The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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Determining the zero-point calibration for AGN black hole mass estimates

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Abstract. By fitting to the quiescent galaxy $M_{\rm BH}$–σ_* relation, we calculate the average shift required to scale reverberation-mapped AGN masses to the same zero-point. We use reanalyzed virial products ($r\ V^2\ /\ G$) and both new and published velocity dispersions to find the offset in the AGN calibration. This scaling factor, $\langle f \rangle$, accounts for the detailed dynamics and geometry of the broad-line region (BLR). Finally, we confirm the rough correlation between σ_* and FWHM([O III]) for these 16 AGNs.

We use the strong correlation linking a galaxy's black hole mass, $M_{\rm BH}$, to its stellar velocity dispersion, σ_*, to calibrate the $M_{\rm BH}$ values found for AGNs via reverberation mapping (RM). RM analysis yields the virial product, $M_{rev} = r\ V^2\ /\ G$, where r is measured by the time delay of the emission lines in response to changes in the continuum, and V is measured from the dispersion of the rms line profile. M_{rev} is related to the black hole mass as $M_{\rm BH} = f\ M_{rev}$, where f accounts for the kinematics and shape of the BLR.

Simple models for the value of f were assumed in earlier work, which found that AGNs are broadly consistent with the quiescent galaxy $M_{\rm BH}$–σ_* relationship. Our approach relies on the assumption that the two relationships are, in fact, identical; the slope of the AGN relation was then fixed to that of the inactive galaxies, and the normalization offset determined the ensemble average scale factor, $\langle f \rangle$. The slope of the $M_{\rm BH}$–σ_* relation is still under debate, so we chose the two most prominent values near the ends of the quoted range: 4.58 (Ferrarese 2002; F02) and 4.02 (Tremaine et al. 2002; T02).

With new measurements of σ_* for six AGNs and additional values from the literature, we used a sample of 16 AGNs with M_{rev} data (from Peterson et al. 2004) to determine $\langle f \rangle$. With the slope fixed to the F02 (T02) value, we find $\langle f \rangle = 5.5 \pm 1.9$ (5.5 ± 1.6). The data are plotted in Figure 1, which also shows the $M_{\rm BH}$ scale on the right-hand axis, obtained by multiplying by $\langle f \rangle$.

Other investigators have used FWHM([O III]) as a proxy for σ_*. With [O III] measurements tabulated by Nelson (2000), we examined the correlation between σ_* and FWHM([O III]) for our 16 AGNs. Significant scatter was found for individual objects, but the two measures are in approximate agreement.

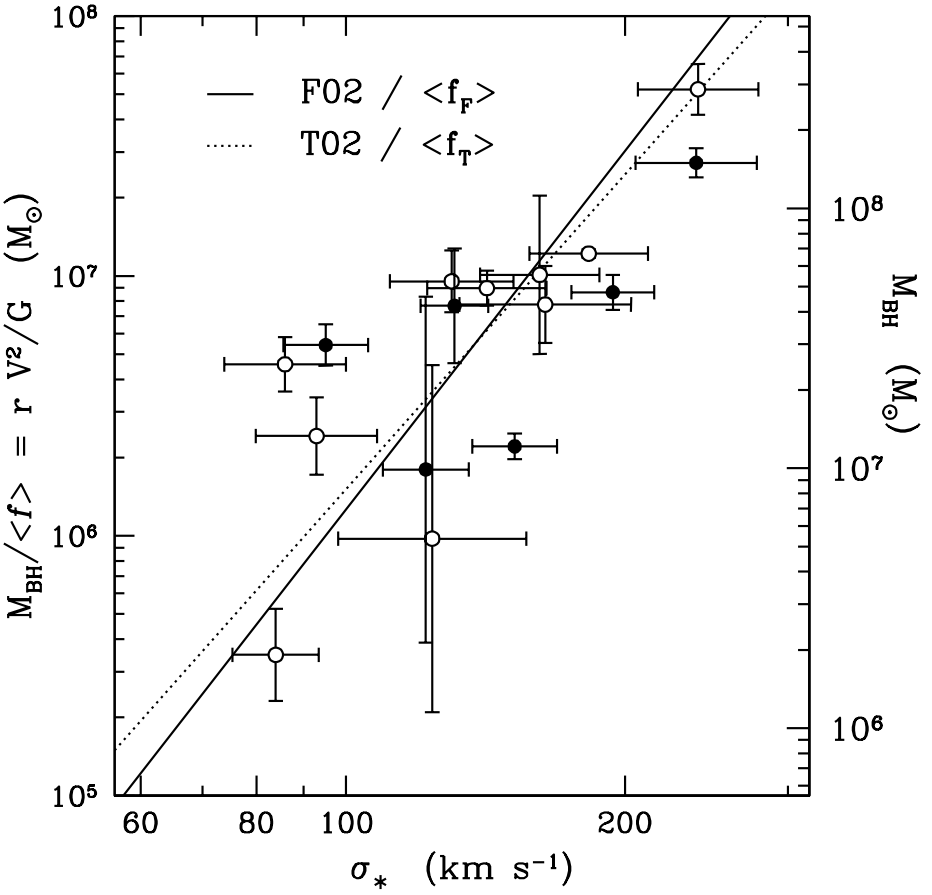

Figure 1. Filled points indicate new σ_* measurements; open points are published values. $M_{\rm BH}/f$ data is from Peterson et al. (2004). Solid (dotted) line indicates F02 (T02) slope, with normalization scaled down by $\langle f \rangle$.

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