Dissertation Summary

Determining Inclinations of Active Galactic Nuclei Via Their Narrow-Line Region Kinematics

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Active galactic nuclei (AGN) are axisymmetric systems to first order; their observed properties are likely strong functions of inclination with respect to our line of sight. However, except for a few special cases, the specific inclinations of individual AGN are unknown. We have developed a promising technique for determining the inclinations of nearby AGN by mapping the kinematics of their narrow-line regions (NLRs), which are easily resolved with Hubble Space Telescope (HST) [O III] imaging and long-slit spectra from the Space Telescope Imaging Spectrograph (STIS). Our studies indicate that NLR kinematics dominated by radial outflow can be fit with simple biconical outflow models that can be used to determine the inclination of the bicone axis, and hence the obscuring torus, with respect to our line of sight. Through NLR analysis of 52 Seyfert galaxies, we successfully modeled 17 individual AGN with clear signatures of biconical outflow and determined their inclinations. From these AGN, we can for the first time assess the effect of inclination on other observable properties in radio-quiet AGN, including the discovery of a distinct correlation between AGN inclination and X-ray column density.

Comparing the column density and inclination of the bicone axis away from our line of sight for each of our modeled AGN, we see a distinct positive correlation between the two parameters. Using all targets, we calculate a Pearson correlation coefficient of $r = 0.78$, which corresponds to a probability of exceeding $r$ in a random sample of observations taken from an uncorrelated parent population of $P = 0.1\%$.

As our line of sight with respect to the bicone axis (polar angle) increases, the torus surrounding the AGN becomes closer to edge-on, and we see an increase in column densities for both Seyfert 1s and Seyfert 2s. Seyfert 1s and 2s can reside at similar inclinations as long as our line of sight is respectively inside or outside the NLR bicone created by the obscuring torus surrounding the AGN. Surprisingly, there appears to be a seamless transition between the Seyfert 1 ionized column densities and Seyfert 2 cold column densities, despite the supposedly different nature of these two AGN components.

With accurate, continuous correlations between AGN inclination and several independent, observable parameters, it may soon be possible to use these comparatively simple methods to obtain observational measurements as a proxy for inclination in AGN with unmodelable kinematics.