Estimating the Mass of the Central Black Hole Using the Sersic Index of the Bulge of the Host Galaxy. M. T. Hartley[1], J. Berrier[1], and B. L. Davis[1] D. Kennefick[1], J. Kennefick[1], M. X. Seigar[2], C. E. Lacy[1], [1]University of Arkansas, Fayetteville [2] University of Arkansas, Little Rock

Introduction: It is commonly accepted that most galaxies contain a supermassive black hole at their center. There are many ways of estimating the mass of these central black holes, such as reverberation mapping, direct measurement of gas or stellar objects, or indirect methods such as the M-sigma relation, among others. However, the vast majority of these need spectral imaging in order to give accurate results.

The Sersic profile is a function that relates how bright a part of the galaxy is as a function of how far from the center it is. Graham, et al. 2007 [1] gave a relationship between the sersic index of the bulge of a galaxy and the mass of the black hole. One of the main advantages of this relationship is that one only need look at images of galaxies in order to estimate the mass of the black hole.

The sersic profile is of the form

$$\ln[I(r)] = kr^{1/n} + \ln I_o$$

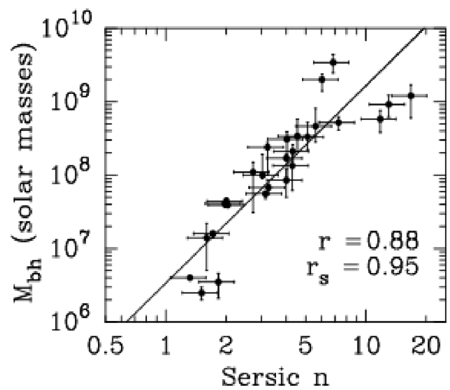
where n is the sersic index, k is a constant, equal to one over the radius enclosing half the light raised to the power of one over the sersic index, and I_o is the central intensity. The sersic index controls the shape of the profile. Specifically, it controls how fast the intensity falls off with radius, with high sersic indices falling off extremely quickly at low radii and low sersic indices approaching exponential decay at n = 1 and a gaussian function at n = ½.

Calculating the sersic index of an elliptical galaxy (early-type galaxy) is fairly straightforward, since it is composed solely of a sersic component. Spiral galaxies (late-type galaxies), on the other hand are composed of a sersic bulge and a disk, which is usually taken to be an exponential disk. Because of this, one can not simply try and fit the profile of a spiral galaxy to a sersic profile, since this does not account for the luminosity contributed by the disk. but rather a bulge-disk decomposition is necessary to seperate out the exponential disk from the sersic bulge.

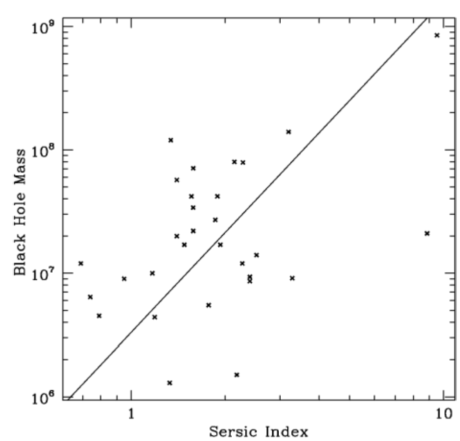
There are many advantages to the M-n relation, such as the fact that one need only have an image in order to estimate the mass of the central supermassive black hole. Also, estimating the sersic index is a relatively light computation, doesn't require much telescope time, and doesn't depend on distance or any unknown quantity.

Method: I have been working with primarily spiral galaxies with images in the I band, which should give good resolution of the bulge, which doesn't have any star forming regions that would be missed in this band. I ran these images through the IRAF routine ellipse, which performed isophote fitting on the images to get a view of the intensity profile. I then ran the data through an idl program that performed bulge-disk decomposition and estimated the sersic index using a 5 component fit routine, then calculated the black hole mass expected from a galaxy with this sersic index. I then estimated the error on the sersic index by subtracting out then adding the poisonnian noise and running the fit on these datasets and then calculating the standard error.

Results: I have found that the black hole masses given by the sersic relation given in Graham, et al. 2007 agree with the black hole masses that were calculated by various methods including estimations from masers, gas and stellar dynamics, reverberation mapping, the M-sigma relation, and some using eddington luminosities. My tentative results have significant scatter compared to the data published by Graham 2007.



the data from Graham, et al. 2007



a graph of my tentative results

It is possible that this is due to the sersic model being worse for late-type galaxies than it is for early -type galaxies. This could also be due to the fact that measuring the sersic index of a spiral galaxy is more difficult than measuring the sersic index of an elliptical galaxy, and there is significant error in my estimates. Also, further work with the data could reduce the scatter to that published by Graham 2007

If the problem does lie in the fact that the sersic index doesn't work as well for late-type galaxies, there is another method to estimate the mass of the central black hole. This involves measuring the pitch angles of the galaxies. Since this method can't possibly work for galaxies that don't have spiral structure, namely early-type galaxies, this leads to a nice complementary relationship between the two methods, with early-type galaxies being fit via the sersic index, and late-type galaxies being fit with pitch angles. If this is indeed the case, then it should be relatively easy to determine the black hole mass of any galaxy we have an image of, since we have a nice regimentation of the methods to use.

References: [1] Graham A. W. and Driver S. P. (2007) APJ 655, 77-87