Co-Evolution of Central Black Holes and Galaxies
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Low-Mass AGN at High Accretion Rates

Dawei Xu[1] **and S. Komossa**[2]

[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
Email: dwxu@bao.ac.cn
[2]Max-Planck-Institut für extraterrestrische Physik, Postfach 1312, 85741 Garching, Germany
Email: skomossa@mpe.mpg.de

Abstract. Galaxies with low-mass black holes and high accretion rates, i.e., narrow-line Seyfert 1 (NLS1) galaxies, are important objects when addressing the issues of black hole growth and evolution, and of feeding and feedback. We have studied a sample of such objects, and find (1) that the locus of NLS1 galaxies on the $M_{\rm BH}$–σ plane appears to follow the relation of non-active galaxies after removing objects obviously dominated by outflows, (2) the presence of "blue outliers" that hint at extreme outflows as predicted by recent merger models, and (3) more subtle evidence for winds/outflows across the whole NLS1 population.

Keywords. galaxies: active, galaxies: Seyfert

We have analyzed the optical spectra of ∼100 NLS1 and broad-line Seyfert 1 (BLS1) galaxies. Our results can be summarized as follows:

1. We investigated the usefulness of the widths of narrow-line region (NLR) lines as surrogate for σ_* (Komossa & Xu 2007). We find that NLS1 galaxies as a class follow the $M_{\rm BH}$–σ relation of non-active galaxies if the width of [S II] $\lambda\lambda$6716, 6731 is used as a substitute for σ_*. We also find that the width of the core of [O III] λ5007 is a good surrogate for σ_*, but only after removing objects with high outflow velocities in the core of the lines (hereafter referred to as "blue outliers").

2. We studied systematically the properties of these blue outliers (Komossa *et al.* 2008). We detect a strong correlation between line outflow velocities and ionization potential in each galaxy, and we report the absence of a zero-blueshift [O III] component from a classical inner NLR , while the presence of a classical outer quiescent NLR is indicated by the existence of low-ionization lines. We favor a scenario in which the NLR clouds of blue outliers are entrained in a decelerating wind.

3. We detect a "zone of avoidance" in the NLR density in the sense that BLS1 galaxies avoid low densities, while NLS1 galaxies show a larger scatter in density, including a significant number of objects with low densities (Xu *et al.* 2007). To explain these observations, we tentatively favor an interpretation that the effects of winds/outflows are stronger in NLS1 galaxies than in BLS1 galaxies.

4. We have identified new correlations that link black hole mass, Eddington ratio, and physical parameters of the emission-line region. A new element is added to the eigenvector 1 space based on principal component analysis (Xu *et al.* 2010, in preparation).

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References

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