Linking AGN Accretion States with Host Galaxy Properties

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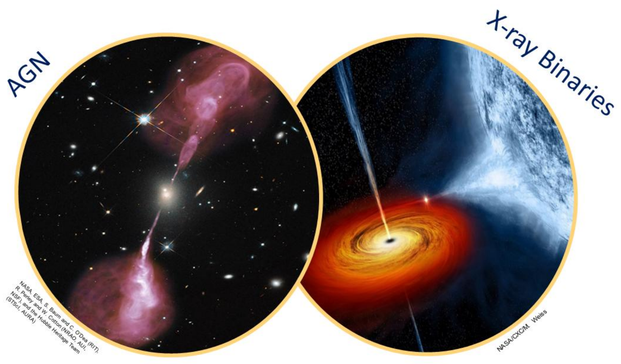
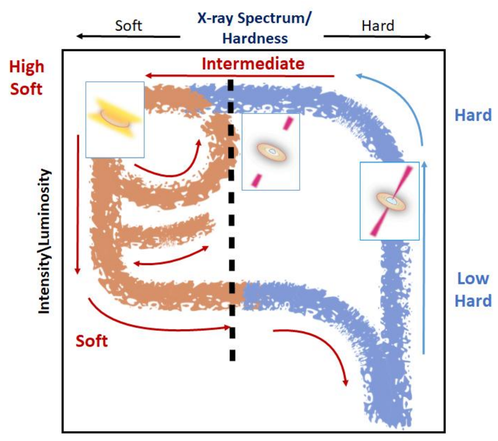
Accretion States across the mass scale

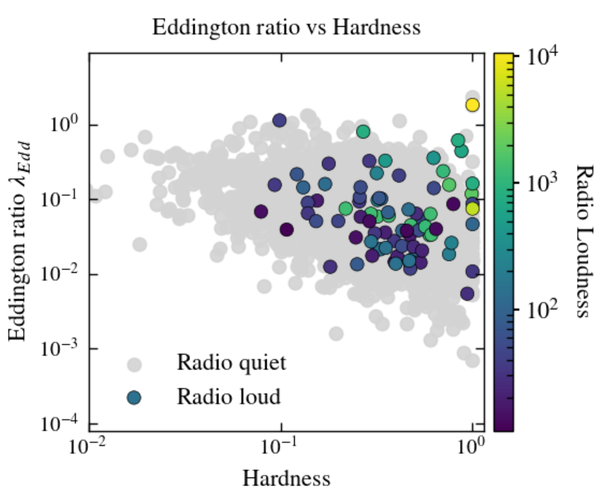
- Stellar-mass black holes in X-ray binaries (XRBs) evolve through different accretion states (see, e.g., Fender et al., 2004):
  - hard state - hard X-ray spectrum from X-ray corona, large variability, accompanied by the presence of a radio jet.
  - soft state - soft X-ray spectrum with thermal emission of the accretion disc, low variability, no jet
- **Do super-massive black holes in active galactic nuclei (AGN) evolve through similar accretion states?**
  - AGN accretion time scales much longer → study of a large sample of sources.
  - Thermal disk emission is colder, peaking in UV, X-ray emission dominated by coronal power-law emission.
  - Wide range of black hole masses.

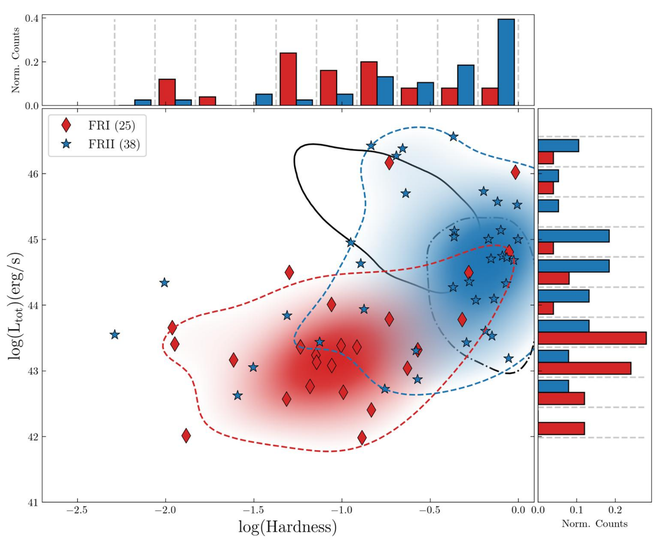




Our AGN Sample:

