Poster contributions of the "Advanced Lectures on the Starburst-AGN Connection", Eds. R. Mújica, I. Aretxaga & D. Kunth, 2001, INAOE Electronic Edition (http://www.inaoep.mx/∼agn00/posters.html), pp. 81-83

Testing the Unified Model with an Infrared Selected Sample of Seyfert Galaxies

Henrique R. Schmitt[1]

Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD21218, USA

Abstract. We present a series of statistical test done to a sample of Seyfert galaxies selected by mostly isotropic properties, the flux at 60μm, and warm infrared colors. Since this selection procedure is almost independent of the torus orientation, this is one of the best samples to compare the properties of Seyfert 1's and Seyfert 2's and test the Unified Model. We show that Seyfert 1's are usually not found in edge-on galaxies, that there is no statistically significant difference in the Morphological type distribution of Seyfert 1's and 2's, as well as in their radio luminosity distributions. We also find that the size of the extended radio emission in Seyfert 2's is larger than that in Seyfert 1's, as expected from the Unified Model.

1. Introduction

The Unified Scheme is based on the idea that the nuclear engine is surrounded by a dusty molecular torus, with orientation angle being the parameter which determines whether an AGN is perceived by observers as a Seyfert 1 or as a Seyfert 2 (Antonucci 1993). This scenario is supported by several evidence, like the detection of polarized broad emission lines in Seyfert 2's (Antonucci & Miller 1985; Tran 1995), or the escape of collimated radiation from the nucleus, seen in the form of Narrow Line Regions with conical shapes (Pogge 1989; Schmitt & Kinney 1996), or linear extended radio emission in Seyfert 2's (Ulvestad & Wilson 1989, Schmitt et al. 2000).

It is now accepted that the Unified Model is correct to zeroth order, i.e. that it applies qualitatively to at least some large fraction of the objects being studied. However, there have been some claims of intrinsic observational differences between Seyfert 1's and Seyfert 2's, like, that Seyfert 1's usually are found in earlier type host galaxies than Seyfert 2's (Malkan et al. 1998).

We believe that one of the main reasons for finding such differences is the use of samples not chosen from isotropic properties. An example of this is samples selected fom their UV excess. According to the Unified Model, in Seyfert 2's we may see 1% of the nuclear light reflected in our direction, while in Seyfert 1's we see the whole thing. This means that in such samples, Seyfert 2's are being selected from two orders of magnitude higher in the luminosity function than the Seyfert 1's. In a situation like this, it is natural to expect to see differences between Seyfert 1's and 2's. However, they are not intrinsic, but simply due to the selection criteria.

2. Sample and data

Our sample was extracted from de Grijp et al. (1987, 1992), and corresponds to all Seyfert galaxies with z$\leq$0.031 in that sample, giving a total of 88 galaxies, 29 Seyfert 1's and 59 Seyfert 2's. The de Grijp sample was selected based on the quality of their IRAS 25μm and 60μm fluxes, warm infrared colors ($-1.5 < \alpha(25/60) < 0$), and high galactic latitude ($|b| > 20°$). According to Pier & Krolik (1992) torus models, the circumnuclear torus radiates nearly isotropically at 60μm, which makes this sample one of the best ones to study the Unified Model.

This sample was primarily selected to study the orientation of radio jets relative to their host galaxies disks (Kinney et al. 2000), and, as a part of this project, we obtained high quality radio 3.6cm and broad-band B and I images, which were measured in a homogeneous way. This is important for the study presented here, since data collected from the literature usually are inhomogeneous and of different quality. Details about the radio images can be seen at Schmitt et al. (2001), while information about the B and I imaging data can be obtained at Schmitt & Kinney (2000).

