The origin of the faintness in the X-ray weak QSOs: the case of PG 0043+039

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ABSTRACT A fraction of QSOs, called **soft X-ray weak QSOs**, shows unusually low emission in the hard X-rays. Although the nature of these sources as homogeneous class is not well assessed, their optical emission-line properties suggest that the primary physical parameters can be extreme. Several scenarios for the X-ray weakness have been proposed: the presence of **absorbers** (neutral or partially ionized), or strong **variability** of the intrinsic continuum and/or of the absorber. Recently, the light bending has been proposed as an alternative explanation. Finally, for at least some of these sources it can be an **intrinsic** property, calling for a different X-ray emission mechanism.

We present the XMM-*Newton* observation of **PG 0043+039**, detected *for the first time* in the X-ray band. A more detailed description of these results will appear in a forthcoming paper (Ballo et al. 2008a, submitted). The observed flux is consistent with the non-detection in previous ROSAT and ASCA observations, and the EPIC spectra do not show any absorption features. Although a strong variability in the X-ray emission cannot be completely ruled out, the XMM-*Newton* data firmly suggest that PG 0043+039 can be numbered among the few sources known to be **intrinsically X-ray faint**.

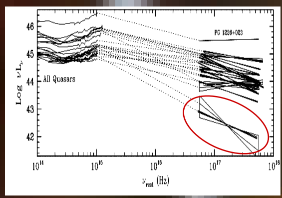
1. X-ray weak AGN

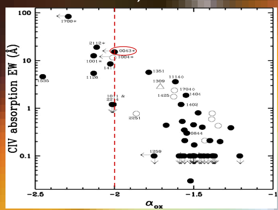
They are AGN notably faint in soft X-rays with respect to their optical fluxes:

$\alpha_{OX} = \log (F_{2keV}/F_{3000Å})/\log (\nu_{2keV}/\nu_{3000Å}) < -2$

Possible origins:

- correlation observed between α_{OX} and absorption features in the UV band → X-ray absorption as primary cause of their soft X-ray weakness;
- variability of the intrinsic continuum → classification from observations on a low emission state;
- intrinsic property: X-ray weak quasars could be characterized by extreme physical parameters in the nuclear region (e.g., high $\dot{m}$).





Laor et al. 1997, Brandt et al. 2000

2. The state-of-art

New X-ray observations questioned the nature of these sources as homogeneous class, emphasizing at the same time their peculiarities. Recent results from our group:

- strong absorption & presence of nuclear outflows e.g. Mrk 304 *Piconcelli et al. 2004* PG 1535+547 *Ballo et al. 2008b*
- variability of the intrinsic continuum & light bending effects e.g. PG 2112+059 *Schartel et al. 2007*

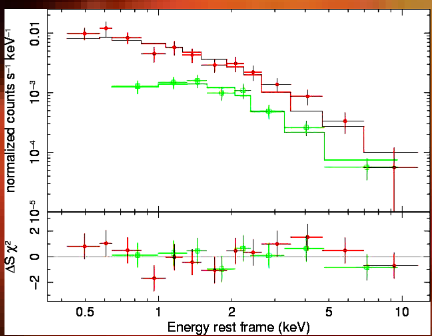
3. PG 0043+039

Broad Emission Line QSO at z = 0.385, not detected either by ROSAT or ASCA →
- $\alpha_{OX} < -2.2$ *Brinkmann et al. 1999*
- implied $N_H \sim 10^{23}$ cm^{-2} assuming a typical intrinsic QSO continuum *Gallagher et al. 1999*

Possible presence of Broad Absorption Lines in its optical/UV spectrum *Turnshek et al. 1994*

From the FWHM(Hβ) – λLλ(5100 Å) and the L_{bol} – λLλ(5100 Å) relations: *Hao et al. 2005*

$M_{BH} \sim 10^9 M_{SUN}$ $L_{bol} \sim 3 \cdot 10^{46}$ ergs s^{-1} $\dot{m} \sim 0.27$



3. XMM-*Newton* observation

Our ~30 ksec exposure time observation provides the *first* X-ray detection of PG 0043+039:

- continuum well fitted by an unabsorbed PL typical of radio quiet AGN:

$$\Gamma = 1.86 +/- 0.2 \qquad N_H < 3 \cdot 10^{20} \text{ cm}^{-2}$$

- no emission feature detected in the X-ray spectrum:

$$EW(6.4 \text{ keV}) < 80 \text{ eV}$$

- flux and luminosity consistent with previous non-detection in ROSAT & ASCA data:

$$F_{2\text{-}10\,keV} \sim 2 \cdot 10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1} \qquad L_{2\text{-}10\,keV} \sim 9 \cdot 10^{42} \text{ erg s}^{-1}$$

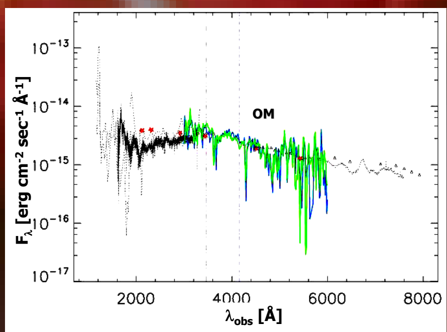
- extreme X-ray bolometric correction implied by the above mentioned L_{bol} and the observed $L_{2\text{-}10\,keV}$:

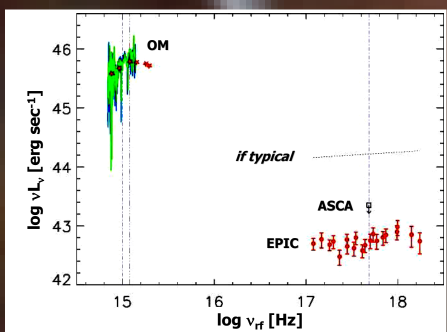
$$k_{2\text{-}10\,keV} \sim 3800$$

Ballo et al. 2008a, submitted

4. Origin of the X-ray weakness

From simultaneous OM (filters & grisms) and EPIC data we confirm that PG 0043+039 appears to be a soft X-ray weak QSO: $\alpha_{OX} = -2.11$





- low emission state unlikely:
  - if the origin is variability, then all X-ray observations have found the source in a low emission level;
  - observed X-ray spectrum at odd with flat PL shown by variable sources in low emission state;
  - simultaneous variability at low and high energy rejected by agreement between various optical/UV datasets + simultaneity of OM and EPIC data.
- No absorption origin:
  - no signature of Compton-thin cold absorber;
  - if reflection-dominated, the absence of Fe line and spectral shape steeper than expected rule out a cold reflector;
  - if reflection-dominated, the extreme value of the ionization parameter (ξ~5600 erg cm s^{-1}) to avoid the production of line, makes the presence of an ionized reflector unlikely;
  - a warm absorber compatible with the EPIC spectra cannot modify the luminosity enough to justify the X-ray weakness.

Intrinsically faint

BUT with an accretion rate lower than expected from theoretical models.

Ballo et al. 2008b, A&A, 483, 137
Brandt et al. 2000, ApJ, 528, 637
Brinkmann et al. 1999, A&A, 345, 43
Gallagher et al. 1999, ApJ, 519, 549
Hao et al. 2005, ApJ, 625, 78
Laor et al. 1997, ApJ, 477, 93
Piconcelli et al 2004, MNRAS, 351, 161
Schartel et al. 2007, A&A, 474, 431
Turnshek et al. 1994, ApJ, 428, 93

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