Measuring the Central Mass and Pitch Angle of Type 2 Active Galaxies

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Introduction: An Active Galactic Nucleus (AGN) is the nucleus of a galaxy with higher luminosity. The nucleus is usually the brightest object in the whole galaxy. One of the more obvious differences between a Type I and Type II AGN Is that Type I AGN have broad emission lines and Type II AGN have narrow emission lines. Broad emission lines are believed to help the observer assume that there is activity there, instead of there just being chemicals. Many of these galaxies have a supermassive black hole at their centers which are physical objects that power the AGN. There has been evidence that the evolution of a black hole and a galaxy are linked but it is not clear which one comes first. This project allows us to investigate the relationship between the pitch angle of a galaxy and the mass of the central super massive black hole in the galaxy at higher redshifts as well as local galaxies.

This research project is important because it will tell us about the connection between the structure of a galaxy and the mass of a black hole.

Selection of Sample: The experiment began with a parent sample containing 2172 galaxies and the galaxies were then immediately classified to identify whether or not they contained spiral structure. This process helped to eliminate a lot of the galaxies that did not fit the criteria, leaving the sample containing 783 galaxies. Next we began to find and download the SLOAN images for all of the galaxies so that they could be used later in the research and we also downloaded the Hubble images for the 17 galaxies that were offered. The final sample was representative of the galaxies with very prominent spiral structure and consisted of 27 galaxies over a range of redshifts.

Method: The images were then prepped for both the Spectral measurement and also the pitch angle measurement. The Image Reduction Analysis Facility (IRAF) was used to de-project the images and get them ready for the next step, which was to measure them for their respective pitch angles. At this point a specialized computer script used by Davis et al (2012) was used to measure their respective pitch angles. The pitch angles were measured by first looking at the spirals of the galaxies to see in which direction the spiral arms with turning, this revealed the chirality of the galaxy. When the galaxy was turning clockwise then that meant that it was positive and if the galaxy was turning counter-clockwise then that showed that the chirality was negative.

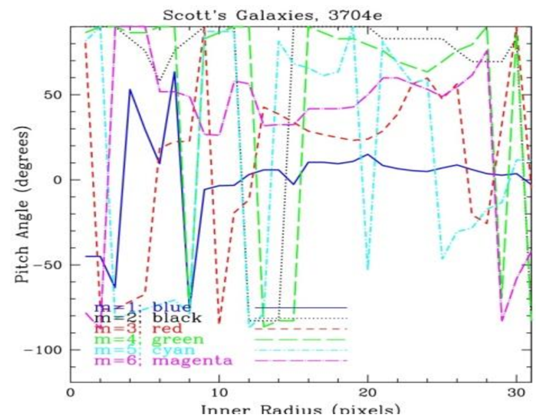

Figure 1: This graph depicts the pitch angle of the galaxy as calculated by a specialized computer program and allows the stable region to be found which allows for pitch angle measurement.

At this point the graph in Figure 1 was being analyzed and the process of trying to locate the most stable region that was valid, based on the chirality of the galaxies, had been started. That information was then used to get the pitch angle of the galaxies. While the measuring of the pitch angles were taking place it was discovered that the signal to noise ratio made five of the pitch angles immeasurable. This further decreased the sample to 22 galaxies.

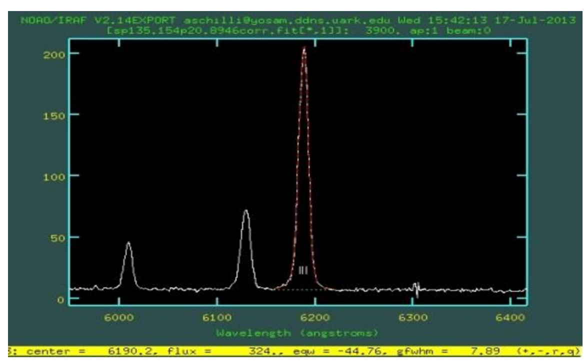

Figure 2: This is a spectral measurement graph for one of the galaxies. The graph shows which OIII lines are being fit for measurement and the Gaussian it is being measured to.

While the pitch angles of the galaxies were being measured and recorded, the spectral emission lines were also being measured. The spectral emission line measurement was important because it was going to tell us the mass of the black hole in the galaxy. As seen in Figure 2 for the spectral measurement only the OIII lines were measured and they were fit to a Gaussian.

Results: Once the OIII lines were measured since we were working with Type II AGN we were able to use the narrow line width as a proxy for stellar velocity dispersion. We used the equation

$$\sigma_* = \sigma_{NL} = \frac{FWHM([OIII])}{2.35}$$

to be able to use it in the equation for mass. Once the necessary data was gatheres the mass of the black hole could be measured using the equation,

$$\log_{10}\left(\frac{M_{BH}}{M_{sun}}\right) = \log_{10}\left(\left(10^{8.13}\right) \times \left(\frac{\sigma_*}{200 km/s}\right)^{4.02}\right)$$

After all available data had been utilized and the mass, had been figured out, since we already had the pitch angles of the galaxies, we were able to make a graph depicting the relationship between the pitch angle of the galaxy and the mass of the black hole.

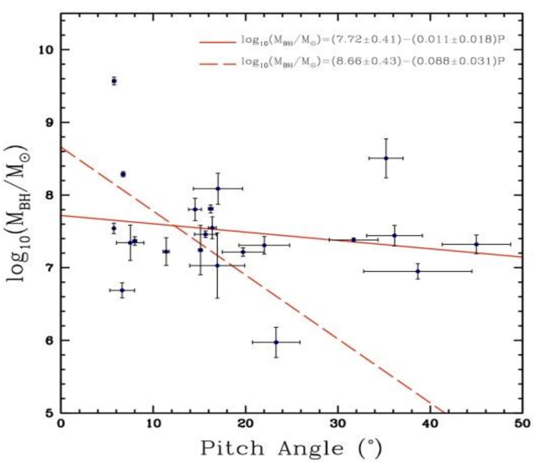

Figure 3: In this figure the solid red line represents a fit to the data I gathered. The dotted red line demonstrates the fit to a data set consisting of local, nonactive galaxies from Berrier et al. the horizontal lines on the plot represent the error of the pitch angle measurement the vertical lines represent the error of the mass of the black hole.

Conclusions: From Figure 3 it can be seen that the slope of the data with the higher redshift is significantly shallower than the black hole mass of the local galaxies. It can also be observed that the higher the pitch angle is for the galaxies, the lower the mass of the black hole is. It can also be observed that the mass of the active galaxies does not decrease aS quickly as the non active galaxies.

There were two main sources of inconsistency between the research data points and the Berrier data points that it was compared to. The first source of error would be that the research sample from this particular project contained significantly higher redshifts than the data that was collected for the Berrier research. This means that more of my galaxies were not local galaxies which means that they could not be measured as easily as the more local galaxies.

The second source of error would be that the sample for this particular research project completely consisted of active galaxies and the sample for Berrier research were mostly for non-active galaxies. Active galaxies and non-active galaxies behave in different manners completely.

Also with a active galaxy you are not able to directly measure the mass because the luminosity from the center makes it nearly impossible. With a non-active galaxy you are able to do direct measurent which could give you a result with less error involved.

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