The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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$M - \sigma$ relation in radio-loud AGNs and NLS1s

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Abstract. There is a tight $M - \sigma$ relation in nearby inactive galaxies. Nearby radio-quiet AGNs also followed this relation. In order to investigate whether radio-loud AGNs and NLS1s follow this relation or not, we estimated their central black hole masses from Hβ and the bulge velocity dispersions from [O III] linewidth. We found that radio-loud AGNs and NLS1s seemed to deviate from this relation.

1. Introduction

Evidence shows that the evolution of black holes and their host galaxies appear to be closely coupled. For nearby inactive galaxies, there exists a tight correlation (hereafter $M_{bh} - \sigma$ relation) $M_{bh} = 10^{8.13}(\sigma/(200kms^{-1}))^{4.02}\, M_{\odot}$ (Tremaine et al. 2002). Whether all kinds of AGNs follow this relation or not is still a matter to debate. There are many theory discussing about this $M_{bh} - \sigma$ relation. Some suggested that NLS1s would deviate from this relation because they are in the early stage of AGNs evolution and the black holes grow fast via the super-Eddington accretion (e.g. Lu & Yu 2003). And the super-Eddington accretion leads to the steep X-ray slope founded in NLS1s. It is necessary to investigate the $M_{bh} - \sigma$ relation in a large sample of different kinds of AGNs, especially in NLS1s and radio-loud AGNs. It would also provide information about the availability of the methods to derive M_{bh} and σ in these kinds of AGNs.

2. Results and discussion

Black hole masses in NLS1s are calculated using Hβ linewidth and the size-luminosity empirical relation (Kaspi et al. 2000). We discussed the NLS1s sample from SDSS presented by Williams et al. (2003). All the samples we used to discussion the $M_{bh} - \sigma$ relation is showed in detail in Bian & Zhao (2004a).

From Fig. 1, it is found that radio-quiet AGNs follow the $M_{\rm bh}$–σ relation defined by Tremaine et al. (2002) but with a larger scatter. However, the radio-loud AGNs and NLS1s seemed not to follow this relation. For more detail, please read Bian & Zhao (2004a). Here our question is that whether this deviation is true or not?

(1) Smaller BLRs inclinations in NLS1s?
If NLS1s indeed follow $M_{bh} - \sigma$ relation and σ from [O III] linewidth is correct, we suggested the mean inclination of NLS1s is about 7 deg, which support the pole-on model of NLS1s. However, it is also possible that NLS1s indeed deviated from this relation for they are in the early stage of AGN evolution. It is also possible that [O III] linewidth is broaden by some mechanism (e.g. jet). In order to clarify this question, we need to directly measure the bulge stellar velocity dispersion. Other independent methods to estimate masses in NLS1s are also needed, such as the statured X-ray luminosity (Bian & Zhao 2004b).

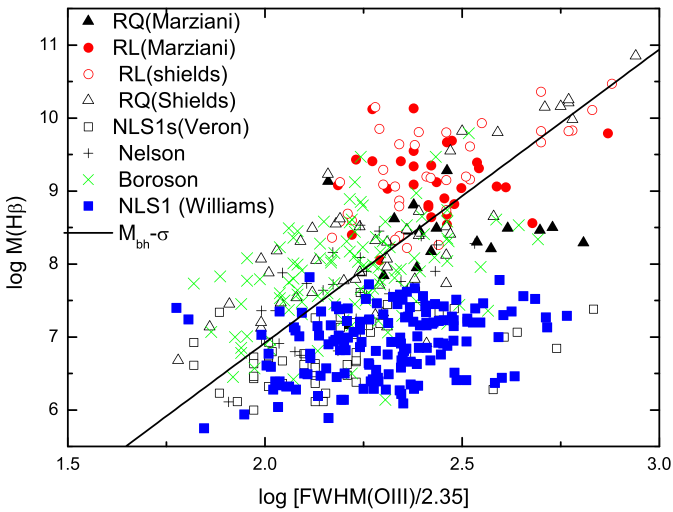

Figure 1. Black hole masses derived from Hβ linewidth versus [O III] linewidth for broad-line AGNs, radio-loud AGNs, and narrow-line AGNs.

(2) Overestimate of the BLRs sizes in radio-loud AGNs?
For radio-loud AGNs, BLRs velocity may be related to FWHM of Hβ as $V = 1.5 \times \mathrm{FWHM}_{[\mathrm{H}\beta]}$, which is equivalent to assume smaller inclination in them. However, smaller inclination in radio-loud AGNs would make radio-loud AGNs deviate much from the $M_{bh} - \sigma$ relation defined by Tremaine et al. (2002). One possible solution is that BLRs zises are overestimated in radio-loud AGNs because their optical luminosity may be contaminated by bright emission lines and/or the synchrotron emission from the jet, which would lead to the overestimated BLRs sizes.

(3) Cautious to use virial mass in NLS1s and radio-loud AGNs!
If we think all type of galaxies follow the same $M_{\mathrm{bh}} - \sigma$ correlation, our results suggested that we should be cautious to use the virial black hole masses assuming random BLRs orbits for radio-loud AGNs and NLS1s.

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