WHAT DISTINGUISHES THE HOST GALAXIES OF RADIO-LOUD AND RADIO-QUIET AGNS?

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INTRODUCTION

Active galactic nuclei (AGNs) are known to cover an extremely broad range of radio luminosities and the spread of their radio-loudness (the ratio of the radio luminosity to the AGN bolometric luminosity, L_{bol}) is very large at any value of the Eddington ratio λ. The efficiency of jet production ranges from $\sim 10^{-4}$ up to ~ 1 (Sikora, Stawarz & Lasota 2007). This implies that this efficiency must depend on parameters other than just the accretion rate, most likely on the black hole (BH) spin and magnetic flux.

The rather moderate spread of AGN BH spins, as indicated by the 'Sołtan-argumen' (Soltan, 1982) and by simulations of the cosmological evolution of supermassive BHs (Volonteri et al. 2013), suggests that the very broad range of AGN radio-loudness is primarily determined by the spread of BH magnetic fluxes. Magnetic fluxes can be developed stochastically in the innermost zones of accretion discs (Begelman & Armitage 2014), or can be advected to the central regions of a galaxy prior to the AGN phase (i.e. Sikora et al. 2013). In the latter case one might expect systematic differences between the properties of galaxies hosting radio-loud and radio-quiet AGNs. In the former case the differences should be negligible for objects having the same Eddington ratio. Therefore we ask the question: **are radio-loud and radio-quiet AGNs hosted by the same or different galaxies?**

METHOD

We consider the sample selected from the SDSS DR7 database, comprising galaxies that:
(a) belong either to the Main Galaxy sample or the Luminous Red Galaxy sample, have spectrum with signal-to-noise ratio in continuum of at least 10, velocity dispersions larger than 70 km s^{-1}, and redshift in the range of 0.002 - 0.4 (to include Hα line);
(b) are located above the K01 line (Kewley et al. 2001) in the BPT diagram (to remove galaxies dominated by star-formation);
(c) are not "retired" according to the EW(Hα) vs [NII]/Hα diagram (Cid Fernandes et al. 2011), i.e. their lines are not produced by hot low-mass evolved stars but by an AGN;
(d) are AGNs with $\lambda \geq 0.003$.
These criteria leave 18230 AGNs. The radio-loud (RL) galaxy sample was selected by cross-matching this sample with radio AGNs from the Best & Heckman (2012) catalogue, and contains 376 objects. The remaining 17 854 objects that are not in Best & Heckman catalogue comprise our radio-quiet (RQ) sample.

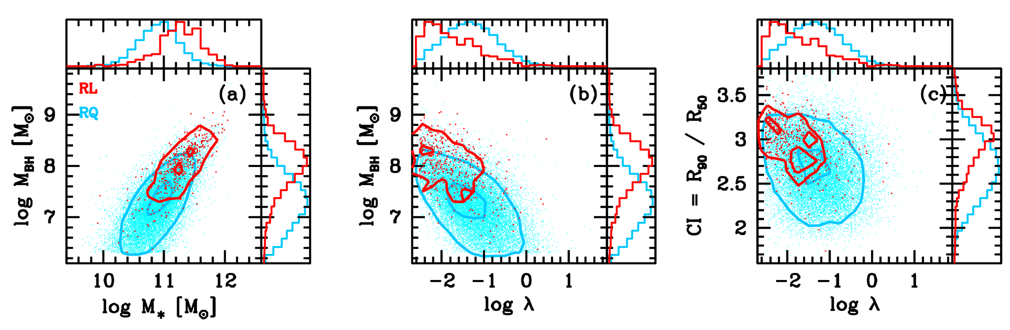

Figure 1. The distribution of RL (red) and RQ (cyan) samples in BH mass (M_{BH}) vs. stellar mass (M_*), M_{BH} vs. Eddington ratio ($\lambda = L_{bol}/L_{Edd}$), and concentration index (CI) vs. λ diagrams. The contours correspond to 20 and 80% of the objects. The normalized histograms shown on both axes use the same colors.

