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On the Physical Mechanism Underlying PC1 and Baldwin Effect in Quasars

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Recent work (Baskin & Laor 2004; Dong *et al.* 2009a,b) suggests that the Eddington ratio ($\ell \equiv L/L_{\rm Edd}$) is the origin of all the significant first-order object-to-object variations of quasar spectral properties from the zeroth-order similarity of AGN spectra; specifically, this includes the PC1 of Boroson & Green (1992), the classic or inverse Baldwin effect (Baldwin 1977), and even blueshifting (i.e., blue asymmetry) of high-ionization emission lines (Dong *et al.* 2009c).

To understand such unification, we shift our docus from the detailed physics of the accretion process (microphysics) to "statistical physics" (macrophysics) of the broad-line clouds (Dong *et al.*, in preparation; cf. Korista 1999). With more realistic constraints (e.g., the distribution of the number of line-emitting clouds with ℓ and other physical parameters), we believe that the first-order regularities and even the second-order effects of quasar emission lines may be reproduced exactly by future "locally optimally-emitting cloud" models (LOC; Baldwin *et al.* 1995).

On one hand, for clouds gravitationally bound around the central engine, there is a lower limit on the column density $N_{\rm H}$ that is set by and roughly scales with $L/L_{\rm Edd}$ (Dong *et al.* 2009a). On the other hand, in accretion-powered radiation systems such as quasars, $L/L_{\rm Edd}$ is closely related to $\dot{m}$; thus the increase in $L/L_{\rm Edd}$ requires an increase in the gas supply. It is reasonable to conclude that at least a significant part of the gas required originates in the line-emitting clouds. Thus, as $L/L_{\rm Edd}$ increases, the total mass of line-emitting clumpy gas increases. Combining the above two factors, *the distribution of the line-emitting clouds is ultimately regulated by* $L/L_{\rm Edd}$.

Note that the strength of high-ionization lines (e.g., C IV) and optically thick lines (e.g., Lyα and Mg II) is roughly proportional to the summed area of the illuminated surface of line-emitting clouds while that of low-ionization, optically thin lines (e.g., narrow-line and broad-line optical Fe II) is roughly proportional to the summed volume of the clouds. Thus, generally, the EW of high-ionization lines and optically thick lines correlates negatively with $L/L_{\rm Edd}$ whereas that of low-ionization, optically thin lines correlates positively. The exact logEW–log$L/L_{\rm Edd}$ slope for a particular emission line depends on both the cloud distribution and the atomic physics — the latter is the very physics underlying the LOC model.

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