Problems, Tutorial 1

Space physics EF2240, 2016

The answers to some of the exercises may vary considerably, depending on what approximations and assumptions one has used. This may not necessarily mean that the answer is "wrong", in particular when dealing with estimates of orders of magnitude. If in doubt, do not hesitate to ask at a lecture or tutorial, or via email. Some exercises may seem trivial, but are there to let the student get a feeling for typical magnitudes and dimensions.

1. Estimate the gyro radius and gyro frequency (not angular frequency, but ordinary frequency) for

   a. an auroral electron with energy 5 keV a few hundred km above the auroral oval, where the magnetic field may be approximately 50 μT.
   b. a proton with the same energy at the same place.
   c. an alpha particle (He^{2+}) with the energy 1 keV in a sunspot.
   d. a proton in the solar wind, with the energy 10 eV.
   e. an electron in the E layer (dayside), with the energy 0.1 eV. Use the same magnetic field strength as in (a).

2. Calculate the Parker spiral angle for the average solar wind speed at

   a. Mercury's orbit
   b. Earth's orbit
   c. Jupiter's orbit

   The relevant distances can easily be found on the internet.

3. In a sunspot the plasma temperature is approximately 4000 K (compared to the average photospheric temperature of 6000 K). If the magnetic field is 0.3 T inside the sunspot and close to zero outside of it, and the particle density is $2.1 \cdot 10^{19}$ cm^{-3} outside of the sunspot; determine the ratio of particle densities inside and outside of the sunspot, using pressure balance.

4. Make an approximation of the total amount of magnetic energy in a solar flare-related coronal loop. Look for reasonable parameters in the lecture notes, literature or on internet. Compare to the total energy radiated away from a solar flare, which typically is of the order of 10^{20}-10^{24} J.

5.

a) If you consider your own body to be a black-body radiator, what is the wavelength at which the highest intensity of electromagnetic waves is emitted. What kind of an electromagnetic wave is this? (*Hint:* 0 K = -273 C).

b**)** We usually think of sunspots as black, since they appear so when observed close to the intense emissions from the undisturbed solar surface. But what colour are they really, if we assume that they have a temperature of 4200 K? (See Figure 5.)

c) The emitted power per unit area P, from a black-body radiator is

$$P = \sigma_{SB} T^4$$

where σ_{SB} is the Stefan-Bolzmann constant. Calculate the decrease (in percent) of total emitted power from the Sun due to a large, circular sunspot with a radius of 100 000 km.

(From Exam, Oct., 2010)

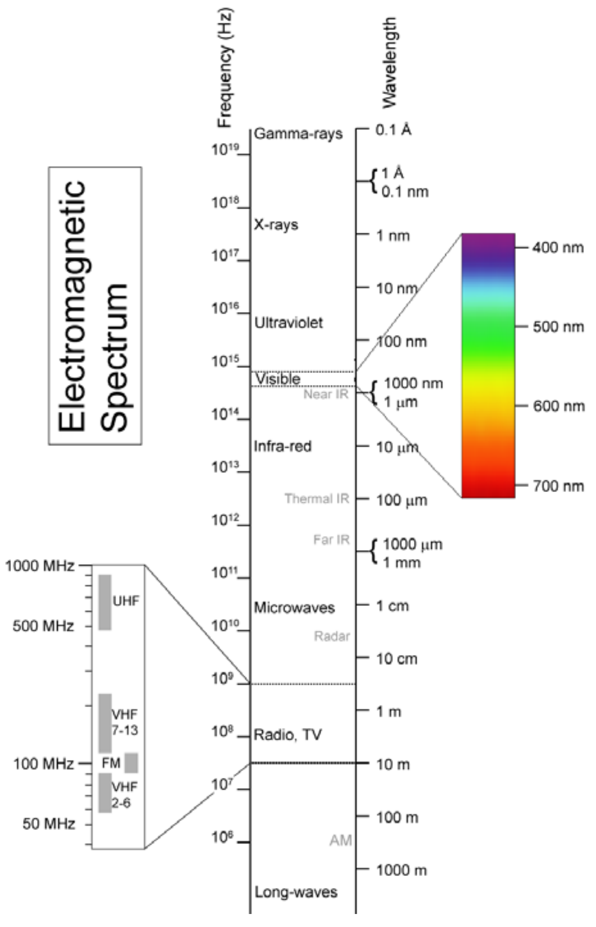

Figure 5. The electromagnetic spectrum.