THE BLACK HOLE MASS – SÉRSIC INDEX RELATION FOR BULGES AND ELLIPTICAL GALAXIES

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Overview

Scaling relations between supermassive black hole (SMBH) mass, $M_{\rm BH}$, and various host spheroid properties are a powerful tool for studying galaxy-(black hole) coevolution. Furthermore, these relations enable us to predict the masses of SMBHs in other galaxies, and to measure the SMBH mass function and quantify the SMBH space density in our local Universe. Graham & Driver (2007) presented evidence for a strong correlation between $M_{\rm BH}$ and the central light concentration of the host bulge, quantified by the Sérsic index n. The $M_{\rm BH} - n$ relation might be one of the simplest and strongest black hole mass scaling relations, requiring only uncalibrated galaxy images. Given the existence of the luminosity$-n$ relation (Young & Currie 1994, Binggeli & Jerjen 1998) and the $M_{\rm BH}-$luminosity relation (Magorrian et al. 1998), an $M_{\rm BH} - n$ relation must exist. However, several recent studies have found only a weak $M_{\rm BH} - n$ relation...

1. Data collection

We collected literature Sérsic index measurements, compared multiple measurements belonging to the same galaxy, excluded the outlying measurements and averaged the remaining ones. Our exclusion algorithm took into account a systematic bias produced by different observational bandpasses and different galaxy modelling methods (1D or 2D techniques).

2. The observed $M_{\rm BH} - n$ relations

The resulting $M_{\rm BH} - n$ diagram is shown in Figure 1. A Spearman's test confirmed the strength of the correlation.

After excluding the discrepant Sérsic indices, presumably from poor fits, we recover a clear trend between black hole mass and Sérsic index.

We have carefully checked for substructure in the $M_{\rm BH} - n$ diagram in terms of disc/elliptical and Sérsic/core-Sérsic galaxies.

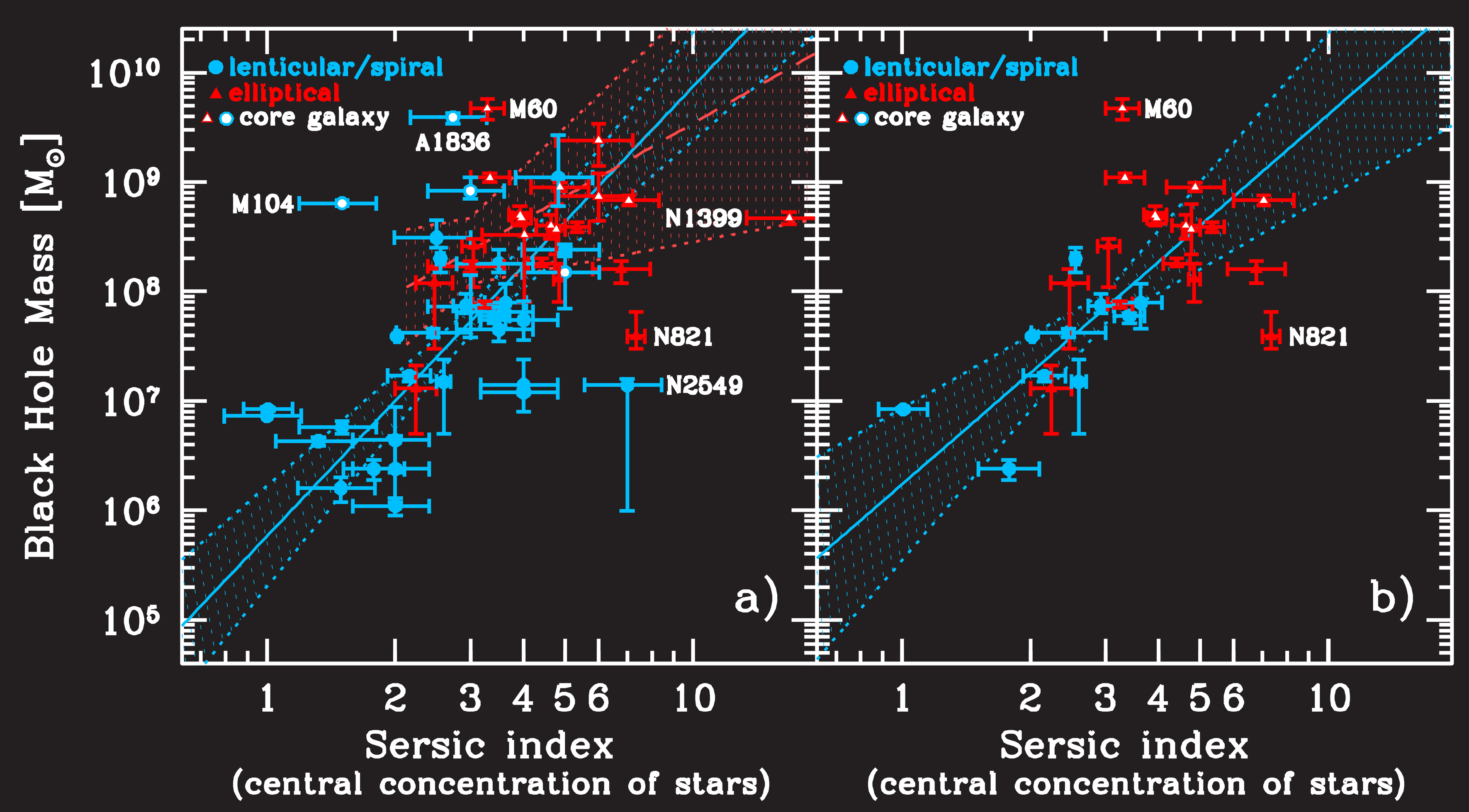
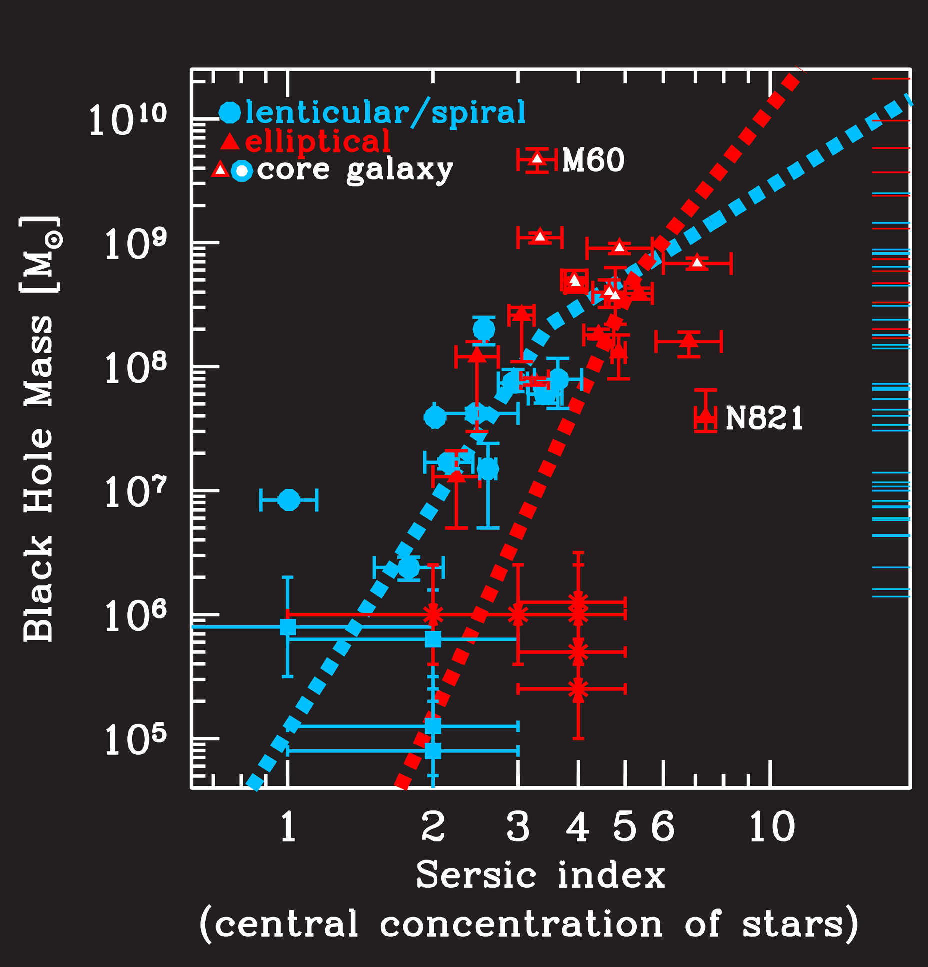


