Soft γ-ray selected radio galaxies: a high-energy view of jetted AGNs

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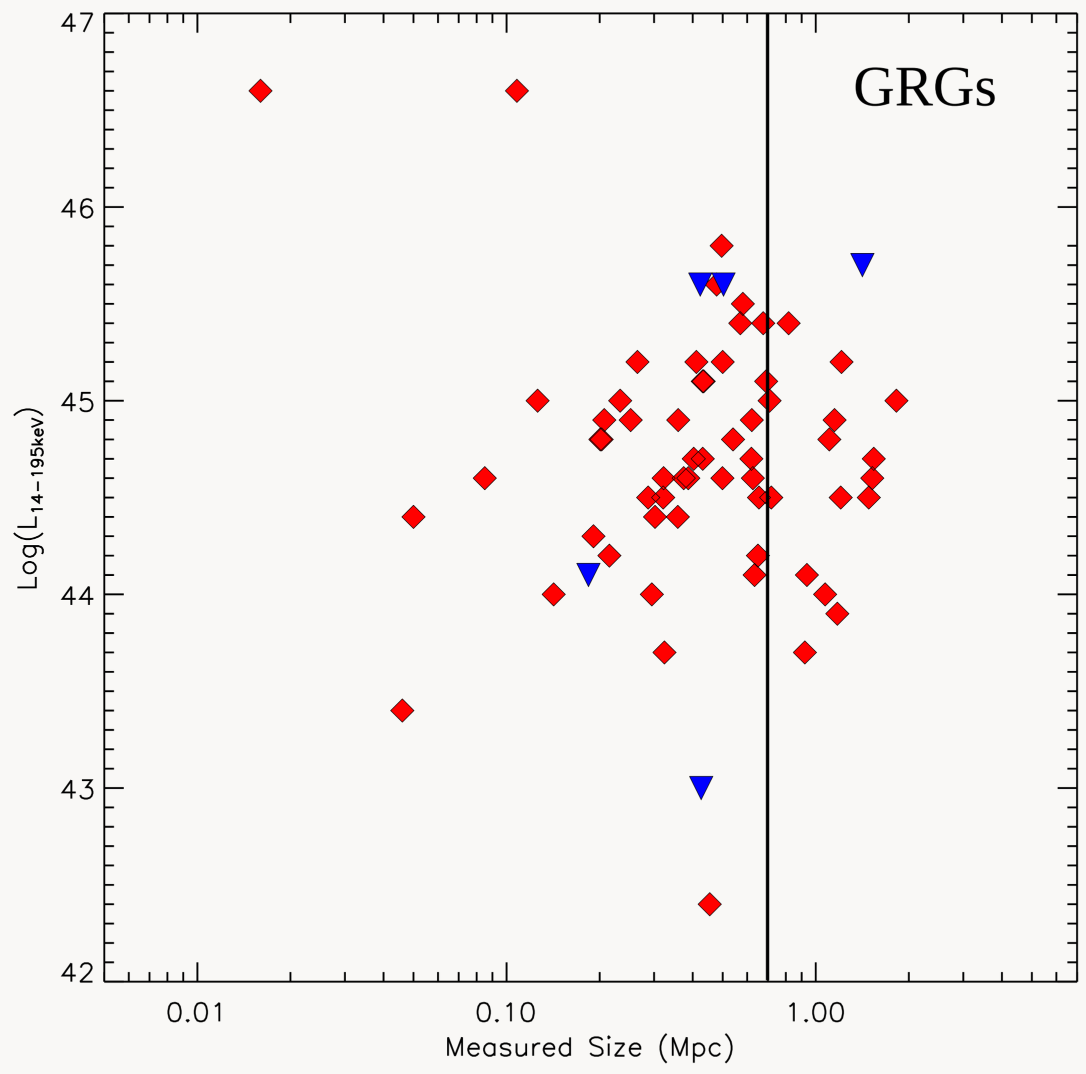
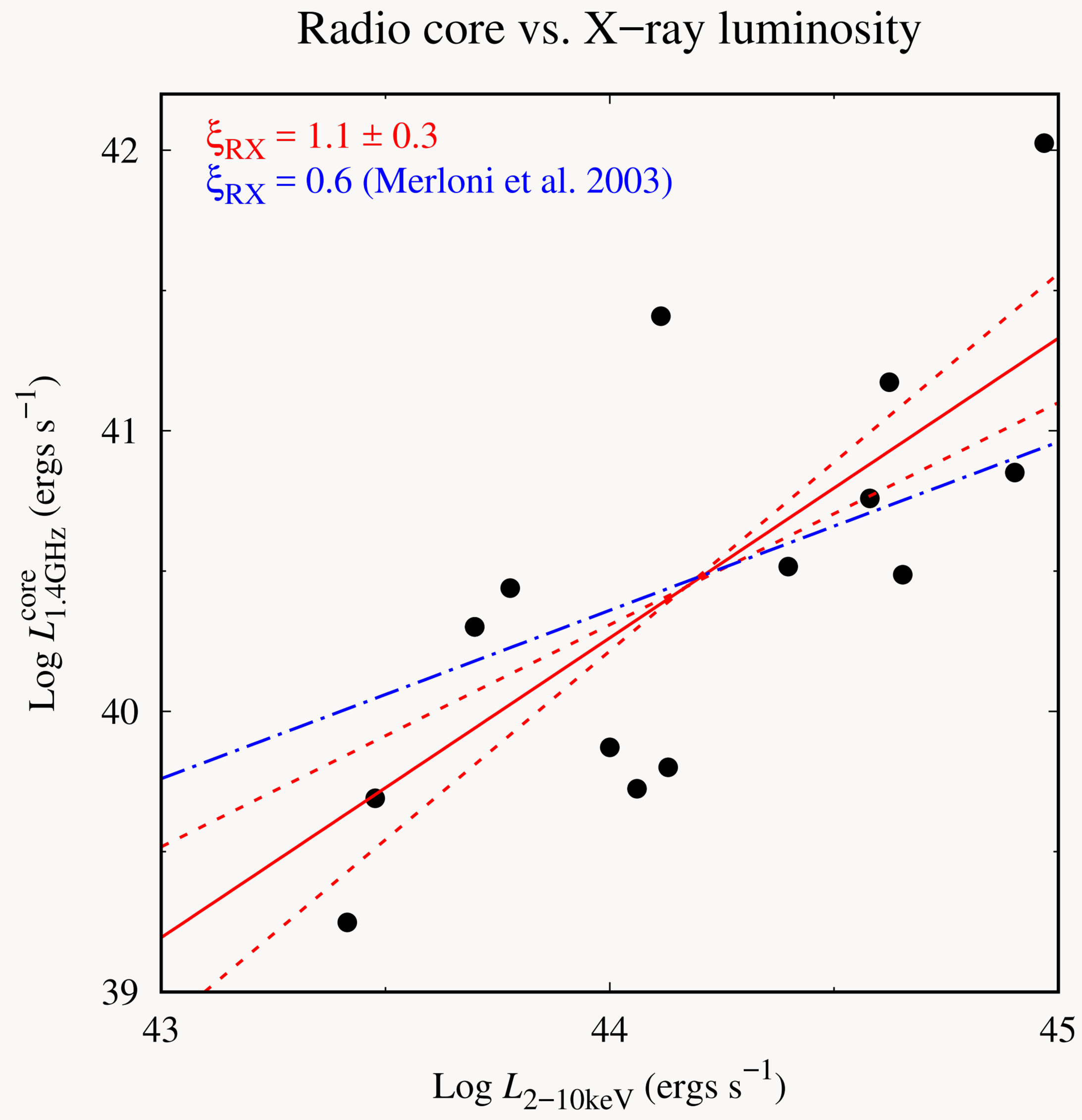
