The development of a color-magnitude diagram for active galactic nuclei (AGN): hope for a new standard candle

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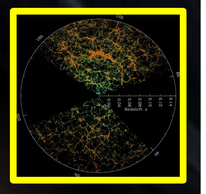
Abstract

Type I active galactic nuclei (AGN) selected from the NASA/IPAC Extragalactic Database (NED) were used in an attempt to establish a correlation between the ratio of the dust emission and the accretion disk emission (color) to the AGN luminosity. This work built on previous NITARP team attempts to establish such a relationship, but was novel in that it used near-infrared (NIR) wavelengths as a better discriminator of the transition between accretion-dominated and dust/torus-dominated emission. Type I Seyferts and quasars with redshifts between .001<z<.20, and with photometry available from the Sloan Digital Sky Survey (SDSS) and the Two Micron All Sky Survey (2MASS) were used. We made several color-magnitude diagrams analogous to a Hertzsprung-Russell (HR) diagram for the area where the dust vaporizes. The expectation was that the more luminous the AGN, then the more extended the dust sublimation radius, causing a larger hot dust emitting surface area which corresponds to a greater NIR luminosity. Hence the transition between the accretion disk emission to the dust emission was studied at 1micron in an effort to show different colors for different luminosity AGN, leading to a predictive color-magnitude diagrams which may result in a mechanism for using AGN as a standard for cosmic distances.

Two Micron All-Sky Survey (2MASS)

Sloan Digital Sky Survey (SDSS)



Introduction

An active galactic nucleus (AGN) is an extremely luminous, compact region at the center of an active galaxy. The high luminosity of AGN is the result of accretion of dust and gas by a supermassive black hole at the center of the galaxy. When gas and dust spiral into the black hole, the particles form an accretion disk and rapidly heat up, emitting immense amounts of energy across the entire electromagnetic field in the process.

If the luminosity of an AGN is known, then its distance can be calculated by comparing its luminosity to its brightness. This comparison can be done by making a color-magnitude diagram.

Our project focused on Type I Seyfert galaxies. These active galaxies are closer and less luminous than quasars. Unlike Type II Seyferts, Type I Seyferts are not obscured by a dust torus. Because of this, they emit broad hydrogen lines, making them more ideal to study.

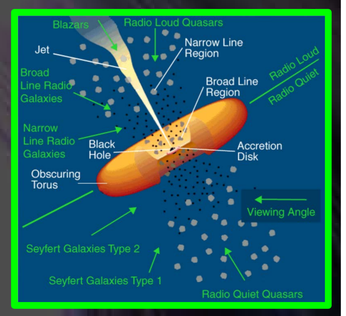


Figure 1-1
Our model of an active galactic nucleus (AGN)

Data

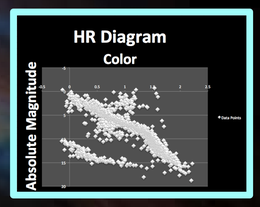


Figure 2-1
H-R Diagram

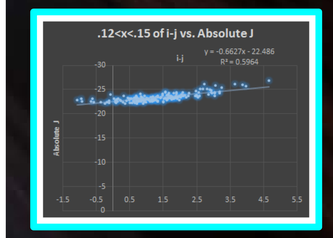


Figure 2-2
.12<z<.15 i-j vs. Absolute J

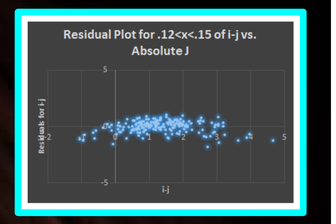


Figure 2-3
Residual Plot for .12<z<.15 i-j vs. Absolute J

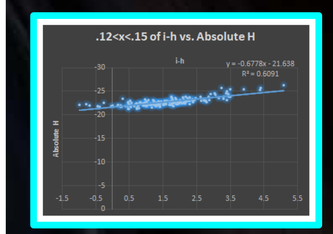


Figure 2-4
.12<z<.15 i-h vs. Absolute H

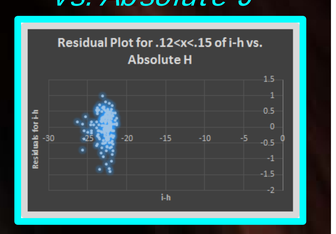


Figure 2-5
Residuals for .12<z<.15 i-h vs. Absolute H

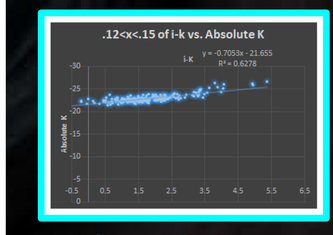


Figure 2-6
.12<z<.15 i-k vs. Absolute K

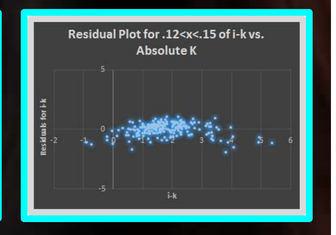


Figure 2-7
Residuals for .12<z<.15 i-k vs. Absolute K

Results

Our data is very promising. Plotting data from the i-J bandwidths (Figure 2-2, 2-3) showed an excellent slope of -1.0707 with an accuracy (R^2) of 0.40263. The i-H bandwidths (Figure 2-4, 2-5) had a -0.6778 slope with 0.6091 accuracy. Finally, the i-K bandwidths (Figure 2-6, 2-7) had slopes of -0.63 with an R^2 of 0.552.

We also plotted graphs of residuals (Figures 2-3, 2-5, 2-7), a visual representation of the R^2 value showing how well the points fit the line. Our graphs are not as predictive as an HR diagram (Figure 2-1), but they are still indicative of a positive correlation.

Our results indicate that there is a relationship between the color and luminosity of an AGN. While the relationships are not as predictive as the HR diagram, with further research—perhaps using a different redshift range or different data—it may be possible to find a predictive relationship for AGN.

Conclusion

- High correlations correspond to colors associated with the Sloan i band and any of the 2MASS bands with slight variations dependent on redshift.
- These color-magnitude diagrams may result in a mechanism for using AGN as a standard candle for cosmic distances.

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