ASCA VIEW ON HIGH-REDSHIFT RADIO-QUIET QUASARS

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ABSTRACT We briefly discuss the latest ASCA results on the X-ray spectral properties of high-redshift radio-quiet quasars.

KEYWORDS: active galaxies; quasars; nonthermal mechanism; X-rays

1. INTRODUCTION

The study of quasar X-ray properties as a function of redshift can address some important issues such as (a) the history of accretion processes over the cosmic time, (b) the evolution of quasar activity and (c) the condition of the Universe at the epoch of quasars formation. So far, while high-redshift radio-loud quasars (RLQs) have been widely studied in hard X-rays in the last few years (Cappi et al. 1997, Yamazaki et al. 1998), the X-ray properties of high-z radio-quiet quasars (RQQs) are still poorly known (even though they constitute about 90 % of the quasar population), due to their weaker X-ray flux with respect to radio-loud objects (Zamorani et al. 1981). In order to fill this gap we have performed a pilot study with ASCA of a sample of high-redshift (z > 1.85) RQQs.

2. THE SAMPLE

The objects presented here have been chosen among the brightest ones found through a cross correlation of the Véron-Véron quasars catalogue (Véron-Cetty & Véron 1996) with the ROSAT All-Sky Survey catalogue of X-ray sources (Voges et al. 1999). We have obtained relatively good ASCA spectra for 9 sources (see Table 1 for the relevant data). The sample is clearly not complete and, due to its soft X-ray selection, may be biased toward less absorbed objects. Nonetheless, it may be considered adequate in order to obtain, for the first time and prior to XMM
Table 1 - The Radio-Quiet Quasars sample

| Object        | z    | $N_{H,gal}$ | $m_V$ | Exp_{SIS(GIS)} (k$\alpha$) | CR_{SIS(GIS)} (10^{-2} c/s) | $\alpha_{ox}$ |
|---------------|------|-------------|-------|-----------------------------|----------------------------|--------------|
| 0151−4046     | 1.85 | 2.07        | 18.1  | 32 (36)                     | 4.0 (2.3)                  | 1.15         |
| 0040+0034     | 2.00 | 2.45        | 18.0  | 30 (36)                     | 3.8 (3.2)                  | 1.17         |
| 1352−2242     | 2.00 | 5.88        | 18.2  | 31.4                        | 1.7 (1.5)                  | 1.29         |
| 1247+267      | 2.04 | 0.9         | 15.6  | 36 (34)                     | 1.3 (1.1)                  | 1.69         |
| 1400+10       | 2.07 | 1.81        | 86.5  |                             | 2.4 (1.8)                  |              |
| 1101−264      | 2.15 | 5.68        | 16.0  | 17.4 (19.7)                 | 1 (0.6)                    | 1.71         |
| 0059−304A     | 2.17 | 2.00        | 19.3  | 31 (37.4)                   | 0.5 (0.6)                  | 1.23         |
| 0300−4542     | 2.30 | 1.83        | 19.2  | 37.7                        | 1.3 (1.2)                  | 1.16         |
| 0130−4124     | 2.46 | 2.20        | 20.8  | 35.3 (38)                   | 1.2 (1.1)                  | 0.95         |

$^a$ In units of $10^{20}$ cm$^{-2}$, Dickey & Lockman 1990; $^b$ $\alpha_{ox} = -\frac{\log(F_{\nu}/F_{\nu})}{\log(\nu/\nu_0)}$

launch, a reliable measurement of the X–ray spectral properties of high-z RQQs. A standard analysis has been applied to the data, taking into account the most recent calibration uncertainties, and extensive checks on background subtraction have been performed. A detailed description of the data analysis and the first results can be found in Vignali et al. (1999) on a subsample of 4 objects, plus WEE 83, which is now excluded from discussion since its redshift has been re-measured and the revised value puts it fairly near ($z$=0.311, Wu et al. 1999).

3. RESULTS

The results of the spectral analysis are presented in Table 2 and summarized in the following.

- The spectra are well fitted by a single power law model over the $\sim$ 2–30 keV energy range (rest frame). The average spectral slope is <$\Gamma$> = 1.75, with dispersion $\sigma$ = 0.12, which agrees very well with the value ($\Gamma$ = 1.72±0.03) obtained from the co-added GIS+SIS spectra of all the sources in the overlapping rest-frame energy range ($\sim$ 2.4–28.4 keV).

- A comparison with various samples of lower-z RQQs from ASCA (Reeves et al. 1997, George et al. 2000) and BeppoSAX (Costantini 1998) is showed in Fig. 1, suggesting either a possible flattening of the power law slope with redshift or toward high energies.

- There is no evidence of the signatures of cold matter either in transmission (the upper limits on intrinsic absorption ranging from 3 up to $8 \times 10^{21}$ cm$^{-2}$ rest frame) or in reflection, with upper limits on Fe K$\alpha$ line EW of $\sim$ 70–200 eV (rest frame). The lack of intrinsic absorption in high-z RQQs is at variance with the findings by Elvis et al. (1994) and Cappi et al. (1997) for high-z RLQs. If this result will be confirmed by future observations, then a different evolution for RQQs and RLQs, possibly related to their environment, could be envisaged.

