Do Galaxies with Water Megamaser Emission obey the Fundamental Plane of Black Hole Accretion?

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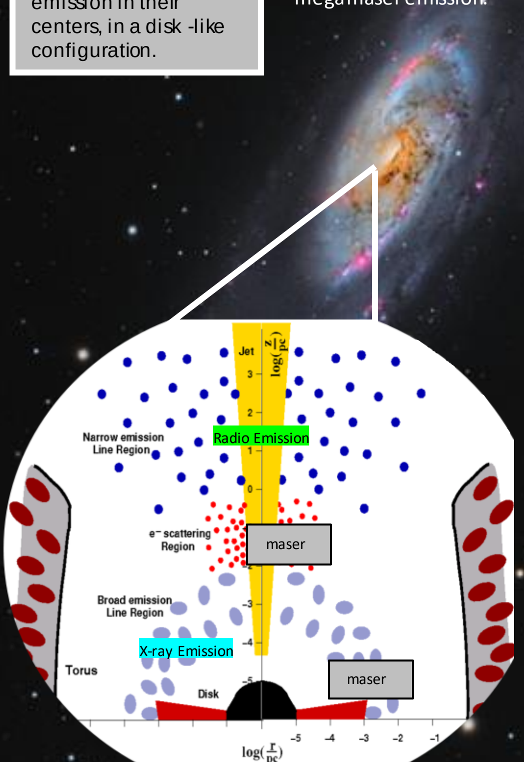
With **this project,** we investigate the degree to which the Fundamental Plane for Black Hole activity applies to a particular type of galaxies: the galaxies that show water megamaser emission in their centers, in a disk -like configuration.

NGC 4258
- The "poster child" of megamaser emission.

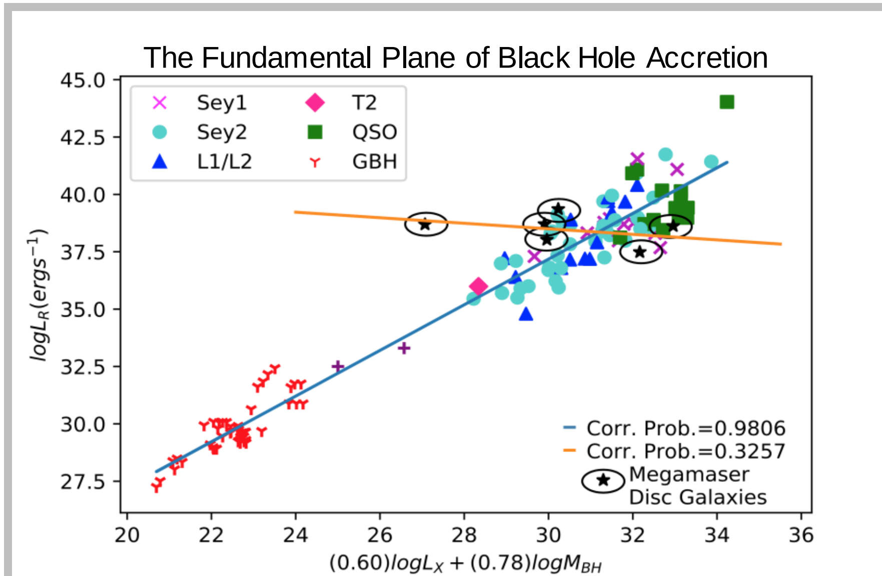


What is the Fundamental Plane of Black Hole Accretion? One of the most fundamental finding about how black holes operate is an empirical relation between three of the most fundamental measures of black hole activity: the X-ray luminosity (as a measure of the power of the accretion of matter onto the black hole), the radio luminosity (as a measure of the kinetic power extracted from the black hole via jet activity), and the mass of a black hole. This relation spans over six orders of magnitude in mass, from stellar mass black holes of only tens of solar masses, to supermassive black holes of millions to billions of solar masses, that are found in galaxy center. This rather immense range of masses makes this mathematical "plane" especially important since it provides a unification scheme for all black holes that we found evidence for in our universe, regardless of their mass. Even more interestingly, this Fundamental Plane for Black Hole activity seems to be obeyed by a diverse population of galaxies with a wide range of luminosities and spectral types in their emission associated with accretion of matter onto their central black holes. Therefore, it seems that, basically, all known states of black hole accretion can be characterized by this fundamental relation.

The **megamaser disc galaxies** are particularly important as they are uniquely posed to provide us with:
i) direct measures of extragalactic distances (i.e., without assumptions of the geometry of the universe), and
ii) the most accurate measurements of supermassive black hole masses.
Unfortunately, these megamaser disk systems are extremely rare.

Only < 3% of all survey's galaxies show some type of water maser emission, of which, only half reveal the high intensities of megamasers, and the disk morphology. Nothing else in the universe can provide these measurements, so we are interested in finding more of these megamaser discs.

In order to detect more megamaser disc in galaxy centers, we need to better understand their physical nature, and in particular, the link to the supermassive black hole accretion activity. We compiled all the available measurements of X-ray luminosity, radio luminosity, and black hole mass for the known megamaser disc galaxies, and we present here and discuss their location on the fundamental plane relation.



Conclusion: Our investigation suggests that the standard Fundamental Plane relationship between the BH mass and host galaxy properties, that applies relatively equally for quite a variety of galaxy types (Sey 1 and 2, LINERs, Transition objects, Quasars), no longer seem to hold for those hosting megamaser disc emission.

Possible interpretation:
- we did not properly include the measurement errors in gauging the consistency of the maser-disk galaxy data with the general FP relation. It is possible that the errors associated with the X-ray and radio emission in the maser galaxies place these systems within the general scatter of the FP.
- Variability in both radio and X-ray emission could play a major role in establishing an average place on the FP relation; the X-ray/radio measurements are non-simultaneous (however, that remains true for the parent sample based on which the FP was first built).
- the maser emission is not associated with the synchrotron emission arising from a jetted (low-accretion state) BH, as it have been suggested that the FP may only apply to this particular state of accretion (Falcke et al. 2004). Ways to test this idea are: 1) to obtain accurate estimates of their accretion rates, and/or 2) investigate with higher quality data the true nature of their X-ray/radio emission, to distinguish between jet or coronal emission in X-ray, and better quantify the steepness of the radio energy distribution.

References: Castangia et al. (2013); Falcke et al. (2004); Greene et al. (2016); Greenhill et al. (2008); Gultekin et al. (2009); Kording et al. (2006); Liu et al. (2017); Masini et al. (2016); Merloni, Heinz & Di Matteo (2003); Plotkin et al. (2012); Zhang et al. (2012)

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