Fig. 1 shows that the RL and RQ samples differ in the distributions of their main properties, so to answer our question we need to apply **a pair-matching technique**. For each galaxy from the RL sample we compare one or several galaxies from the RQ sample that have very similar values of M_{BH}, λ and redshift.

RESULTS

To visualize possible differences between RL and matched RQ (mRQ) samples we plot in Fig. 2 the values of selected parameters for the RL sample as a function of the radioloudness, $\mathcal{R}$ (defined here as the ratio of the radio luminosity to the Hα luminosity, Fig. 2). For comparison RQ points are plotted at the same abscissa that the parent RL points. That kind of presentation allows us to check if the differences between RL and RQ samples hold for both strong and weak radio sources.

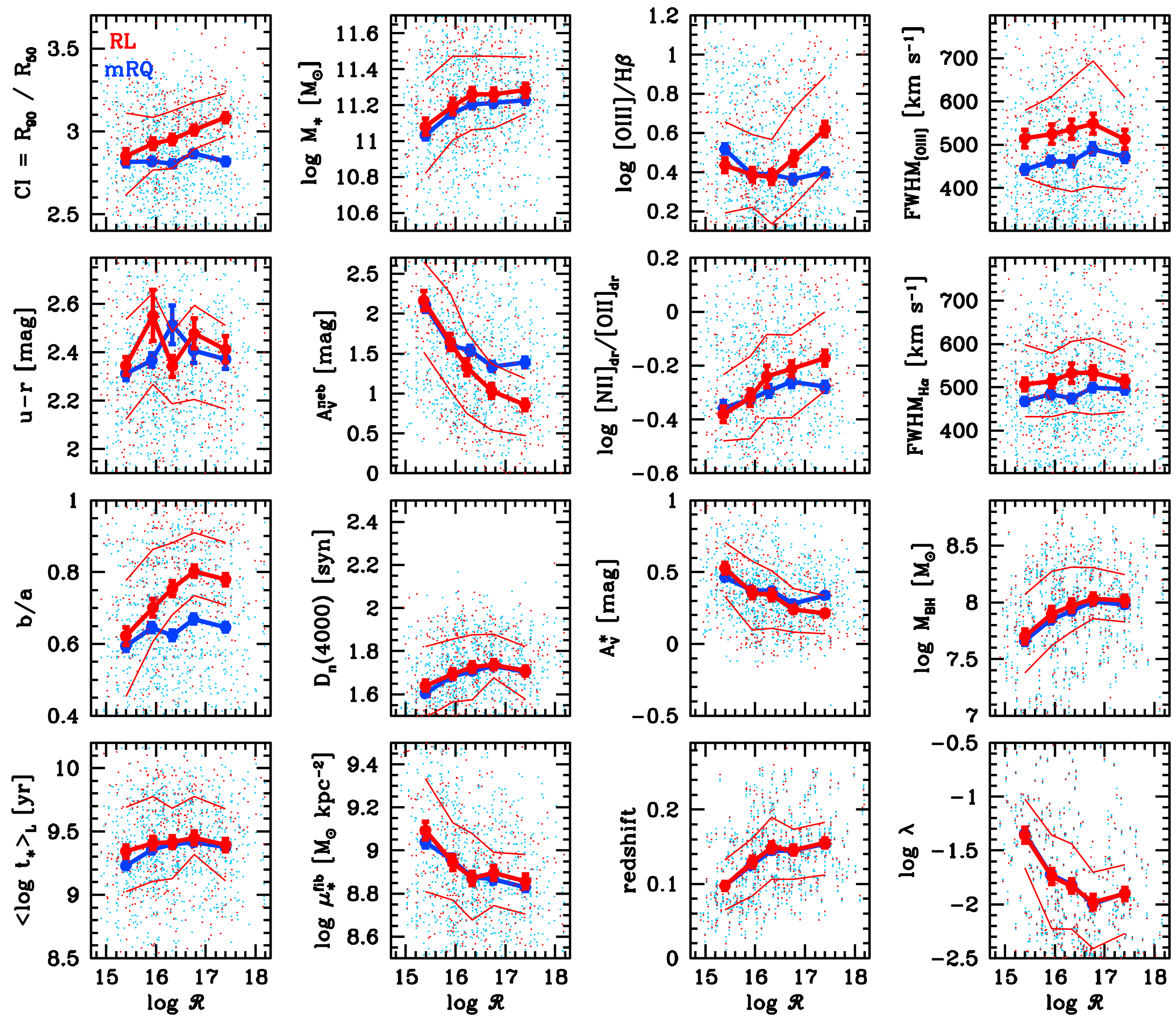

Figure 2. Values of selected parameters for the objects in the RL (red) and in the matched RQ (blue) samples as a function of the radioloudness $\mathcal{R}$ of the RL object. Big points show the mean and the associated dispersion of the mean. Thin red lines show the quartiles for the RL sample.

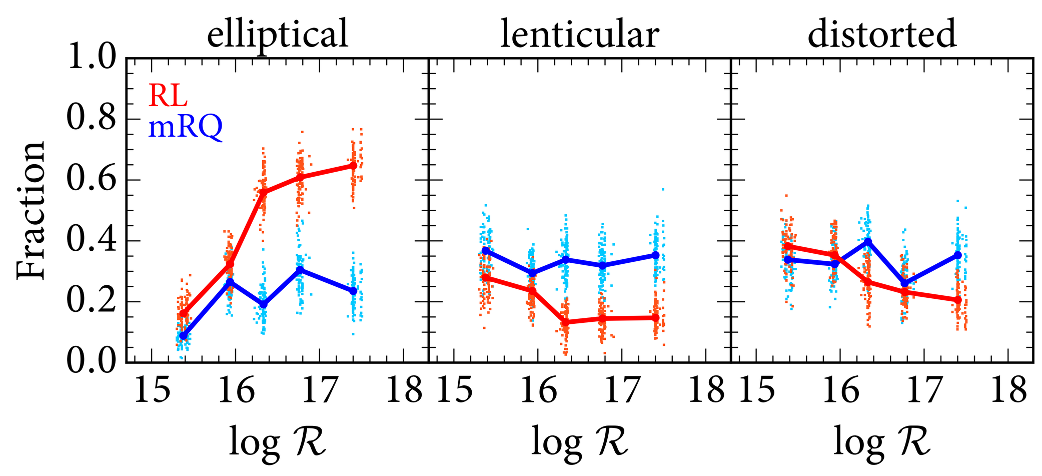

Figure 3. Fraction of RL (red) and matched RQ galaxies (blue) classified as elliptical, lenticular and distorted in bins of radio-loudness. The small dots are the 100 bootstrap realisations used to assess the intrinsic uncertainty in our classifications.

The concentration index of the RL hosts increases with the radio-loudness, while it is constant and smaller in the paired RQ hosts. Differences between CI and b/a are supported by the differences in morphological type of the host galaxies of RL and RQ AGNs. RQ galaxies tend to be located in less concentrated galaxies, mostly in lenticular galaxies, while RL AGNs in elliptical galaxies. We note also that emission lines are broader in the RL galaxies.

CONCLUSIONS

While line widths are likely directly related to the mechanical effect of the jet, differences in CI and morphological type clearly point to different physical properties of the radio-loud and radio-quiet galaxies. Our results indicate that **the efficiency of the jet production** is not fully determined by just the Eddington ratio, but **may depend** also on BH mass, spin and magnetic flux, i.e. **on parameters which are established by the cosmological evolution** of BHs and their host galaxies **prior to the AGN phase.**

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