3. Results

The principal results of this study are presented in Figure 1. A detailed analysis will be presented in Schmitt et al. (2001, in preparation). On the top left panel we compare the distribution of the ratio between the minor to the major axis galaxy lengths (b/a). We can see that there is a deficiency of Seyfert 1 galaxies with large inclinations. Comparing Seyfert 1's and 2's, a KS test shows that two samples selected from the same parent population would differ this much only 4.7% of the time, meaning that they

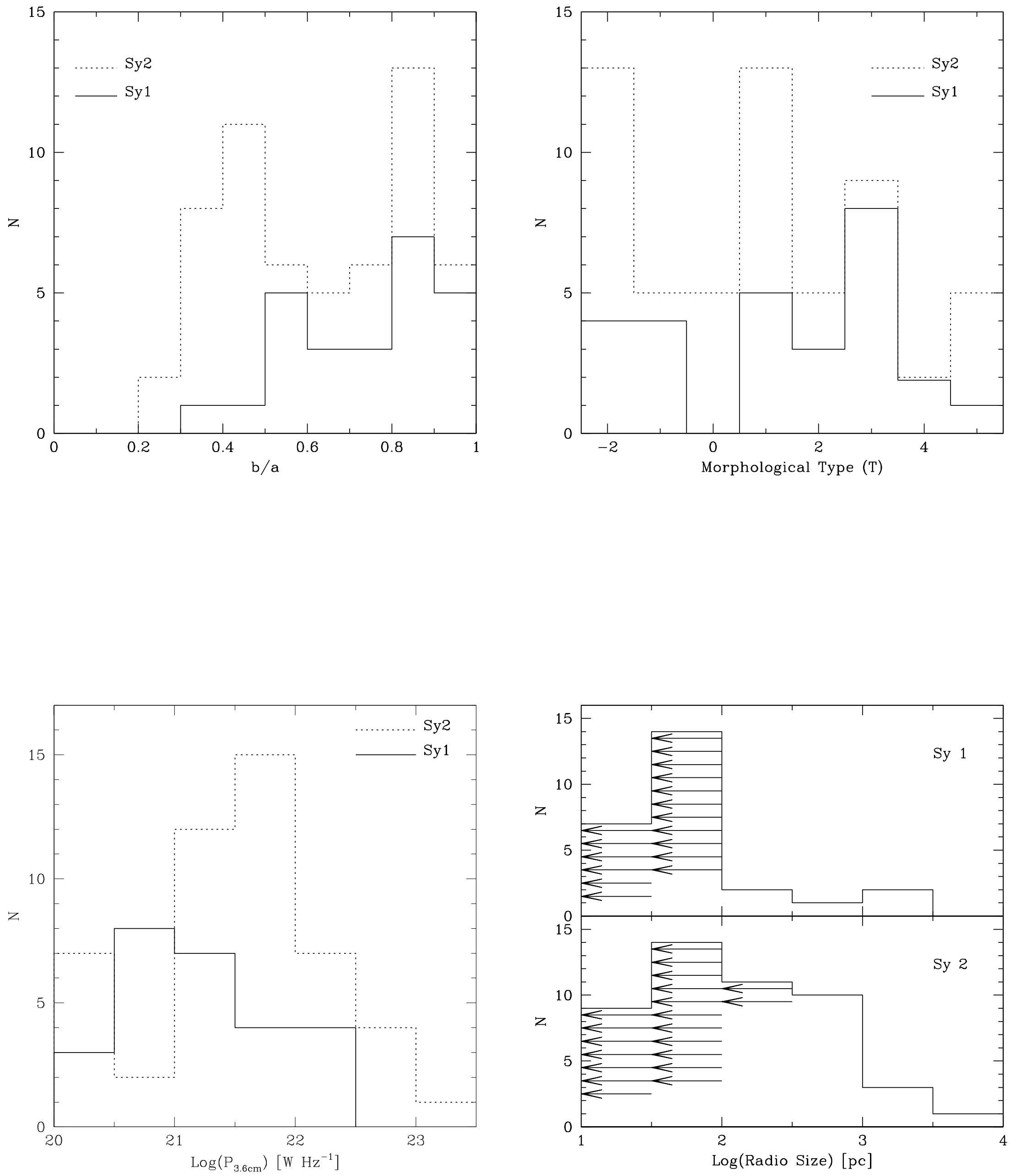

Fig. 1. Top Left: Observed distribution of the ratio between the host galaxy minor and major axis (b/a). Top Right: Observed distribution of morphological types (T). Bottom Left: Observed distribution of the radio luminosities at 3.6cm. Seyfert 1's are represented by a solid line and Seyfert 2's by a dotted line. Bottom Right: Observed distribution of radio extensions at 3.6cm, arrow denote upper limits.

are statistically different. This result supports previous results from other authors (e.g. Maiolino & Rieke 1995) which suggest that in highly inclined galaxies dust and gas along the disk can act as a torus, hiding the Broad Line Region in Seyfert 1's.

On the top right panel of Figure 1 we show the comparison between the host galaxy morphological types (T) of Seyfert 1's and 2's. We found that, contrary to what have been suggested by other works, both Seyfert types have similar distributions, with the KS test showing that there is an 80% chance that the two samples are drawn from the same population.

The bottom left panel of Figure 1 shows the comparison between the nuclear 3.6cm radio luminosities of both types of Seyferts. We find that there is no statistically significant difference in the radio luminosities of Seyfert 1's and Seyfert 2's, with the KS test showing that two sample selected from the same parent population differ this much 11% of the time.