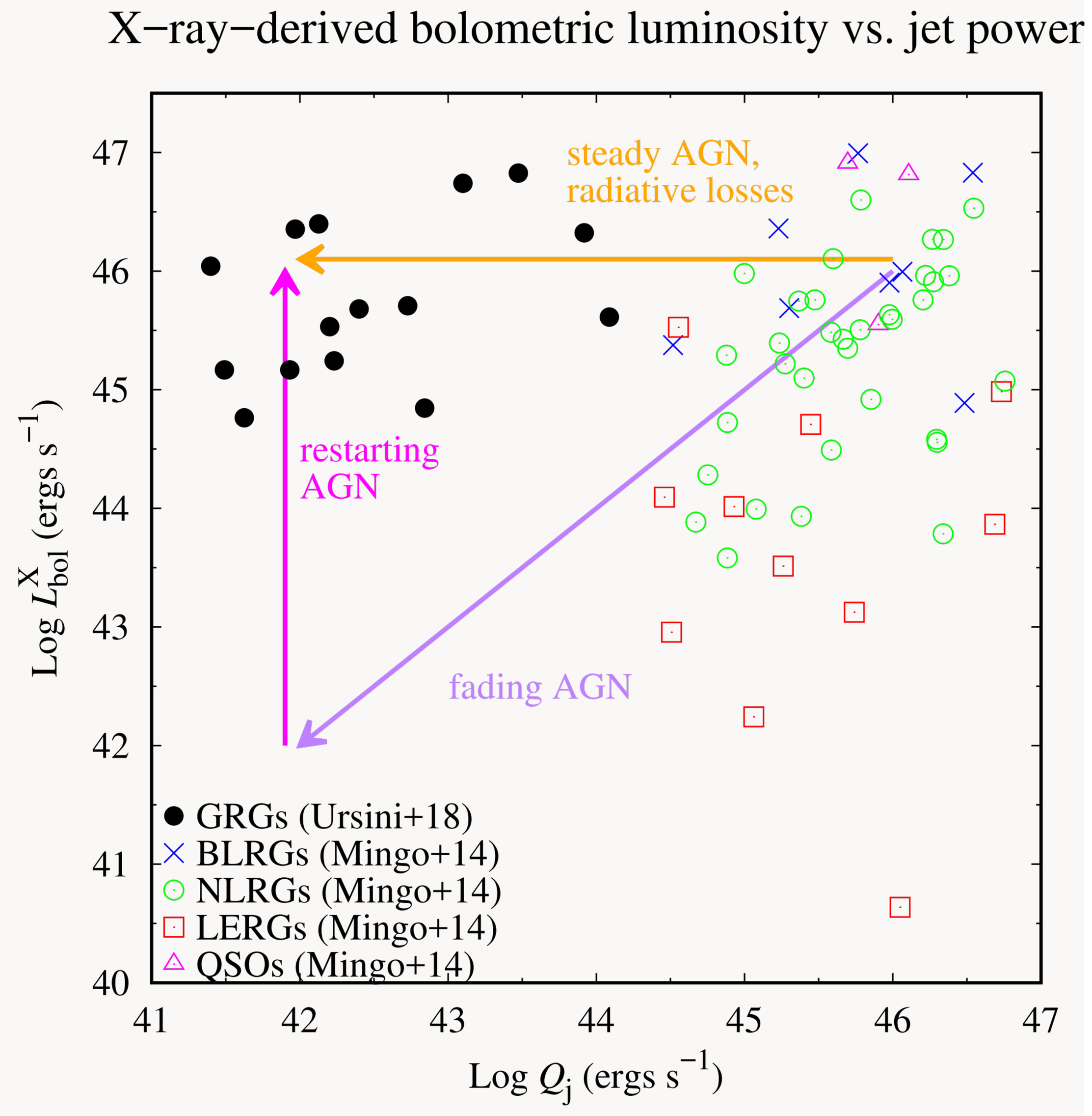
Hard X-ray selection favours giant size discovery



