Astr 423, Spring 2019

Homework 4: Line broadening

1 Natural broadening

Calculate a Lorentz profile for an absorption line corresponding to a transition with level lifetimes $\Delta t = 10^{-8}$ s, and frequency ν_0 equivalent to a wavelength of 5000 Å. Make your calculation for an array of 100 frequencies centered at ν_0 (choose the range of frequencies wisely). Next, calculate and plot the Lorentz profile as a function of wavelength. Choose plot limits that will allow to appreciate the peak and wings of the profile. Estimate on your plot the FWHM of the profile in Å. It should agree with $\Gamma/2\pi$ transformed into Å.

2 Doppler broadening

Calculate $V_{\rm th}$ and $\Delta\lambda_{\rm D}$ for the Mg II line at 4481 Å, at a temperature of 10000 K. Calculate a Gaussian profile

$$\exp\left(-\frac{(\lambda-\lambda_0)^2}{\Delta\lambda_{\rm D}^2}\right)$$

and plot it. Calculate the intensity of the Gaussian profile at a wavelength $\lambda = \lambda_0 + \Delta\lambda_{\rm D}$. Now compare with the Lorentz profile calculated in Section 1. At what wavelength, measured from λ_0, will the Lorentz profile become higher than the Doppler profile? Make a plot showing both profiles (it may be more illustrative to plot the log of the intensity as a function of wavelength).

3 Rotation

Calculate the escape velocities for main sequence stars of spectral types O, B, A, F and G. The stellar parameters may be taken from the Hertzsprung-

Russell diagrams shown in the first Power-Point, or from any edition of Allen's Astrophysical Quantities. Make a table with your input parameters and results. Which stars have the highest escape velocities? Calculate the maximum rotational broadening (total width of line profile), in Å, that we can expect to find for a B-type star. Assume a non-Hydrogen spectral line at 5000 Å. Why did I specify that it cannot be a H-line?