An extreme, blueshifted iron line in the Narrow Line Seyfert 1 PG 1402+261

J.N. Reeves[1,2], D. Porquet[3], T.J. Turner[1,4]

jnr@milkyway.gsfc.nasa.gov

ABSTRACT

We report on a short *XMM-Newton* observation of the radio-quiet Narrow Line Seyfert 1 PG 1402+261. The EPIC X-ray spectrum of PG 1402+261 shows a strong excess of counts between $6-9$ keV in the rest frame. This feature can be modeled by an unusually strong (equivalent width 2 keV) and very broad (FWHM velocity of 110000 km s^{-1}) iron K-shell emission line. The line centroid energy at 7.3 keV appears blue-shifted with respect to the iron Kα emission band between $6.4-6.97$ keV, whilst the blue-wing of the line extends to 9 keV in the quasar rest frame. The line profile can be fitted by reflection from the inner accretion disk, but an inclination angle of $> 60°$ is required to model the extreme blue-wing of the line. Furthermore the extreme strength of the line requires a geometry whereby the hard X-ray emission from PG 1402+261 above 2 keV is dominated by the pure-reflection component from the disk, whilst little or none of the direct hard power-law is observed. Alternatively the spectrum above 2 keV may instead be explained by an ionized absorber, if the column density is sufficiently high ($N_{\rm H} > 3 \times 10^{23}$ cm^{-2}) and if the matter is ionized enough to produce a deep ($\tau \sim 1$) iron K-shell absorption edge at 9 keV. This absorber could originate in a large column density, high velocity outflow, perhaps similar to those which appear to be observed in several other high accretion rate AGN. Further observations, especially at higher spectral resolution, are required to distinguish between the accretion disk reflection or outflow scenarios.

Subject headings: galaxies: active — Seyferts: individual: PG 1402+261 — X-rays: galaxies

[1]Laboratory for High Energy Astrophysics, Code 662, NASA Goddard Space Flight Center, Greenbelt Road, Greenbelt, MD 20771, USA

[2]Universities Space Research Association

[3]Max-Plank-Institut für extraterrestrische Physik, Postfach 1312, 85741 Garching, Germany

[4]Joint Center for Astrophysics, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA

1. Introduction

PG 1402+261 is a type-I radio-quiet quasar at z=0.164 (Schmidt & Green 1983). It emits narrow optical permitted lines with FHWM (Hβ)=1910 km s^{-1} and can also be classified as a Narrow Line Seyfert 1 (NLS1). The mass of the supermassive black hole in this quasar has been estimated to be 2×10^{7} M$_\odot$ and the bolometric luminosity is about 1.3×10^{45} erg s^{-1} (Woo & Urry 2002). This leads to a high accretion rate relative to Eddington of about 50% (Porquet et al. 2004). PG 1402+261 was previously observed in X-rays with *Beppo-SAX* by Mineo et al. (2000). They found that the data were satisfactorily represented by a broken power law continuum of $\Gamma = 2.59 \pm 0.10$ and $\Gamma = 1.52 \pm 0.30$ for the soft and hard X-ray bands, respectively, although there was some evidence for an excess of counts above 7 keV in the MECS spectrum. A preliminary analysis of a recent (2002) XMM-Newton observation of PG 1402+261, reported by Porquet et al. (2004) amongst a sample of PG quasars, shows that the spectrum cannot be represented by a simple broken power-law continuum alone, but exhibits a large deviation between $6-9$ keV in the quasar rest frame, in the form of an apparent broad and blue-shifted iron K emission line. This observation adds to the number of AGN (and NLS1s in particular) that appear to exhibit unusually strong emission or absorption features above 7 keV in the iron K-shell band; e.g. 1H 0707-495 (Boller et al. 2002), IRAS 13224-3809 (Boller et al. 2003), PDS 456 (Reeves, O'Brien & Ward 2003) and PG 1211+143 (Pounds et al. 2003). These iron K band features have either been interpreted as the signature of enhanced reflection from the inner accretion disk, e.g. 1H 0707-495, (Fabian et al. 2002), but in some cases may also be interpreted as evidence for an additional high column density absorber, either from matter partially covering the X-ray source (Boller et al. 2002) or even from a high velocity ($\sim 0.1c$) outflow (Pounds et al. 2003; Reeves, O'Brien & Ward 2003).

Here we present a spectral analysis of the *XMM-Newton* observation of PG 1402+261, modeling the strong iron K-band emission (or absorption) feature. We investigate the possible physical origins for this feature; either in the form of an extreme broadened iron emission line produced via X-ray reflection from accretion disk or alternatively a very high column density ionized absorber. Note that all fit parameters are given in the quasar rest frame, with values of H$_0$=75 km s^{-1} Mpc^{-1}, and q$_0$=0.5 assumed throughout. Errors are quoted at 90% confidence (e.g. $\Delta\chi^2 = 2.7$, for 1 parameter of interest).

