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TEMPERATURE DIAGNOSTICS OF THE BROAD LINE REGION IN ACTIVE GALACTIC NUCLEI

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Diagnostics of the physical properties in the Broad Line Region (BLR) of Active Galactic Nuclei (AGN) is a difficult subject to study since there is no simple and direct method as is a case for the Narrow Line Region. We propose here a direct method for the temperature estimates in the BLR, that is using the broad Balmer and helium lines (He II λ4686 and He I λ5876).

The Boltzmann-Plot (BP) method, commonly used for laboratory plasma diagnostics (Griem 1997), can be applied to the broad Balmer lines emitted from the same region in order to estimate the temperature in the BLR (Ilić et al. 2006; Popović 2003; Popović 2006). This method assumes that the upper energy states ($n > 3$) can be described with Saha-Boltzmann equation and that if the normalized line intensities $I_n = F_u\lambda/g_uA_u$ can be fitted with

$$\log_{10}(I_n) = B - A \cdot E\,, \qquad (1)$$

then from the temperature parameter A a temperature could be estimated $A = \log(e)/(kT)$, where k is is the Boltzmann constant (see Ilić et al. 2007 for details).

Using the photoionization code CLOUDY (version 06.02, Ferland 2006), we generate a grid of the BLR emission-line spectra for different values of hydrogen gas density n_{H} and hydrogen-ionizing photon flux Φ_{H}, assuming to have solar chemical abundances and constant hydrogen density (Ilić et al. 2007). The hydrogen gas density and ionizing photon flux are varied in the range: $log\ n_{\mathrm{H}} = [8,12]$, $log\ \Phi_{\mathrm{H}} = [17,21]$. We assumed all clouds having a single column density $N_{\mathrm{H}} = 10^{23}$ cm^{-2} (Dumont et al. 1998; Korista & Goad 2004). The next step was to apply the BP method on the Balmer line ratios calculated by CLOUDY and estimate the temperature T_{BP} of the region where Balmer lines are formed. We also consider in our analysis the normalized fluxes of the helium lines He II λ4686 and He I λ5876, as well as the temperature averaged over radius T_{av}.

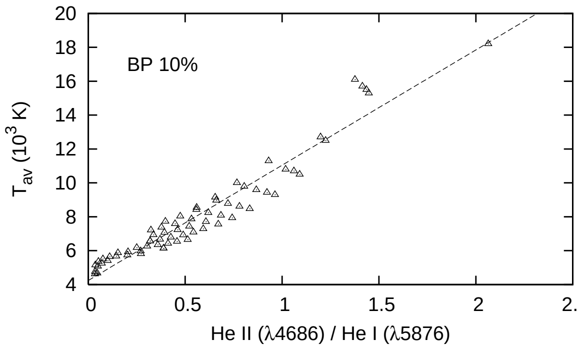

Fig. 1. The average temperature T_{av} of the emitting medium plotted versus the He II λ4686/He I λ5876 line ratio for data set “BP 10%”. The best-fitting is presented with dashed line.

We analyze the cases where the BP method could be applied on the simulated Balmer lines, i.e. the normalized intensities could be fitted with the equation (1) with the error smaller then 10%. For these cases there is a good correlation (the correlation coefficient is r=0.96) between the average temperature T_{av}, that is obtained from the model, and the helium line flux ratio: $T_{\mathrm{av}} = (4241.6 \pm 158.1) + (6802.0 \pm 226.6) \cdot R$, where $R =$ He II λ4686/He I λ5876 (Figure 1). The above correlation could be used for estimation of the average temperature in those BLR where BP can be applied. More detail discussion will be given elsewhere (Ilić et al. 2007).

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