Dependence of X-ray loudness of AGN on Eddington ratio and black hole mass

Maitrayee Gupta[1] and Marek Sikora[1]

1. Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Bartycka 18, 00–716 Warszawa, Poland

In this paper we present the preliminary results of an investigation into the X-ray properties of radio-loud (RL) and radio-quiet (RQ) quasars, since the largest differences in accretion structure of these objects are expected to be imprinted in the UV and X-ray spectra. Using the SDSS DR7 Quasar catalog and Second ROSAT all-sky survey (2RXS) data we demonstrate strong anti-correlation of X-ray loudness on the Eddington ratio, for both RL and RQ AGNs. RL AGNs are found to be on average X-ray louder than RQ AGN (Active Galactic Nuclei), which agrees with previous studies. We also see a dependence of the X-ray loudness on the black hole mass for both our samples. Our results are discussed in the context of theories of the X-ray production in AGN.

1 Introduction

In quasars the primary X-ray emission is believed to be produced by inverse Compton scattering of the optical/UV disk photons (Sunyaev & Titarchuk, 1980). In existing literature, the scattering region is proposed to be either a hot corona above the cold disc (Haardt & Maraschi, 1993), or an advection dominated accretion flow (ADAF) (Narayan & Yi, 1994; Esin et al., 1997) or the base of the jet or the relativistic jet (Markoff et al. 2005). In this paper we present the results of an investigation into the X-ray properties of RL and RQ quasars since largest differences in accretion structure of these sources, as implied by the value of the BH spin and presence or absence of the magnetically arrested disk MAD zone, are expected to be imprinted in UV and X-ray spectra.

2 The sample

We compiled the samples of RL and RQ quasars from SDSS DR7 quasar catalogue (Schneider et al., 2010; Shen et al., 2011) by cross matching it with the NRAO VLA Sky Survey (NVSS) (Condon et al., 1998) and Faint Image of Radio Sky at Twenty-centimeters (FIRST) (Becker et al., 1995) radio catalogs. We applied the following criteria for redshift, black hole mass and Eddington ratio: $z < 2$; $M_{\rm BH} > 10^8\,{\rm M}_\odot$; $\lambda_{\rm E} > 0.01$. We rejected those RL quasars which are classified as blazars because in these objects the radiation is dominated by a jet rather than by an accretion disk. All selected objects were matched with Second ROSAT all-sky survey (2RXS) source catalogue (Boller, Th. et al., 2016). Our final samples contain: 273 RL quasars and 2640 RQ quasars. Fig. 1 shows the distribution of our RL and RQ samples in redshift, black hole mass and Eddington ratio.

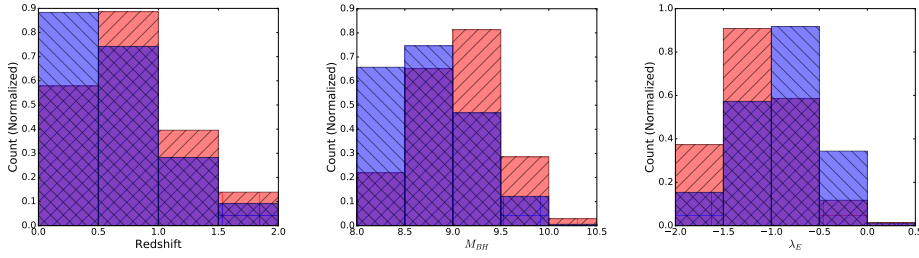

Fig. 1: Distributions of our RL (red) and RQ (blue) samples of quasars in redshift z, black hole mass $M_{\rm BH}$, and Eddington ratio $\lambda_{\rm E}$.

3 Methodology

The RL and RQ samples were selected based on the cut-off of the radio-loudness which was calculated as $R = L_{1.4}/L_{\rm u} = 30$, where $L_{1.4}$ is the monochromatic luminosity at 1.4 GHz, and $L_{\rm u}$ is the monochromatic luminosity at central frequency in the u-band of SDSS photometry system. Such a division value of radio-loudness is equivalent to the one adopted by Kellermann et al. (1989), $R \sim 10$, In order to assure that objects with no NVSS and FIRST detection are really RQ, i.e. having $R < 30$, we introduced for our samples the minimum optical flux $F_{\rm u,min} = F_{1.4\rm min}/30 \sim 0.1$ mJy. The X-ray luminosity was calculated using the count rate provided by Boller, Th. et al. (2016), adopting the formula for X-ray flux $F_{\rm X} = (5.3{\times}{\rm HR1}{+}8.31) \times 10^{-12}$ erg cm^{-2} s^{-1}, where HR1 is the hardness ratio named X-ray-loudness: $R_{\rm X} = L_{\rm X\text{-}ray}/L_{\rm u}$, where $L_{\rm X\text{-}ray}$ is the X-ray luminosity in the 0.1 – 2.4 keV band.