We study a sample of 64 AGNs with extended radio morphology, selected from the hard X-ray catalogues of *INTEGRAL*/IBIS and *Swift*/BAT [1]. 14 sources are giant radio galaxies (GRGs), i.e. with a linear size >0.7 Mpc. The fraction of GRGs is thus 22%, significantly larger than what is generally found in radio surveys (1–6%). Given their huge size, GRGs represent an extreme class among radio-loud AGNs, as they should be very old and/or residing in a very low-density environment compared with regular radio galaxies. The origin and growth of GRGs is still an open issue, and could be related to the restarting of their central engines during multiple activity phases.

Giant sources: X-ray properties and radio connection

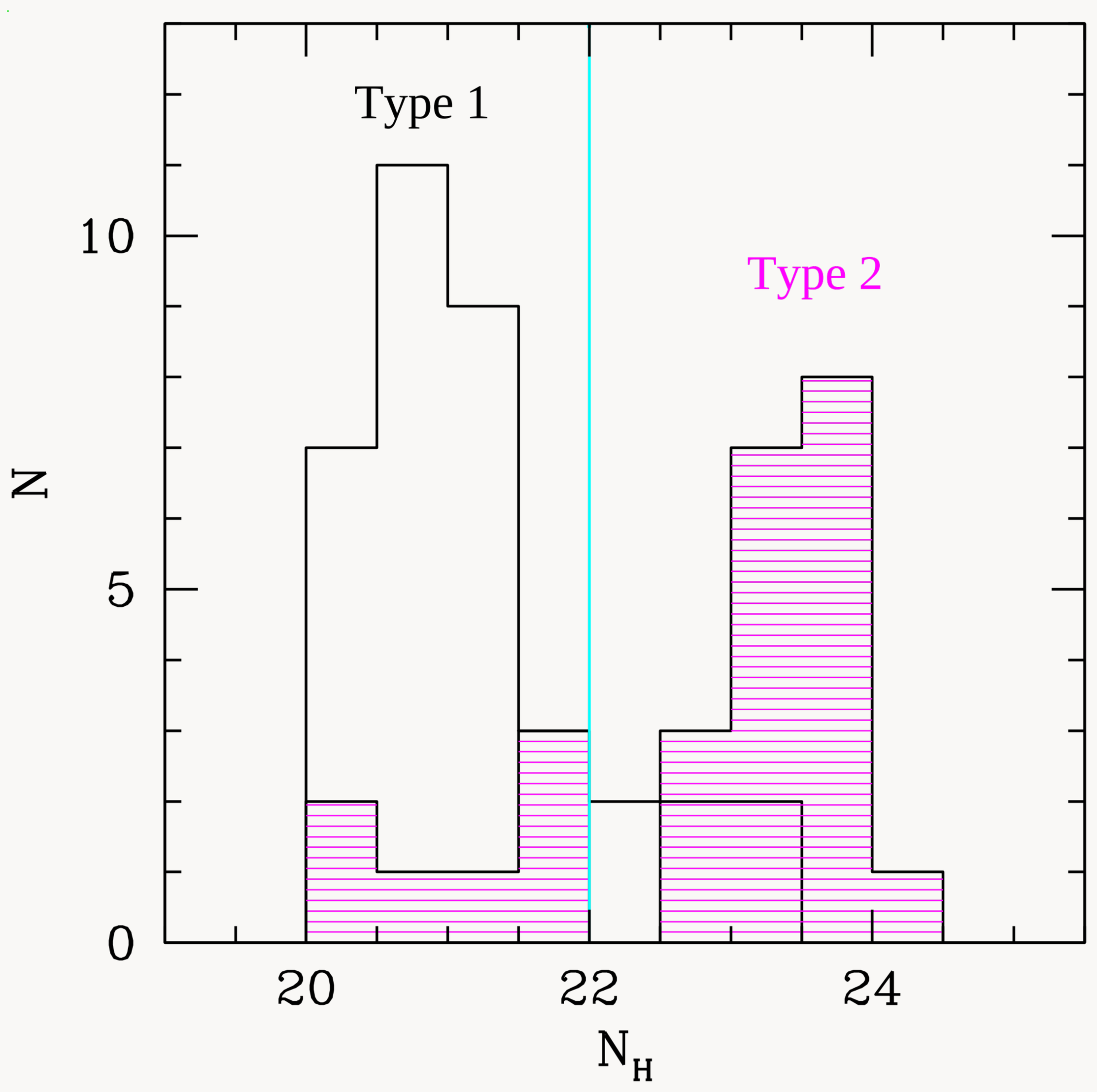


