

AY230 – Homework Set #4

Due November 20, 2008

- (1) The optical depth for an absorption line is related to the column density of gas N by:

$$\tau_\lambda = \frac{\pi e^2}{m_e c^2} f_{ij} \lambda_{ij}^2 N \phi_\lambda \quad (1)$$

where f_{ij} is the oscillator strength, λ_{ij} is the wavelength of the transition and ϕ_λ is the line profile.

- (a) Derive a ‘complete’ expression for the optical depth in velocity space τ_v of the Ly β transition for a slab of gas with velocity dispersion σ and column density N_{HI} .
 - (b) Consider a distant source with continuum I_ν^* that lies behind the slab. Overplot the observed intensity I_ν relative to the continuum for a series of Ly β transitions with $N_{\text{HI}} = 10^{13}, 10^{15}, 10^{18}$ and 10^{21} cm^{-2} and $\sigma = 30 \text{ km s}^{-1}$. Discuss.
 - (c) Plot the equivalent widths W_λ for the Ly β absorption for N_{HI} ranging from 10^{13} to 10^{21} cm^{-2} for velocity dispersions of $\sigma = 10, 30,$ and 100 km s^{-1} . Discuss.
 - (d) For one choice of σ , plot $d(W_\lambda/\lambda)/dN$ vs. N . Discuss.
- (2) ISM analysis and dust depletion:
- (a) On the web site is a normalized spectrum of a high redshift quasar. Along the sightline to this quasar is a damped Ly α system with a redshift of $z \approx 2.309$. Identify and plot the following transitions from this galaxy:

Table 1: ATOMIC DATA

Wave (\AA)	Name	f
1370.131	NiII 1370	0.0769
1393.755	SiIV 1393	0.5280
1402.770	SiIV 1402	0.2620
1454.842	NiII 1454	0.0323
1611.2005	FeII 1611	0.00136
1703.405	NiII 1703	0.0060
1709.6042	NiII 1709	0.0324
1741.5531	NiII 1741	0.0427
2026.136	ZnII 2026	0.48900
2066.161	CrII 2066	0.0515

- (b) Explain the physics which leads to the Si IV doublet and then predict the ratio of the oscillator strengths of these two transitions. Measure the reduced equivalent widths (W/λ) of the Si IV transitions and discuss the values.

- (c) Perform a curve of growth analysis of the Ni II transitions. What is the best 'fit' column density? (You don't have to perform a reduced χ^2 analysis. A simple fit by eye is fine). Present a plot of $\log W/\lambda$ vs. $\log(f\lambda)$ for the data and an overplot of the best fit N and b values. You may neglect Natural broadening in your analysis.
- (d) Measure column densities (I suggest the apparent optical depth method of Savage & Sembach 1991) for all of the transitions in Table 1. Plot your values relative to the Solar values (i.e. [X/H]) against the condensation temperature T_C assuming $N(\text{HI}) = 10^{21.37} \text{ cm}^{-2}$. Discuss (what do you make of [Si/H]?).