The bottom right panel of Figure 1 shows the distribution of the sizes of the extended radio emission in Seyfert 1's (top) and Seyfert 2's (bottom). Only 9 out of 26 Seyfert 1's (35%) show extended emission, the rest are unresolved (shown by arrows in the figure), while in the case of Seyfert 2's, 28 out of 48 galaxies (58%) have extended radio emission. Given the fact that, for a considerable portion of these galaxies the extension of the radio emission is just an upper limit, we had to use survival analysis to compare these two samples. First, the Kaplan-Meier estimator shows that the average size of the extended radio emission is 148±65 pc and 348±97 pc for Seyfert 1's and 2's, respectively. A series of statistical tests for censored data (Gehan-Wilcoxon. Logrank, Peto-Peto and Peto-Prentice) shows that this difference is statistically significant. The 4 tests applied to the data give a probability of less than 4.8% that the two samples are drawn from the same parent population. This result confirms predictions from the Unified Model, from which we expect to see the jets end-on in Seyfert 1 galaxies and edge-on in Seyfert 2's. In other words, the jets in Seyfert 1's should have a smaller projected size when compared to Seyfert 2's, which is confirmed by our results.

4. Conclusions

References

Antonucci, R. R. J. 1993, ARA&A, 31, 473
Antonucci, R. R. J. & Miller, J. S. 1985, ApJ, 297, 621
de Grijp, M. H. K., Lub, J. & Miley, G. K. 1987, A&AS, 70
de Grijp, M. H. K. et al. 1992, A&AS, 96, 389
Kinney, A. L. et al. 2000, ApJ, 537, 152
Maiolino, R. & Rieke, G. H. 1995, ApJ, 454, 95
Malkan, M. A., Gorjian, V. & Tam, R. 1998, ApJS, 117, 25
Pier, E. A. & Krolik, J. H. 1992, ApJ, 401, 99
Pogge, R. W. 1989, ApJ, 345, 730
Schmitt, H. R., Ulvestad, J. S., Antonucci, R. R. J. & Kinney, A. S. 2001, ApJS, in press
Schmitt, H. R. & Kinney, A. L. 1996, ApJ, 463, 498
Schmitt, H. R. & Kinney, A. L. 2000, ApJS, 128, 479
Tran, H. C. 1995, ApJ, 440, 597
Ulvestad, J. S. & Wilson, A. S. 1989, ApJ, 343, 659