Introduction to Astronomy
Exercises week 11

20 December 2019

1. Two clusters are close to each other on the sky and are therefore assumed to have equal (or very similar) interstellar extinction properties. They have angular diameters of α and 3α respectively; and their distance moduli (i.e. apparent magnitude minus absolute magnitude) are 16.0 and 11.0, respectively. Assuming their diameters are equal and the interstellar extinction coefficient a is identical for both clusters, determine their distances and the value for a.

2. Synchrotron radiation is produced when relativistic charged particles are deflected by interstellar magnetic fields. As an example, we consider a proton with a kinetic energy of $E_{\rm kin} = 1.6 \times 10^{-13}$ J moving perpendicular to a Galactic magnetic field with strength $B = 0.1\,$nT. (Remember 1 Tesla = 1 Ws/Am^2). Given that the magnetic field exerts a force of $\vec{F} = q\vec{v} \times \vec{B}$ and that the centripetal force is mv^2/r, calculate the radius of the circular motion of the proton.

3. There is a sharp decrease in the flux density of Cassiopeia A at a frequency of about 10 MHz. If this source is 3 kpc from the Sun and the average electron density is $0.03\,\mathrm{cm}^{-3}$, calculate whether the fall-off can be caused by the free-free absorption of free electrons along the line of sight. Assume the interstellar electron density is constant. (Hint: use the formulae for the emission measure and the optical depth of free-free emission to estimate the temperature the cloud should have in order to have an optical depth larger than unity. Compare this temperature to the typical temperature of ionised interstellar gas (thousands of Kelvins and up).)