Black Holes from Stars to Galaxies – Across the Range of Masses
Proceedings IAU Symposium No. 238, 2006
V. Karas & G. Matt, eds.

doi:10.1017/S1743921307005479

A near-infrared view of the 3CR: properties of hosts and nuclei†

David Floyd,[1] Marco Chiaberge,[1] Eric S. Perlman,[2] Bill Sparks,[1] F. Duccio Macchetto,[1]‡ Juan Madrid,[1] Stefi Baum,[3] Chris O'Dea,[3] David Axon,[3] Alice Quillen,[4] Alessandro Capetti,[5] George Miley[6] and Stefano Tinarelli[1]¶

[1]STScI, USA; [2]UMBC, USA; [3]RIT, USA; [4]University of Rochester, NY, USA; [5]OA Torino, Italy; [6]Leiden Observatory, The Netherlands

email: floyd@stsci.edu

Abstract. The 3CR catalogue provides a statistical sampling of the most powerful radio galaxies out to $z \sim 0.3$. Over the decade and a half of Hubble observations we have amassed a major multi-wavelength dataset on these sources, discovering amongst other things, new jets, hotspots, dust disks, and faint point-like nuclei. We present here the results of our latest snapshot survey, a near-complete sampling of the 3CR host galaxies at $z < 0.3$ in the near-IR (H-band). This un-extinguished view of the host galaxies has provided us with an accurate measure of the stellar/spheroid masses of the sources, and an unbiased view of their morphologies. We show that they exhibit an identical Kormendy relation to nearby QSO's and the massive Elliptical population, but are distinct from the Brightest Cluster Members, and mergers. We find that while a few sources exhibit signs of a recent or impending major merger, many more sources have remnants consistent with a gas-rich minor merger in their recent history. We detect unresolved nuclear sources in most (~80%) of FRI, with their IR luminosities correlating linearly with radio core power. This implies that the IR nuclei are synchrotron radiation produced at the base of the relativistic jet, and confirms that no infrared (thermal) radiation in excess to synchrotron is present in FRIs, unlike in other classes of AGN.

Keywords. Galaxies: active – galaxies: fundamental parameters – (galaxies:) quasars: general

---

We used HST/NICMOS2 and the F160W filter (H-band) in SNAP mode to obtain IR imaging of 89 3CR RG at $z < 0.3$. Adding 11 archival targets, we have 1 ks images for 100 sources in a single infrared band, 90% of the entire sample. Observations and data reduction are described in Madrid *et al.* (2006). Many targets have additional pointings in the optical-UV, making for a rich multi-λ data-set. H-band provides a powerful diagnostic of the gravitationally-dominant stellar mass of the galaxy. We perform 2D fits to the host galaxies using Galfit (Peng, Ho, Impey, & Rix 2002), Ellipse (IRAF), and 2DM (Floyd *et al.* 2004 – for objects dominated by an unresolved nuclear point-source). This allows us to separate bulge and disc-like components in even the most strongly nuclear- dominated sources, and allows us to better characterize any residual features, such as jets, knots, and tidal or merger features. Example single-component Sérsic models are shown for 3C 288 and 3C 310. The host galaxies are generally consistent with the elliptical galaxy

† Based on observations with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under NASA contract NAS5-26555. We gratefully acknowledge support from HST grant STGO-10173.
‡ European Space Agency.
¶ STScI summer student.

population. The peak in the galaxy luminosity distribution is close to $L^{\star}$, with steeper drop-off to high luminosity than low. But they exhibit a large spread in Sérsic index to low values. Sizes and luminosities of the host galaxies correlate with each other and with radio power. Sérsic n correlates with the radio luminosity, and the disky (low-n) wing of the sample is dominated by low-z, low-radio-power sources, merging sources, and sources with luminous companions. Additional detailed comparison with samples of merging galaxies and ellipticals appears to show a cross-over between the 2 populations (Floyd *et al.* 2006). This suggests that disky galaxies are capable of hosting powerful radio sources, providing that they are massive enough, or are undergoing major merger.

Companions and mergers. Approximately 55% of our sample exhibit compact, often unresolved companion sources too red and faint to have been detected in previous optical snapshot programs. Spectroscopy is required to determine the nature and redshifts of these sources, although typical colours of these sources are around $R-H=2-3$, consistent with old stellar populations. These sources are found predominantly in elliptical host galaxies, and have 3 likely origins: Foreground stars (in cases with low galactic latitude); Synchrotron Hotspots (in a few peculiar radio sources); Merger remnants (compact cores from cannibalised small galaxies – e.g. Canalizo+03); Molecular gas clouds infalling into the galaxy (Bellamy & Tadhunter 2004). By comparison, only 10% of our sample show signs of an ongoing or recent major merger (though many more show other signs of disturbance) - typical of the elliptical galaxy population in general. If many of these sources do turn out to be galactic nuclei, it would suggest that a minor merger is sufficient to fuel or re-fuel a quiescent black hole in an elliptical galaxy into radio-loud AGN activity, while disky galaxies appear to require a more major disturbance.

NIR properties of the nuclei. Unresolved nuclear point sources (Central Compact Cores, CCC) are detected in 80% of the FRI in our sample, as well as the majority of FR II. Amongst the FR I, the IR luminosity of the CCC correlates with the radio core power and optical luminosity. The correlation over 4 decades is strong evidence that the optical-IR core emission is synchrotron in nature, and originates at the base of the jet, most likely on scales smaller than 1 pc. The lack of an IR excess implies that synchrotron radiation dominates the IR core luminosity in FRI, unlike in other classes of AGN, where thermal emission from hot dust contributes significantly.

The picture that emerges is that FRI lack a radiatively efficient accretion disk and, possibly, of a circumnuclear dusty torus (Chiaberge *et al.* in preparation). The next step in the immediate future is to combine our studies of the hosts and nuclei and in particular to examine the nature of the powerful (FRII) radio sources hosted by low-n galaxies.

References

Bellamy, M. J. & Tadhunter, C. N. 2004, MNRAS, 353, 105

Canalizo, G. Max, C. Whysong, D., Antonucci, R. & Dahm S. E. 2003, ApJ, 597, 823

Chiaberge, M., Capetti, A. & Celotti, A. 1999, A&A, 349, 77

Chiaberge, M., Capetti, A. & Macchetto, F. 2005, ApJ, 625, 716

Dunlop, J. S., McLure, R. J., Kukula, M. J., Baum, S. A., O'Dea, C. P. & Hughes, D. H. 2003, MNRAS, 340, 1095

Floyd, D. J. E., Kukula, M. J., Dunlop, J. S., McLure, R. J., Miller, L., Percival, W. J., Baum, S. A. & O'Dea, C. P. 2004, MNRAS, 355, 196

Madrid, J. P., Chiaberge, M., Floyd, D., Sparks, W. B., Macchetto, F. & Miley, G. K. *et al.* 2006, ApJS, 164, 307

McLeod, K. K. & McLeod, B. A. 2002, ApJ, 546, 782

Peng, C. Y., Ho, L. C., Impey, C. D. & Rix, H.-W. (2002), AJ, 124, 266

Taylor, G. L., Dunlop, J. S., Hughes, D. H. & Robson, E. I. (1996), MNRAS, 283, 930

https://doi.org/10.1017/S1743921307005479 Published online by Cambridge University Press