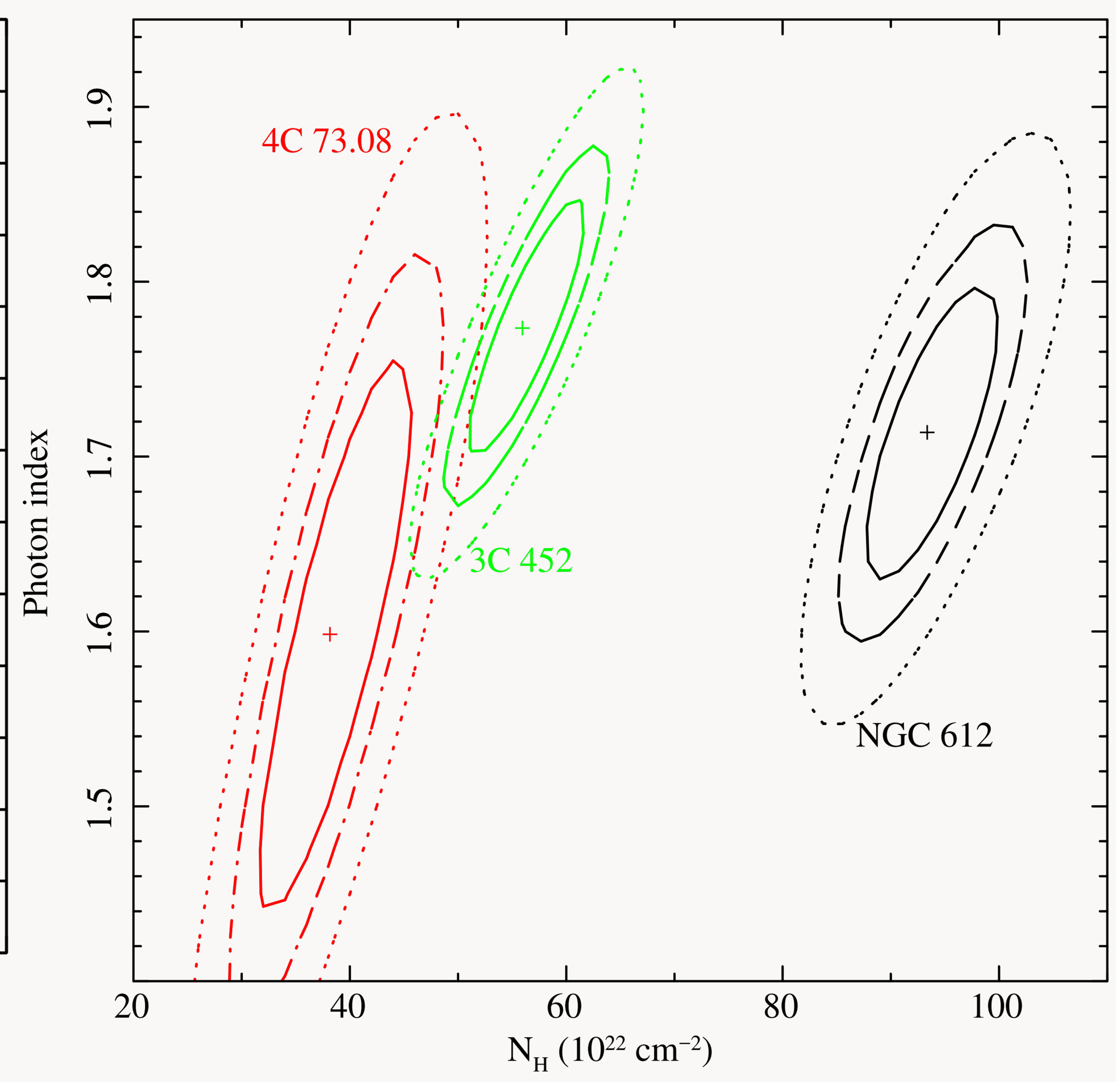


The bulk of the X-ray emission of GRGs in our sample is consistent with originating from a Comptonizing corona coupled to a radiatively efficient accretion flow (Eddington ratio > 0.02) [10], like in normal-size FR II radio galaxies. We also study the relation between the X-ray emission and the radio emission, separating the contribution from the core and from the lobes:

- The X-ray luminosity $L_{2-10\mathrm{keV}}$ correlates with the radio core luminosity $L^{\mathrm{core}}_{1.4\mathrm{GHz}}$, as expected from the so-called fundamental plane of black hole activity [4]. The slope of the correlation is consistent with the 'radiatively efficient' branch of the fundamental plane rather than the 'standard/inefficient' branch [3].
- In most sources, the luminosity of the radio lobes and the estimated kinetic power of the jet (Q_{j}) are much smaller than the bolometric luminosity inferred from the X-ray luminosity ($L^{\mathrm{X}}_{\mathrm{bol}}$). This discrepancy is clear when comparing the values of Q_{j} and $L^{\mathrm{X}}_{\mathrm{bol}}$ with the most radio luminous galaxies [5]. This can be explained by restarting activity (i.e. the sources are currently highly accreting and in a high-luminosity state following a new accretion episode) or by steady activity accompanied by significant expansion losses. The radio morphological/spectral properties show signatures of restarting activity in most sources, favouring this scenario [2].