Figure 1a. *All galaxies with at least one Sérsic measurement from the original works.*
Figure 1b. *Only galaxies with multiple measurements (we plot their average n). Symmetrical bisector regressions have been performed for the Sérsic disc galaxies (blue) and for the core-Sérsic elliptical galaxies (red).*

3. The expected $M_{\rm BH} - n$ relations



From the luminosity$-n$ and the $M_{\rm BH}-$luminosity relations in the literature,

we expect four different trends in the $M_{\rm BH} - n$ diagram corresponding to the disc/elliptical and Sérsic/core-Sérsic classifications.

Figure 2. *Same data as Figure 1b but now shown with the predicted $M_{\rm BH} - n$ relations. Additional data (bottom-left corner) from Greene et al. (2008) confirm the gap between the expected $M_{\rm BH} - n$ relations for disc (blue) and elliptical (red) galaxies at the low-$M_{\rm BH}$ end. The ticks on the right axis indicate recent $M_{\rm BH}$ detections for which we plan to measure their host spheroids Sérsic index, enabling us to better explore the high- and low-$M_{\rm BH}$ ends of the correlation.*

4. Conclusions

Several recent studies have found only a weak $M_{\rm BH} - n$ relation. Working with the authors of those works, we have combined literature data after a careful error analysis, identifying and excluding questionable data, such as two-component (bulge+disc) galaxies fit with just a single Sérsic model.
As a result, we successfully recovered a strong $M_{\rm BH} - n$ relation. In addition, for the first time, we searched for potential substructures in the $M_{\rm BH} - n$ diagram based on both the galaxy morphology (elliptical or disc) and the nature of the central light profile (Sérsic or core-Sérsic) (Savorgnan et al. 2013). We discovered that large (core-Sérsic) elliptical galaxies follow a different relation than (Sérsic) disc galaxies, providing new insight into the connection between galaxy, star formation and black hole growth.

5. Future work

Future work will focus on accurately modelling the bulge/disc structure of ~80 local galaxies with direct $M_{\rm BH}$ values. We will re-investigate several scaling relations between black hole mass and host galaxy properties in a homogeneous analysis (same observational bandpass and same modelling method) and with the largest up-to-date galaxy sample.

References

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