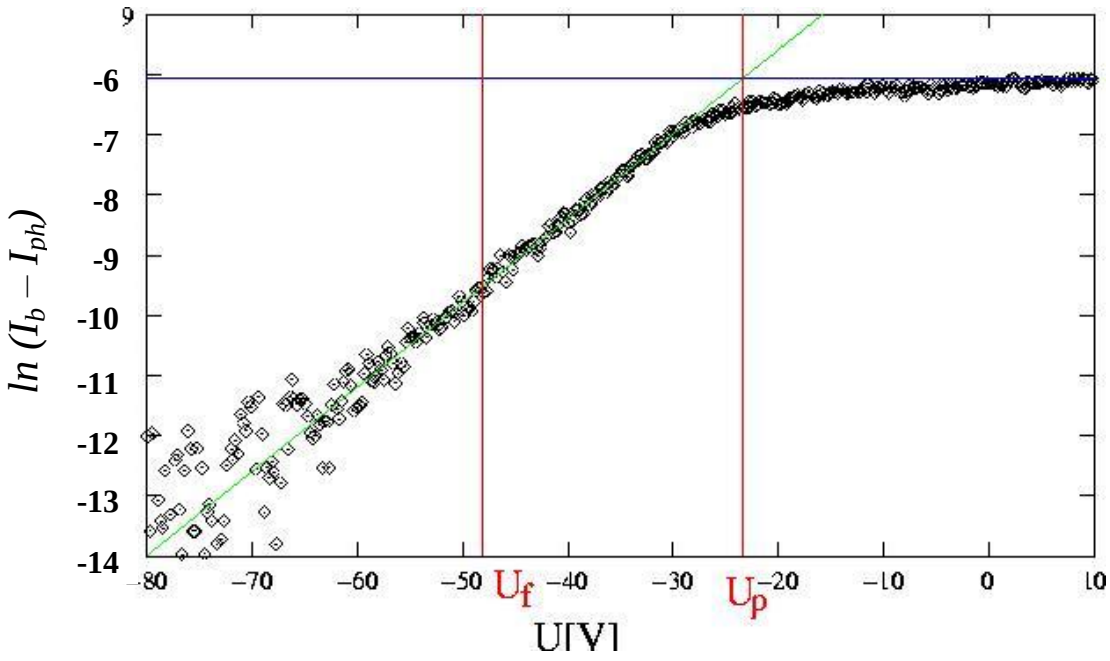


3. Estimate the Alfvén velocity in the solar wind. Use typical parameters from Fälthammar.

4. Figure 4 shows the Cocoon nebula, which is an approximately spherical emission nebula associated with an HII region, surrounding a single central star. It has a diameter of about 15 light years. Assuming that the HII region contains only (ionized) hydrogen and using the fact that the recombination coefficient of hydrogen, $\alpha_H$, varies with the electron temperature $T_e$ as below, determine the electron temperature in the nebula.

   The expression for the recombination coefficient is

   $$\alpha_H\left(T_e\right) = 2\cdot 10^{-16} T_e^{-3/4} \text{ m}^3\text{s}^{-1}.$$

   Assume that the central stare emits $10^{48}$ photons per second with energy greater than 13.6 eV, and that the number density of the HII region is 100 $\text{cm}^{-3}$.

   *(Adapted from Exam, Jan., 2011)*

*Figure 4.*