Super massive black holes in disk galaxies: HST/STIS observations for 3 new objects

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1 Sample selection, ionized-gas kinematics and model

As demonstrated in [1], it is possible to detect from ground-based observations the presence of a circumnuclear Keplerian disk (CNKD) around a super massive black hole (SMBH) with a large mass ($M_\bullet$). Its identification is possible from the study of the position-velocity (PV) diagram as done by [2]. From their work and literature data we select three disk galaxies, namely NGC 2179, NGC 4343 and NGC 4435, which have (i) a PV diagram consistent with the presence of a CNKD and (ii) a central stellar velocity dispersion (σ_c) which falls in a poorly sampled region of the $M_\bullet - \sigma_c$ relation [3,4].

For each target galaxy we obtained with HST/STIS the Hα and [NII] 6583 Å kinematics along the major axis and two 0.″25 parallel offset positions on either sides of the nucleus. We used the G750M grating with 0.″2 slit. For NGC 4435 an HST/STIS spectrum obtained along the disk minor axis was available in HST Archive with the same set-up. For NGC 2179 and NGC 4343 the spectrum reveals a disturbed gas kinematics. These two objects show an irregular dust-lane morphology, too. On the contrary, NGC 4435 shows a regular kinematics as well as a CNKD with a regular dust-lane morphology. This galaxy is a good candidate to model the ionized-gas velocity field in order to determine $M_\bullet$.

In the model we assumed an exponential radial profile both for the velocity dispersion and emission-line flux. We build the model velocity field by considering the contribution of the stellar potential and the Keplerian potential of a SMBH. The stellar potential was measured from the surface-brightness radial profile using a constant mass-to-light ratio and spherical symmetry, by means of the Multi-Gaussian Method [5] as done in [6]. Effects of the STIS PSF, of the slit width and the bleeding of charge between adjacent pixels in the CCD were also taken into account. The analysis of the dust-lane morphology provided the initial guesses for the position angle and inclination of the CNKD. The rotation curves obtained from the best-fit model and adopting a $M_\bullet$ as predicted by the $M_\bullet - \sigma_c$ relation are compared to the observed gas kinematics in Fig. 1.

2 Results and conclusions

Ground-based observations evidence that about 20% of galaxies show a PV diagram which is consistent with the presence of a CNKD [2]. This criterion should

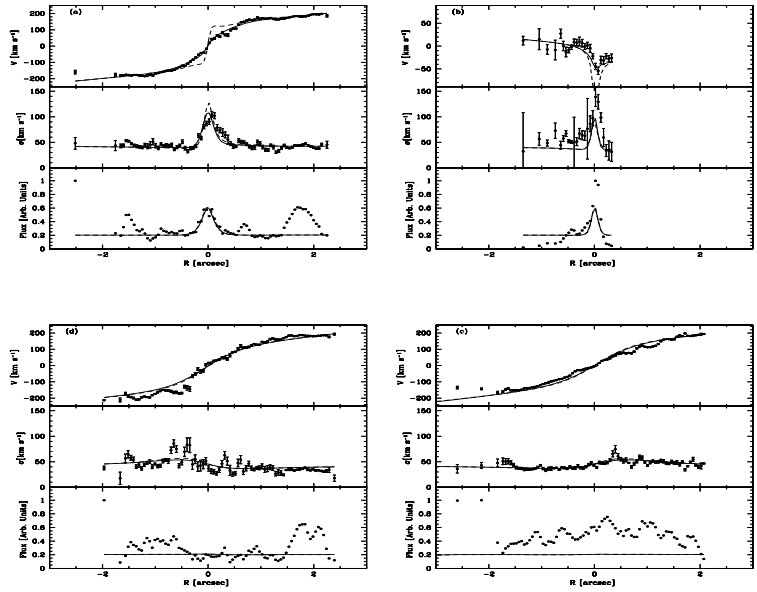

Fig. 1. Observed ionized-gas kinematics (*filled circles*) and model predictions for NGC 4435. Rotation curve (*upper panel*), velocity dispersion profile (*central panel*), and emission-line flux profile (*lower panel*) are shown for the major axis *(a)*, minor axis *(b)*, $+0''.25$ offset axis *(c)*, and $-0''.25$ offset axis *(d)*. The *continuous line* and *dashed line* represent the best-fit model prediction with $M_\bullet \simeq 1 \times 10^7 M_\odot$ and the model with $M_\bullet \simeq 8 \times 10^7 M_\odot$ as predicted by $M_\bullet - \sigma_c$ relation, respectively.

be combined with the presence of a regular dust-lane morphology, according to the results later found by [7]. Indeed in our sample NGC 4435 is the only galaxy that shows a regular dust-lane morphology as well as a regular rotation curve. The modeling work is still in progress, but preliminary results give a $M_\bullet \simeq 10^7 M_\odot$. On the contrary, the $M_\bullet - \sigma_c$ relation predicts for NGC 4435 $M_\bullet \simeq 8 \times 10^7 M_\odot$ for the observed $\sigma_c = 174$ km s^{-1} [8]. However, as shown in Fig. 1, the central velocity gradient obtained for $M_\bullet \simeq 8 \times 10^7 M_\odot$ is not consistent with the observed one.

References

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