

ASTR 545 Fall 2016
Homework 1 (75 points)
Due: Tuesday September 6 (at start of class)

1. (25 pts) Optical Depth, Column Density, Mean Free Path:
 - (a, 2 pts) Write the equation relating optical depth at wavelength λ in terms of the opacity.
 - (b, 3pts) Write the equation defining the opacity at wavelength λ in terms of the number density and cross section for absorption at wavelength λ .
 - (c, 10pts) Write the equation defining column density. Now, starting with the definition of optical depth in (a), derive the definition of column density from the optical depth equation. Explain what is physically assumed about the gas that must be invoked for the derivation?
 - (b, 10pts) If the optical depth at wavelength λ is $\tau_\lambda = 2.5$, what is the mean free path of a photon with this wavelength through a gas structure that is 5 pc thick (show your calculation and give your answer in cm).
2. (50 pts) I am providing you spectra of H α and H β absorption lines from four “stars”. The H α spectra are in the files “star1-Ha.data” through “star4-Hb.data” and the H β spectra are in the files “star1-Hb.data” through “star4-Hb.data”. The profiles are plotted on the attached page. These data files with the spectra can be downloaded from the web at “<http://astronomy.nmsu.edu/cwc/Teaching/ASTR545/HW1/>”

The needed columns in the data files are:

- (col 1) λ_j , the wavelength [\AA] in pixel j
- (col 2) $f_{\lambda_j} = I_{\lambda_j}/I_{\lambda_j}^0$, relative (or “normalized”) flux in pixel j
- (col 3) σ_{λ_j} , the uncertainty in f_{λ_j} at pixel j

Measure the equivalent widths, W , and the uncertainties, σ_W , of all profiles and present the results in a table. To compute the equivalent widths and their uncertainties, use the direct “summation” method

$$W = \sum_j [1 - f_{\lambda_j}] \Delta\lambda_j, \quad \sigma_W = \left\{ \sum_j [\sigma_{\lambda_j} \Delta\lambda_j]^2 \right\}^{1/2}, \quad (1)$$

where $\Delta\lambda_j$ is the pixel width in \AA , and where the sum is over the pixels encompassing the absorption profile (i.e., do not necessarily perform the sum over all the pixels in the spectrum, just the ones encompassing the absorption profile, which you can choose based upon your own discretion). Include a copy of your code. Format your table as follows and quote your equivalent widths as $W \pm \sigma_W$ in units of \AA , i.e.,

Table 1: Equivalent Widths

Object	$W(\text{H}\alpha)$ [\AA]	$W(\text{H}\beta)$ [\AA]
Star 1	$W \pm \sigma_W$	$W \pm \sigma_W$
Star 2	$W \pm \sigma_W$	$W \pm \sigma_W$
Star 3	$W \pm \sigma_W$	$W \pm \sigma_W$
Star 4	$W \pm \sigma_W$	$W \pm \sigma_W$