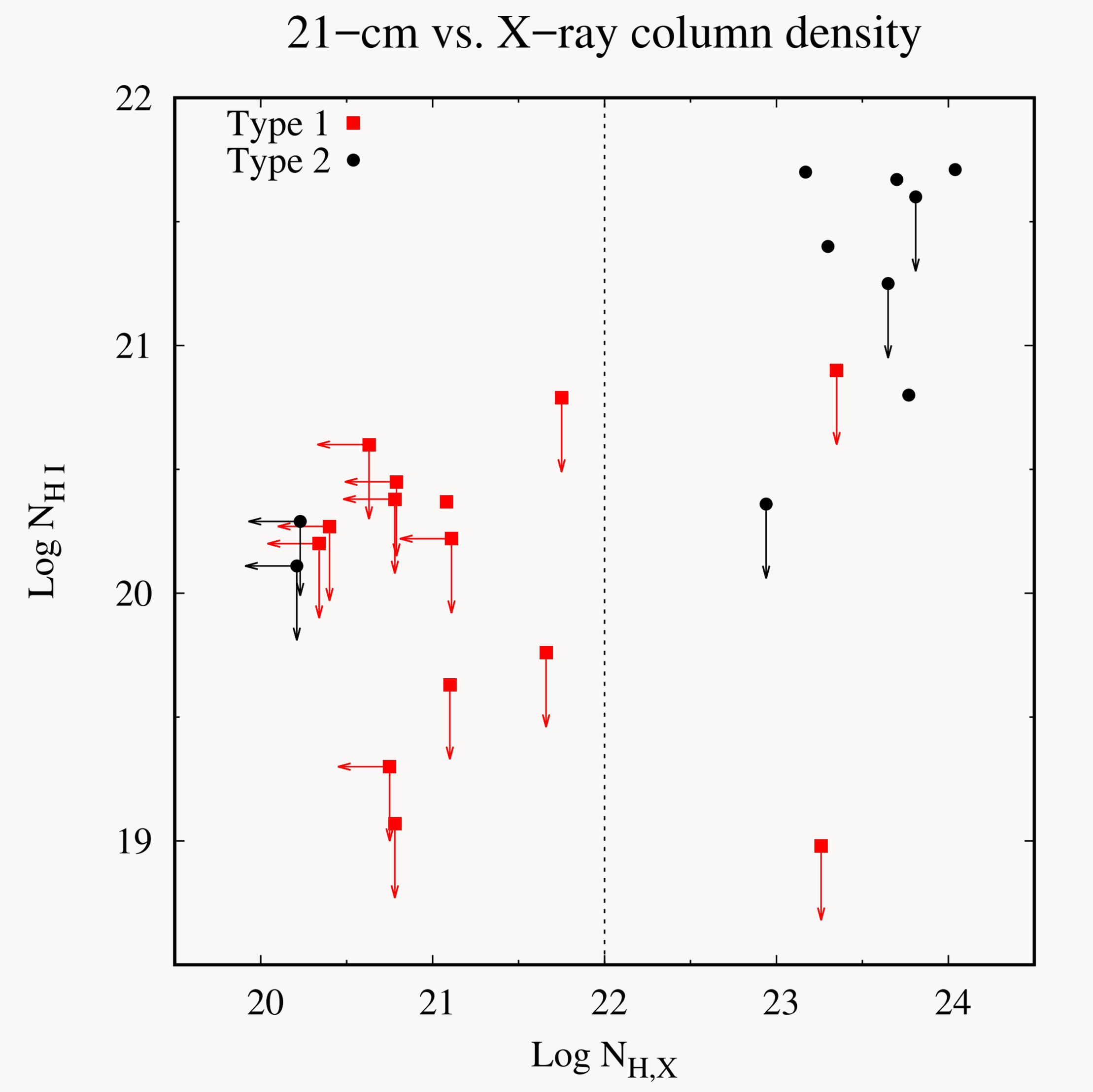
Absorption properties - Where are Compton-thick radio galaxies?





Most of the optical type 2 radio galaxies of our sample are X-ray absorbed ($N_{\mathrm{H}} > 10^{22}$ cm^{-2}), while most of the optical type 1s are unabsorbed, consistent with the zeroth order predictions of unified models of AGNs [8]. However, even the most absorbed sources are not Compton-thick, i.e. $N_{\mathrm{H}} < 1.5 \times 10^{24}$ cm^{-2} [9]. In general, although a few radio galaxies have been reported as Compton-thick candidates in the literature, we currently lack strong evidence for heavily absorbed radio galaxies [9]. This could be due to either a selection bias or an intrinsic discrepancy between the average absorption properties of radio-loud and radio-quiet AGNs.

Radio vs. X-ray absorption: a relation?



Recent studies found a correlation between the 21-cm H I column density ($N_{\mathrm{H\,I}}$) and the X-ray hydrogen column density ($N_{\mathrm{H,X}}$), especially in compact radio galaxies [6, 7]. From the existing literature, we find a 21-cm detection rate of 7/11 among X-ray absorbed sources of our sample, and of 1/15 among unabsorbed sources. This shows that X-ray absorbed sources have a higher probability of 21-cm detection, suggesting a link between the two gas populations. However, this connection is not well understood in extended radio galaxies, where the H I gas is likely associated to galactic-scale structures. Further 21-cm observations will allow us to to test this correlation with higher significance.

References

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