4 Results

We observed a strong anti-correlation of X-ray-loudness on the Eddington ratio $\lambda_{\rm E}$ Fig. 2). RL AGN are found to be on average X-ray louder than RQ AGN, which agrees with previous studies. The X-ray-loudness increases with decrease of the $M_{\rm BH}$, and at the lowest $M_{\rm BH}$ we observed that there is a sharp increase in X-ray-loudness. We must note that the sensitivity of ROSAT is too low to present the average X-ray-loudness of our sample.

5 Conclusions

RL objects are X-ray louder than RQ objects, which can be attributed to stronger coronal activity in RL AGN and/or significant contribution to X-ray flux by jet base. We demonstrated that there is a strong anti-correlation between X-ray-loudness and Eddington ratio, as well as black hole mass for both RL and RQ quasars. These results are from our preliminary analysis of the X-ray data.

Acknowledgements. We acknowledge financial support by the Polish National Science Centre grant No. 2016/21/B/ST9/01620.

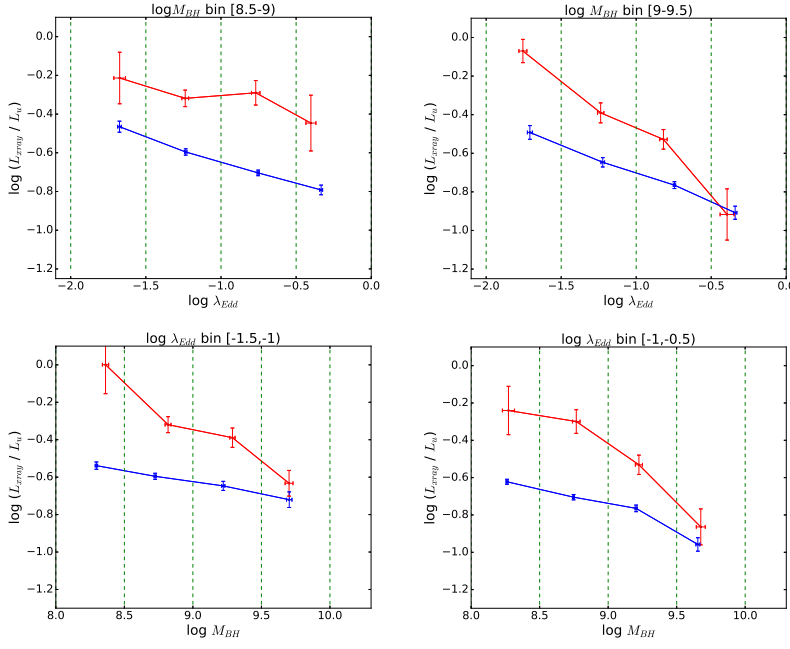

Fig. 2: The dependence of X-ray-loudness on $M_{\rm BH}$ binned in $\lambda_{\rm E}$ (top), and on $\lambda_{\rm E}$ binned in $M_{\rm BH}$ (bottom). Red lines: RL and blue lines: RQ. The mean values of the X-ray-loudness, $\lambda_{\rm E}$ or $M_{\rm BH}$, and the error in the mean values are also shown for each of the bins. The means are calculated for equally spaced bins.

References

Becker, R. H., White, R. L., Helfand, D. J., *ApJ* **450**, 559 (1995)

Boller, Th., et al., *A&A* **588**, A103 (2016), URL `https://doi.org/10.1051/0004-6361/201525648`

Condon, J. J., et al., *AJ* **115**, 1693 (1998)

Esin, A. A., McClintock, J. E., Narayan, R., *ApJ* **489**, 865 (1997)

Haardt, F., Maraschi, L., *ApJ* **413**, 507 (1993)

Kellermann, K. I., et al., *AJ* **98**, 1195 (1989)

Markoff, S., Nowak, M. A., Wilms, J., *ApJ* **635**, 1203 (2005)

Narayan, R., Yi, I., *ApJL* **428**, L13 (1994)

Schneider, D. P., et al., *AJ* **139**, 2360 (2010)

Shen, Y., et al., *ApJS* **194**, 45 (2011)

Sunyaev, R. A., Titarchuk, L. G., *A&A* **86**, 121 (1980)