Poster Contributions: Line Studies

BLOATED STARS AS BLR CLOUDS: NUMERIC RESULTS

TAL ALEXANDER and HAGAI NETZER
School of Physics and Astronomy, Tel Aviv University, Tel Aviv 69978, Israel

Abstract.
The 'Bloated Stars Scenario' proposes that AGN broad line emission originates in the winds or envelopes of bloated stars (BS) (see *e.g.* Kazanas 1989 and references therein). Its main advantage over BLR cloud models is the gravitational confinement of the gas and its major difficulty the large estimated number of BSs and the resulting high collisional and evolutionary mass loss rates (see *e.g.* Begelman & Sikura 1991). Previous work on this model did not include detailed calculations of the line spectrum, modeled solar neighborhood super giants (SG) and used very simplified stellar distribution functions for the nucleus. Here (Alexander & Netzer, 1993) we calculate the emission line ratios by applying a detailed numerical photoionization code (Rees, Netzer & Ferland, 1989) to the wind and by assuming a detailed nucleus model (Murphy, Cohn & Durisen, 1990). Allowing for the yet unknown effects of the AGN's extreme conditions on stars and stellar evolution, we study a wide range of simplified wind structures rather than confine ourselves to normal SGs. Our model consists of a spherically symmetric outflowing wind that emanates from the surface of the BS ($R_\star = 10^{13}$ cm, $M_\star = 0.8M_\odot$, $\dot{M} = 10^{-6}M_\odot/\mathrm{yr}$) whose size and edge density are determined by various processes: Comptonization by the central continuum source (calculated self consistently for our $L_{\mathrm{ion}} = 10^{46}$ erg/s model continuum by the photoionization code), tidal disruption by the black hole ($M_{bh} = 8 \times 10^7 M_\odot$) and the limit set by the assumption that the wind's mass $\leq 0.2M_\odot$. This results in a large range of wind sizes, from 10^{13} to 10^{16} cm. We find that the line emission spectrum is mainly determined by the conditions at the edge of the wind rather than by its internal structure. Comptonization results in a very high ionization parameter at the edge which produces an excess of unobserved broad high excitation forbidden lines. The finite mass constraint limits the wind's size, increases the edge density and thus improves the results. Studying power-law wind structures ($v(R) = v_\star(R/R_\star)^{-\alpha}$ where $v_\star$ is the wind's base velocity at the BS's surface), we find that slow, decelerating, mass-constrained flows ($v_\star = 50$ m/s, $\alpha = 0.5$) with high gas densities (10^8 to 10^{12} cm^{-3}) are as successful as cloud models in reproducing the overall observed line spectrum. The Mg II λ2798 and N V λ1240 lines are however under-produced in our models. The denser the winds, the more efficient they are as BLR clouds. By calculating the $L\alpha$ emission from the wind we adjust the number of BSs so as to obtain the BLR's observed $EW(L\alpha)$. We find that only $\sim 5 \times 10^4$ BSs with dense winds ($v_\star = 50$ m/s, $\alpha = 0.5$) are required in the inner 1/3 pc (~ 0.005 of the total stellar population). This small fraction approaches that of SGs in the solar neighborhood. The calculated mass loss from such a small number of BSs is consistent with the observational constraints. We find that the required number of BSs, and consequently their mass loss rate, are a very sensitive functions of the wind's density structure (a $\sim 10^4$ factor between the slow $v_\star = 50$ m/s, $\alpha = 0.5$ model and the fast $v_\star = 50$ km/s, $\alpha = -2$ model). In particular, high mass loss rules out SG-like BSs ($v_\star = 10$ km/s, $\alpha = 0$). We conclude that BSs with dense winds can reproduce the BLR line spectrum and be supported by the stellar population without excessive mass loss and collisional destruction rates. The question whether such hitherto unobserved stars actually exist in the BLR remains open.

References

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