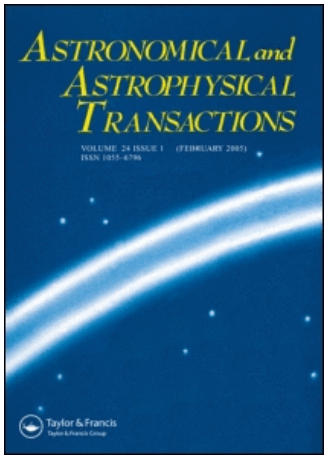

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Seyfert galaxies on milliarcsecond scales

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SEYFERT GALAXIES ON MILLIARCSECOND SCALES

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We present our results from global VLBI observations of a sample of Seyfert galaxies at 5 GHz. Our goal was to test predictions of the Unified Scheme for Seyfert galaxies, in which observed differences between Seyferts of types I and II can be understood as effects of orientation alone. Our Seyferts of the two types were matched in their orientation-independent AGN and host-galaxy properties so that the Unified Scheme may be rigourously tested. We show that the compact radio structures of the two types of Seyferts are similar, supporting the simple Unified Scheme. The implications of our results are discussed.

KEY WORDS Seyfert galaxies, VLBI-observations, radio structure

1 INTRODUCTION

Seyfert (Sy) galaxies are nearby lower luminosity, 'radio-quiet' Active Galactic Nuclei (AGNs) which occur mostly in spiral hosts. We define a Sy galaxy as a low-luminosity ($M_B > -23.0$), radio-quiet object (i.e. the ratio of 5 GHz to B-Band flux density < 10), whose host galaxy is a spiral and has nuclear $[\mathrm{OIII}]_{\mathrm{FWHM}} > 300$ km s^{-1}. Sy galaxies of types I and II are distinguished by the widths of their spectrophotometrically observable emission lines; the inferred Doppler widths for the two types are > 1000 km s^{-1} and < 1000 km s^{-1}, respectively.

The Unified Scheme (US) for Sy galaxies hypothesizes that Sys of type I and II comprise a single population and appear different due to the orientation of the axisymmetric active nucleus with respect to the observer. In Sy Is we have a direct view of the central engine, while in Sy IIs, our line of sight to the central engine is blocked by an obscuring torus, which is present in all Sys.

Sy galaxies have low radio emission, but they do show radio emitting jet-like structures on small scales which appear to be the low-power analogues of jets seen in radio powerful AGNs (e.g. Nagar *et al.*, 1999). The US predicts that the total

radio emission should be similar in the two classes of Sys (since the radio emission is unattenuated by the obscuring torus), and their radio structures should differ only by projection effects. However, this issue is controversial; e.g. Roy *et al.* (1994) using the 275-km long single baseline Parkes-Tidbinbilla interferometer at 2.3 GHz, reported that Sy IIs are more likely to show compact radio emission than Sy Is. This result is inconsistent with the predictions of the simple US. The inconsistency remains even if mild relativistic beaming is invoked, because, the face-on Sy Is, would be more likely to show compact structures. Our goal was to test predictions of the US by investigating the parsec-scale radio morphology of Sys using a *matched* sample of Sy I and Sy II galaxies.

2 SAMPLE AND OBSERVATIONS

Our sample selection criteria were as follows: (i) we chose *bona fide* Sys (cf. our definition), (ii) we required that the host galaxy be a confirmed spiral, and that the Sy (iii) have a detected compact component brighter than 8 mJy at $\lambda_{4-6\ \mathrm{cm}}$ on $\sim 1''$ scale (i.e. as observed by VLA A and B array; this criterion was required to make our experiment feasible). (iv) The host galaxy had to have the observed ratio of minor and major isophotal diameter axes > 0.5; we thereby exclude edge-on host galaxies. We note that Clarke *et al.* (1998) and Nagar and Wilson (1999) have shown that there is no significant correlation between the host galaxy rotation axis and the direction of the radio jet. We chose 10 Sy Is and 10 Sy IIs, which met the above criteria, such that, the two sub-samples had similar distributions of redshift, luminosity of the host galaxy (i.e. minus the AGN) in the B-Band, $[\mathrm{OIII}]_{5007}$ luminosity, and galaxy bulge luminosity. Thereby we ensured that the sub-samples of Sy Is and Sy IIs are *matched* with respect to their intrinsic AGN power and host galaxy properties using *orientation-independent* parameters.

15 objects from our sample were observed during 24 hours of allocated time in Feb 1998 at 5 GHz using the 14 station Global-VLBI including the phased VLA. We thus have simultaneous VLA data (resolution $\sim 1''$) for all of them. Of the remaining 5 sample objects, 4 have VLBI data in the literature which we add to our data in inferring our results. NGC 5135 does not have any observation on mas-scales.

3 RESULTS

We have detected all 15 of our observed objects. At the significance level of 0.02 ('Mann–Whitney U"' test), we conclude that (i) the distributions of radio luminosities on pc- and kpc-scales for the two classes of Sy galaxies are similar. (ii) The fraction of radio emission detected on pc-scales to the emission detected on kpc-scales is not significantly different for the two Sy sub-classes, and (iii) the ratio of compact radio emission (i.e. emission detected with VLBI) to the extended radio

emission detected on kpc-scales (i.e. total radio emission minus the core radio emission detected with VLA) is also not significantly different for the two classes. If the jets were significantly relativistically beamed, we would expect Sy 1s to systematically show more compact radio emission than Sy 2s. We thus find that Sy I and Sy II galaxies have equal tendency to show compact radio structures and our results do not agree with the results obtained by Roy *et al.* (1994).

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