- A further check on the presence of a reflection component (peaking at 20–30 keV rest frame) has been performed on the co-added spectrum. The addition of
this component results in a steeper spectrum ($\Gamma = 1.82^{+0.11}_{-0.09}$) and a value for $R$ (the normalization of the reflected vs. the direct continuum) of $0.89^{+0.01}_{-0.06}$. However, this component statistically is not required by the data. This result, combined with the lack of any iron line, do indicate that in high-luminosity RQQs reprocessing, if present, is different with respect to nearby Seyfert galaxies.

- The lack of a reflection component and absorption features in the spectra of high-z RQQs is not surprising though. It can be explained as the result of a strong ionized reflection, which gives rise to a reprocessed spectrum similar to the incident one; alternatively, it may be caused by a low covering fraction of the reprocessing matter as seen from the X–ray source. The iron line may be weak due to resonant trapping and Auger effects or totally absent if the iron is fully stripped of electrons.

| Object | $N_H$ (10$^{21}$ cm$^{-2}$) | $\Gamma$ | R$^a$ | $\chi^2$/dof | $F_{2–10keV}$ (10$^{-13}$ cgs) | $L_{2–10keV}$ (10$^{46}$ cgs) |
|--------|-----------------|--------|--------|------------|----------------|-----------------|
| 0040+0034 | $\equiv N_{H_gal}$ | 1.66$^{+0.06}_{-0.08}$ | 1.69$^{+0.10}_{-0.08}$ | < 2.34 | 240/237 | 15 | 2.7 |
|  | $< 8.76$ | | | | 239/236 |
|  | $\equiv N_{H_gal}$ | 1.71$^{+0.14}_{-0.14}$ | | | 239/236 |
| 0300–4342 | $\equiv N_{H_gal}$ | 1.64$^{+0.15}_{-0.22}$ | 1.63$^{+0.14}_{-0.12}$ | 3.62$^{+0.38}_{-0.26}$ | 168/148 | 5.0 | 1.2 |
|  | $< 7.15$ | | | | 168/147 |
|  | $\equiv N_{H_gal}$ | 1.96$^{+0.19}_{-0.33}$ | | | 164/147 |
| 1101–264 | $\equiv N_{H_gal}$ | 1.73$^{+0.04}_{-0.05}$ | 2.05$^{+0.43}_{-0.36}$ | unc. | 29.5/23 | 2.9 | 0.7 |
|  | $< 63.1$ | | | | 27.9/22 |
| 1352–2242 | $\equiv N_{H_gal}$ | 1.66$^{+0.12}_{-0.16}$ | 1.65$^{+0.14}_{-0.10}$ | < 23 | 146/147 | 6.1 | 1.1 |
|  | $< 7.53$ | | | | 145/146 |
| 1400+10 | $\equiv N_{H_gal}$ | 1.64$^{+0.08}_{-0.05}$ | 1.64$^{+0.09}_{-0.05}$ | < 1.13 | 292/256 | 9.4 | 1.8 |
|  | $< 7.64$ | | | | 292/255 |
| 0130–4124 | $\equiv N_{H_gal}$ | 1.78$^{+0.14}_{-0.18}$ | 1.83$^{+0.32}_{-0.18}$ | < 2.35 | 132/137 | 5.0 | 1.6 |
|  | $< 54.3$ | | | | 131/136 |
|  | $\equiv N_{H_gal}$ | 1.69$^{+0.38}_{-0.48}$ | | | 132/136 |
| 0059-304 A | $\equiv N_{H_gal}$ | 1.73$^{+0.35}_{-0.55}$ | 1.74$^{+0.36}_{-0.56}$ | unc. | 88/60 | 2.3 | 0.6 |
|  | $< 349$ | | | | 88/59 |
| 0151–4046 | $\equiv N_{H_gal}$ | 1.83$^{+0.66}_{-0.59}$ | 1.84$^{+0.57}_{-0.53}$ | < 2.68 | 163/197 | 11 | 2.0 |
|  | $< 3.97$ | | | | 163/196 |
| 1247+287 | $\equiv N_{H_gal}$ | 2.00$^{+0.13}_{-0.14}$ | 2.01$^{+0.14}_{-0.14}$ | 2.87$^{+0.42}_{-0.43}$ | 130/124 | 4.8 | 1.3 |
|  | $< 2.99$ | | | | 130/123 |

Note: errors are quoted at 90 % confidence level for one interesting parameter.

$^a$ R represents the normalization of reflected vs. direct continuum (R=1 means $\Omega=2\pi$ coverage).

GIS) 0.8–10 keV Spectral Results

Table 2 - ASCA (SIS+GIS) 0.8–10 keV Spectral Results
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FIGURE 1. RQQs photon spectral indices as a function of redshift.