

Astrophysics II - Exercise Sheet 6

EPFL Physics section, Prof. Pascale Jablonka

1 Doppler profile of absorption lines

1. Show that, if the ions of a stellar atmosphere follow a Maxwellian distribution in the velocities v_x :

$$f(v_x) = \frac{dN_x}{N} = \frac{1}{\sqrt{\pi}} \sqrt{\frac{m}{2kT}} e^{-\frac{mv_x^2}{2kT}} dv_x \quad (1)$$

then the line profile can be written, by neglecting the intrinsic width of the profile:

$$\frac{I_\nu d\nu}{I} = \frac{1}{\sqrt{\pi}} e^{-\left(\frac{\Delta\nu}{\Delta\nu_D}\right)^2} \frac{d\nu}{\Delta\nu_D} \quad (2)$$

with $\Delta\nu \equiv \nu - \nu_0$ et $\Delta\nu_D \equiv \frac{\nu_0}{c} \sqrt{2kT/m}$, où ν_0 being the mean frequency of the line.

2. What is the Doppler width (in Å) of an iron line at 5000 Å formed in a layer of a stellar atmosphere at temperature $T = 5700$ K?
3. Are the lines of a heavy element wider or narrower than those of a light one ? In what proportions ? (we neglect the velocities due to microturbulence).

2 Rayleigh and Thomson scattering

1. Starting from the formula of the harmonic oscillator, for the imaginary part of the refraction index,

$$n' \simeq \frac{Ne^2}{2m_e} \frac{\nu \gamma / 2\pi}{(\nu_0^2 - \nu^2)^2 + \nu^2 \left(\frac{\gamma}{2\pi}\right)^2} \quad (3)$$

and from the expression of γ ,

$$\gamma = \frac{8\pi^2 e^2 \nu^2}{3m_e c^3} \quad (4)$$

show that you can recover Rayleigh's scattering law, i.e. $\kappa\rho \propto 1/\lambda^4$, in the case of an electron that is strongly bound to the atom.

2. Starting from the same equations, show that the opacity approaches a constant when the electron is so weakly bound to the atom or ion that it becomes free.