The peculiar properties of the narrow-line quasar PG 1543+489 at z=0.40

C. Vignali[1,2], E. Piconcelli[3], S. Bianchi[4] and G. Miniutti[5]

(1) Dipartimento di Astronomia, Universita` di Bologna, Italy; (2) INAF - Osservatorio Astronomico di Bologna, Italy; (3) INAF - Osservatorio Astronomico di Roma, Italy; (4) Dipartimento di Fisica, Universita` di Roma Tre, Italy; (5) Laboratoire APC, Paris, France

We present the analysis of three XMM-*Newton* observations of the narrow-line quasar PG 1543+489 at z=0.400 carried out over a rest-frame time scale of about three years. The X-ray spectrum is characterized by the presence of a relativistic iron Kα emission line and a steep photon index, both accounted for in the context of a ionized reflection model, where the source of X-ray photons is presumably very close to the black hole. The strong light-bending effects expected in such scenario provide the most plausible explanation for the large equivalent width (EW=3.1±0.8 keV in the source rest frame) of the iron line. However, to reproduce the source properties, it is not possible to rule out an absorption model, where obscuring matter partially covers the X-ray source. The apparent lack of variations in the properties of the absorber over the time scale probed by our observations suggests that this model is less likely. (**arXiv:0805:1227**)

PG 1543+489: source properties

➢ **PG 1543+489** is a narrow-line [FWHM(Hβ)≈1630 km/s; Aoki et al. 2005] QSO (**NLQSO**) at **z=0.400**. With a black hole mass of ≈(1-2.4)10^8 $M_\odot$, its Eddington ratio is estimated to be ≈(1.3-3.7), assuming Richards et al. (2006) bolometric corrections, or a factor ≈5 lower assuming Marconi et al. (2004).

➢Its optical spectrum shows a **blueshift of the [OIII]5007Å line** (150 km/s with respect to the systemic velocity of the galaxy) and a **blue asymmetry** in both the **[OIII]** (Aoki et al. 2005) and **CIV line** (Baskin & Laor 2005) **profiles**. These properties characterize PG 1543+489 as a "**blue outlier**": the large blueshift is interpreted as the result of an outflow whose receding part is obscured by an optically thick accretion disk (Zamanov et al. 2002) or by a scenario where NLR clouds are entrained in a decelerating wind (Komossa et al. 2008). A connection likely exists between being a "blue outlier" and the Eddington ratio.

➢Like many other NLQSs, also PG 1543+489 has a steep X-ray spectrum, as already shown by the *ASCA* observation (George et al. 2000). This result, coupled with the presence of a narrow Hβ emission line, is suggestive of an high accretion rate (e.g., Shemmer et al. 2006, 2008), likely related to the outflow phenomena.

X-ray observations

Table 1: XMM-Newton observations

Observation OBS_ID	Start Date	Net Exposure Time / Source Counts pn	MOS1	MOS2
0153220401	2003 Feb 08	9.3/3010	11.6/860	11.8/910
0505050201	2007 Jun 09	6.6/3530	8.8/1030	8.8/950
0505050701	2007 Jun 15	6.7/3160	8.8/950	8.7/920
0505050301	2007 Jun 17	10.4/4730	13.6/1520	13.6/1480

➢Motivated by the intriguing X-ray properties found in the 2003 archival XMM-*Newton* observation (see Fig. 1), we were awarded three more observations (see Table 1); of these, only two (0505050201 and 0505050701) were used in the analysis because of the limited impact of flares.

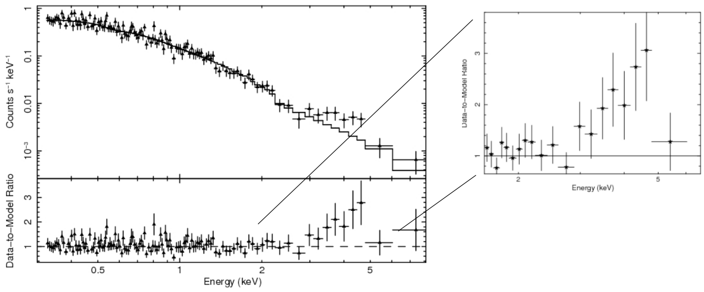


Figure 1: *Left panel* Fitting to the archival pn data of PG 1543+489 over the 0.3-10 keV range with a power law and Galactic absorption. *Right panel* Close up of the deviations (in units of σ) in the ≈1.5-7 keV energy range.

