Limits on the Masses of Supermassive Black Holes in 105 Nearby Galaxies

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Secure measurements of the mass of the central supermassive black hole, $M_{BH}$, in external galaxies are traditionally obtained through the modeling of the stellar and/or gaseous kinematics, most often derived using Hubble Space Telescope (HST) observations in the optical domain. The modeling of the nuclear ionized-gas kinematics has led to accurate $M_{BH}$ measurements at a relatively cheap cost in terms of observation time compared to stellar-dynamical $M_{BH}$ determinations. But only a handful of the objects have turned out to have sufficiently regular gas velocity fields for the purpose of modeling. Nevertheless, the HST archive contains a yet untapped resource that can be used to better constrain the $M_{BH}$ budget across the different morphological types of galaxies, which consists of the vast number of the Space Telescope Imaging Spectrograph (STIS) spectra from which a central emission-line width can be measured. These data allow to put an upper limit on $M_{BH}$ for a large number of galaxies and promise to compensate for the lack of exact measurements when studying the $M_{BH}$–host galaxy relationships.

For this reason, we used STIS to obtain $H\alpha$ spectra of the nuclei of 105 nearby ($D < 100$ Mpc) galaxies spanning a wide range of Hubble types (E–Sc) and values of the central stellar velocity dispersion, $\sigma_c$ (58–419 km s$^{-1}$). We obtained stringent upper bounds on their black hole masses (Beifiori \textit{et al.} 2009). For the vast majority of the objects, the derived upper limits on $M_{BH}$ run parallel to and above the well-known $M_{BH}$–$\sigma_c$ relation, independent of the galaxy distance, suggesting that our nebular line-width measurements trace the nuclear gravitational potential rather well. For values of $\sigma_c$ between 90 and 220 km s$^{-1}$, 68\% of our upper limits fall immediately above the $M_{BH}$–$\sigma_c$ relation without exceeding the expected $M_{BH}$ values by more than a factor 4.1. No systematic trends or offsets are observed in this $\sigma_c$ range as a function of the galaxy Hubble type or with respect to the presence of a bar. For 6 of our 12 upper limits on $M_{BH}$ with $\sigma_c < 90$ km s$^{-1}$, our line-width measurements are more sensitive to the stellar contribution than to the gravitational potential, either due to the presence of a nuclear stellar cluster or because of a greater distance compared to the other galaxies at the low-$\sigma_c$ end of the $M_{BH}$–$\sigma_c$ relation. Conversely, our $M_{BH}$ upper bounds appear to lie closer to the expected $M_{BH}$ in the most massive elliptical galaxies with values of $\sigma_c$ above 220 km s$^{-1}$. Such a flattening of the $M_{BH}$–$\sigma_c$ relation at its high-$\sigma_c$ end would appear consistent with a coevolution of supermassive black holes and galaxies driven by dry mergers, although more consistent measurements for $\sigma_c$ and $K$-band luminosity are needed for these kind of objects before systematic effects can be ruled out.

Reference