Chapter 3 : Optically Thin Photoionization Models and Predictions for Time Variability

3.1 : Photoionization and the Ionization Parameter

Photoionization/recombination is the most likely process which establishes the ionization conditions in the BALR. Models show that this is more consistent with the relative strengths of the BALs (*cf.* Turnshek 1988) than collisional ionization. Also, if there were a significant amount of collisional ionization, this would produce excessive amounts of line emission, even for small covering factors (Junkkarinen *et al.* 1987). In addition, the time variability of BALs over a wide range of outflow velocities favors photoionization by the central source. If there were a secondary energy source driving the collisional ionization, we would not *necessarily* expect this source to propagate in synchronization with the continuum photons *and* dominate the continuum photons as in source of ionization (Barlow *et al.* 1992, Barlow *et al.* 1992b).

Our primary hypothesis is that BAL changes are due to ionizational level changes which cause a redistribution of the fractional ionic abundances for each element. Given this, we wish to know the fractional abundances, for all the relevant ions, as a function of the ionization parameter (U, defined below). We especially want to know at what value of U does the abundance of each ion peak. This will enable us to set limits on U based on the relative BAL changes between various transitions.

In equilibrium, the rate of photoionization ($\propto n_\gamma n_{\rm H^0}$) equals the rate of recombination ($\propto n_e n_{\rm H^+}$), which means (approximately) $n_\gamma/n_e \propto n_{\rm H^+}/n_{\rm H^0}$. We define the ionization parameter as the number density of hydrogen ionizing photons (n_γ) divided by the number density of free electrons (n_e) :

$$U = \frac{n_\gamma}{n_e} = \int_{\nu_o}^{\infty} \frac{L(\nu)}{h\nu c 4\pi r^2 n_e} d\nu \quad ,$$