- simultaneous UV (accretion disc emission) and X-ray (corona) observations with *XMM-Newton* and *Swift* observatories.
- cross-matching with AGN catalogues (Véron-Cetty & Véron, 2010; SDSS - Paris et al., 2018).
- radio properties (VLASS; Gordon et al., 2021), Seyfert classification (Véron-Cetty & Véron, 2010, Koss et al., 2022).
- star formation and mass of host galaxies (Barrows et al., 2021)

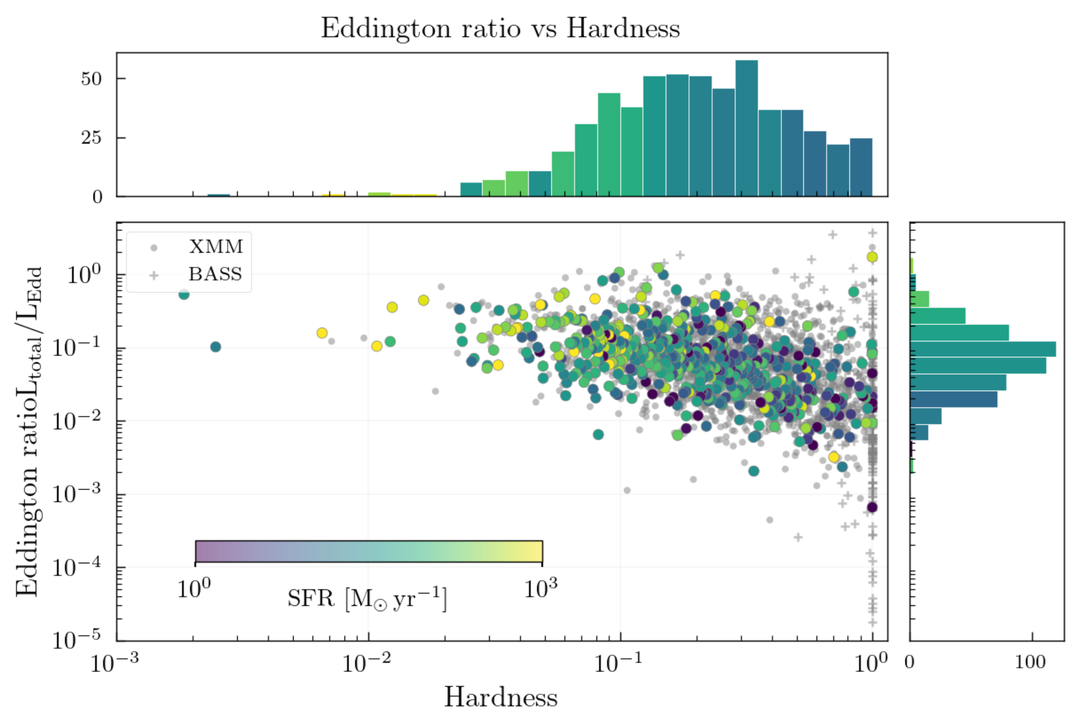




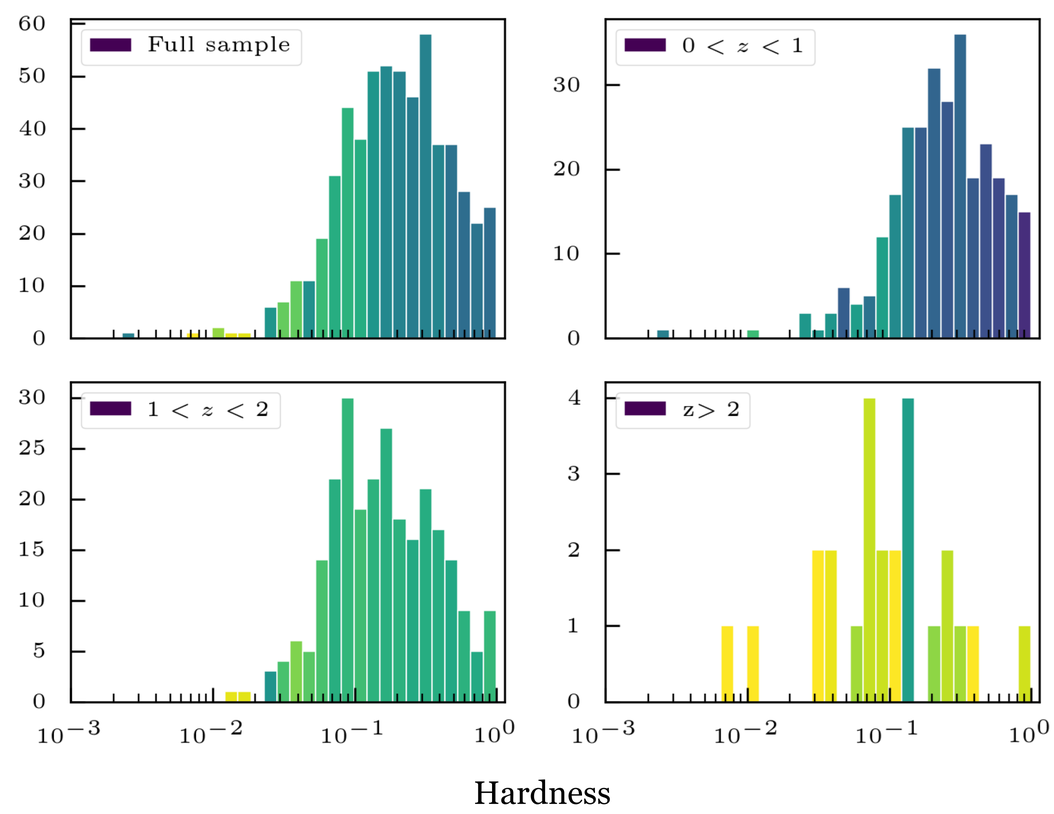
AGN hardness-Luminosity diagram with **radio loudness** (left) and the **radio morphology** (right) according to the Fanaroff-Riley classification: FR–I - core dominated (red), FR–II - lobe dominated (blue).

The radio–loud quasars are located in the top-right area of the hardness-intensity diagram. FR–Is and FR–IIs occupy different areas of the diagram. (Borkar et al., in prep., Moravec et al., 2022)

AGN accretion states and star formation



AGN hardness-Eddington ratio diagram with the colour denoting the **star formation rate** (SFR). Highly accreting sources also show high star formation. These are mostly AGN at high redshift (see below).



Take Home Message

- AGN and XRBs display qualitatively similar accretion states.
- Radio–loud AGN have high hardness and AGN with different radio morphology occupy distinct areas in the hardness-intensity diagram, analogously to XRBs.
- AGN accretion states and SFR are correlated, suggesting co-evolution of AGN and host galaxy.
- High-z sources are softer and more star-forming while low-z sources are harder, accreting at lower Eddington ratio in low-SFR galaxies, indicating cosmic downsizing.

Further reading:
Körding E., Jester S. Fender R., 2006, MNRAS, 372, 1366K
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Moravec E., Svoboda J., Borkar A. et al., 2022, A&A, 662A, 28M
Svoboda J., Guainazzi M. & Merloni A.. 2017, A&A, 603, A127
Borkar A., Svoboda J. et al., 2026, in preparation