X-ray spectral properties

➢The lack of significant spectral variations among the observations, despite the ≈50% increase in flux from 2003 ($F_{0.5\text{-}10\ \mathrm{keV}}$≈5 10^{-13} erg/cm^2/s) to 2007, allows for summing up all the pn and MOS data.

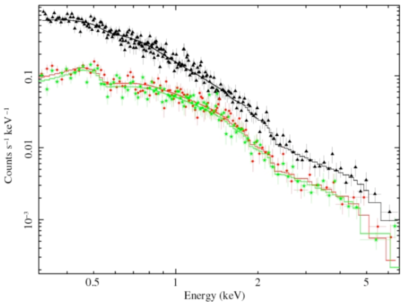
➢A steep power law (Γ≈2.7) plus a relativistic iron line (significance >99.999%, laor model preferred) provides a good fit to the data (χ^2=459/440 dof).

➢The iron line **EW=3.1±0.8 keV** in the source rest frame) is **among the strongest ever found** [see, e.g., the cases of PG 1402+261 and IRAS 13224+3408; see also the recent compilations of iron lines in AGN by Guainazzi et al. (2006) and Nandra et al. (2007)].

➢Similarly to other NLQs, a **ionized reflection model, convolved with a relativistic kernel** from the Laor (1991) code, is able to explain the overall properties of PG 1543+489 (see Fig. 2). The resulting Γ is 2.35±0.02, but the ionization parameter ξ is unconstrained (>6760 erg cm/s). In these conditions, the disc acts like a perfect reflector (Ross & Fabian 2005).

➢A partial-covering model provides a slightly better result (χ^2=445/440); the column density is $2.1^{+1.9}_{-0.9}10^{23}$ cm^{-2} and the covering fraction is 0.53±0.11. However, the lack of significant variations in the absorber's properties from one observation to another (due, e.g., to orbital motions of the matter around the black hole) casts some doubts on this model.

Figure 2: pn (triangles), MOS1 (filled circles) and MOS2 (stars) spectral data of the three XMM-*Newton* observations fitted with a ionized reflection model convolved with a relativistic blurring kernel from the Laor code.



Very strong (EW=3.1±0.8 keV) and relativistic iron line

Light-bending effects are likely at work in PG 1543+489 and provide a natural explanation of all of the X-ray properties

A partial covering provides an alternative explanation, but the lack of variations in the absorber may indicate that this model is less likely

In the framework of the light-bending model, the reduced variability of the reflection component with respect to the continuum can be explained. If the continuum variability is not entirely intrinsic but is mainly due to changes in the location of the primary source of hard X-rays, light-bending effects close to the central massive black hole predict little variability of the spectral components reprocessed by the accretion disc (Miniutti & Fabian 2004)

References

•Aoki K., Kawaguchi T., Ohta K., 2005, ApJ, 618, 601 •Baskin A., Laor A., 2005, MNRAS, 356, 1029 •George I.M., et al., 2000, ApJ, 531, 52 •Guainazzi M., Bianchi S., Dovciak M., 2006, Ast. Nach., 88, 789 •Komossa S., Xu D., Zhou H., Storchi-Bergmann T., Binette L., 2008, ApJ, in press (arXiv:0803.0240) •Laor A., 1991, ApJ, 376, 90 •Marconi A., Risaliti G., Gilli R., Hunt L.K., Maiolino R., Salvati M., 2004, MNRAS, 351, 169 •Miniutti G., Fabian A.C., 2004, MNRAS, 349, 1435 •Nandra K., O'Neill P.M., George I.M., Reeves J.N., 2007, MNRAS, 382, 194 •Richards G.T., et al., 2006, ApJ Suppl., 166, 470 •Ross R.R., Fabian A.C., 2005, MNRAS, 358, 211 •Shemmer O., Brandt W.N., Netzer H., Maiolino R., Kaspi S., 2006, ApJ, 646, L29 •Shemmer O., Brandt W.N., Netzer H., Maiolino R., Kaspi S., 2006, ApJ, in press (arXiv:0804:0803) •Zamanov R., Marziani P., Sulentic J.W., Calvani M., Dultzin-Hacyan D., Bachev R., 2002, ApJ, 576, L9

`CV, EP and SB thank for support the Italian Space Agency (contracts ASI-INAF I/023/05/0 and ASI I/088/06/0); GM acknowledges support from the UK PPARC`