HOST GALAXIES OF RADIO-LOUD & RADIO-QUIET AGN

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A clear understanding of both the differences and similarities between the host galaxies of the three main classes of powerful active galaxy – radio-quiet quasars (RQQs), radio-loud quasars (RLQs) and radio galaxies (RGs) – is vital in any attempt to unify or relate the various manifestations of the AGN phenomenon. The unification of RLQs and RGs via orientation effects requires that the hosts of the two types be derived from the same population of galaxies. Meanwhile, the correlation between radio power and host morphology in nearby AGN, with radio-quiet objects (Seyferts) occurring in disc systems and radio-loud sources in ellipticals, is generally assumed to persist at higher redshifts and nuclear luminosities. However, in both cases the evidence remains ambiguous and, moreover, many previous studies have been based on poorly selected samples.

In an attempt to unambiguously determine the impact of the host on the observed properties of an AGN we have assembled three *carefully matched* comparison samples of RQQs, RLQs and RGs covering redshifts $0.1 \leq z \leq 0.3$. The RLQ and RQQ samples were carefully constructed so that their distributions in the $V - z$ plane are statistically indistinguishable (Dunlop *et al.* 1993) and the sample of RGs was compiled to match as closely as possible the radio-power and redshift distributions of the RLQ sample (Taylor *et al.* 1995). Using ground–based observations we have approached the question of host galaxy properties from two independent directions: infrared (K-band) imaging, to determine the host morphologies, and off-nuclear optical spectroscopy to investigate their star-formation histories.

In any attempt to study the host galaxies of quasars the main problem lies in separating the underlying galaxy light from the PSF of the bright

active nucleus. By observing in K-band (2.2μm), using IRCAM on UKIRT, we were able to maximize the the ratio of host galaxy to quasar light, so that the stellar contribution was more dominant. 2-D modelling of the images has been highly successful (Dunlop *et al.* 1993, Taylor *et al.* 1995) and we find that, consistent with the current 'unified scheme', *all* of the RGs and RLQ hosts prefer to be described by an elliptical (de Vaucouleurs) model. Overall the majority of the RQQs do seem to lie in (exponential) disc systems, but for the *most luminous* RQQs in our sample the best fit model is more often an elliptical than a disc. Another highly significant result of this study is that we find no evidence for any systematic differences in the near infrared luminosities of RGs and RQQ & RLQ hosts, all of which have K luminosities $> L_K^*$. Finally, all of the model galaxies have very large half-light scalelengths (typically 20 kpc), consistent with the values for brightest cluster galaxies (Taylor *et al.* 1995).

We are currently working to complete a programme to obtain deep off–nuclear optical spectra of all the objects in our three samples. Our results demonstrate that it is now feasible to obtain quasar host galaxy spectra from the ground which are of sufficient quality to constrain spectrophotometric models of the stellar populations. This was made possible by our deep K–band images, which, because they are uncontaminated by emission lines, allow us to identify where best to place the slit to maximize the level of stellar continuum at least 5 arcsec off–nucleus, thereby avoiding scattered light from the quasar. In all of the objects observed so far the best fit model requires a very old ($\sim$ 13 Gyr) and red underlying stellar population ($B - K$ colours are typically $4 \to 5$). Many of the quasar hosts also require the additional contribution of a blue component (the strength of which varies considerably from object to object) but longward of the 4000Å break the detailed level of the fits is remarkably good, indicating that the spectra are completely dominated by starlight.

Summary: The hosts of all three types of object are large and bright at K-band. The morphologies of the RLQ hosts and the RGs are consistent with unification and, interestingly, we find that for the more luminous RQQs the best-fitting host model tends to be an elliptical. All of the hosts appear to contain an old stellar population and to have red optical - infrared colours. This, coupled with the large scalelengths of the galaxies, probably explains the relative failure of recent attempts to detect quasar hosts with the HST in V-band (*eg* Bahcall *et al.* 1995).

References

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