2. The XMM-Newton observation

PG 1402+261 was observed by *XMM-Newton* on 2002 February 27 (OBSID: 0109081001), with an exposure time of only 9.1 ks. Data were taken with the EPIC pn and MOS CCDs

(Strüder et al. 2001; Turner et al. 2001), in Large Window Mode with the thin filter. The data was reduced using version 5.4.1 of the XMM-SAS software. Data were selected using event patterns 0-4 and 0-12 for pn and MOS respectively, whilst only good X-ray events (with 'FLAG=0') were included. The source spectra were extracted from a circular source region of $\sim 40''$ radius, whilst background spectra were extracted from a box of $1.85'$ radius around the source, but excluding the circular source region. Response matrices and ancillary response files were generated using the SAS tasks RMFGEN and ARFGEN respectively. EPIC-pn lightcurves were also extracted over two energy bands, however no dramatic variability was observed, therefore the spectral analysis is performed on the whole *XMM-Newton* exposure.

3. X-ray spectral analysis

In all subsequent fits, the column density is fixed to the Galactic value, i.e, $1.47 \times 10^{20}\,\mathrm{cm}^{-2}$. Both the EPIC-pn and the co-added MOS spectra are shown in Figure 1, with the data/model ratio residuals plotted against a power-law continuum of photon index $\Gamma = 2.2$ fitted in the $2-5$ keV band. A strong soft excess is present below 2 keV and the continuum shape can be parameterized by a simple broken power-law, with a soft index of $\Gamma = 2.84 \pm 0.04$ and a hard index of $\Gamma = 2.17 \pm 0.12$ above a break energy of $E = 1.8 \pm 0.2$ keV. A hard excess is also clearly observed above 5 keV in both the pn and MOS detectors. For this broken-powerlaw continuum, the unabsorbed 0.3–10 keV (2–10 keV) band flux is $7.3\times10^{-12}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ ($1.8\times10^{-12}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$), with a corresponding luminosity of $4.4\times10^{44}\,\mathrm{erg\,s^{-1}}$ ($1.0\times10^{44}\,\mathrm{erg\,s^{-1}}$). About 77% of the flux is emitted below 2 keV, consistent with the strong soft X-ray excess. Note that at this flux level, photon pile-up of the source X-ray spectrum is negligible.

As the pn spectrum contains significantly more counts than the MOS above 6 keV in the iron K band, we now concentrate on the pn spectral analysis. Figure 2 shows the data/model ratio to the broken-power-law continuum, plotted from 3-11 keV in the quasar rest frame. Notice that the majority of the flux of the iron K band feature is observed above 7 keV, i.e. above the rest energy for H-like iron, whilst a sharp drop in the spectrum is observed at 9 keV in the rest frame. A single broad Gaussian emission line models the hard excess rather well, with a centroid energy of $\mathrm{E} = 7.3^{+0.4}_{-0.5}$ keV, a line width of $\sigma = 1.2^{+0.6}_{-0.4}$ keV (FWHM velocity of 1.1×10^{5} km s^{-1}) and a very high equivalent width of ~ 2 keV (Table 1, fit 1). The fit statistic is acceptable, with $\chi^2/dof = 390.5/377$, with the feature detected at $> 99.99\%$ significance according to an F-test.

3.1. Comparison with a previous *ASCA* observation.

PG 1402+261 was also previously observed by *ASCA* on January 12, 2000. The *ASCA* data are composed of the SIS0 (exposure time $\sim$ 43.2 ks), SIS1 ($\sim$ 37.7 ks), GIS2 and GIS3 (each $\sim$ 57.3 ks) data. A fit above 1 keV using all four detectors, with a single power-law ($\Gamma = 2.3 \pm 0.2$) plus a broad emission Gaussian line, gives a good representation of the data (χ^2/d.o.f=404.2/361) and the line is required at a confidence level of >99.95%. The energy of the line is $7.2^{+0.4}_{-0.6}$ keV and its width is high with σ=$0.8^{+0.7}_{-0.4}$ keV (Table 1, fit 2). The EW of $\sim$ 1 keV, is lower than the one found during the XMM-Newton observation, but is compatible within the errors. During the ASCA observation the 2–10 keV unabsorbed flux was 2.5×10^{-12} erg cm^{-2} s^{-1} (SIS0), i.e. about 40% higher than the XMM-Newton observation.

3.2. A broad disk emission line?

Given the large width of the emission line in the *XMM-Newton* (and *ASCA*) fits, we attempted to fit the iron line profile with emission from the inner accretion disk around a Kerr black hole, using the xspec LAOR model (Laor 1991). We assumed an inner radius of $1.2R_g$ ($R_g = GM/c^2$, i.e. one gravitational radius) and an outer radius of $400R_g$. Initially we fixed the disk inclination angle at 30°, reasonable for a type I AGN. We obtained a very high line energy at $8.5^{+0.3}_{-0.2}$ keV, required to fit the blue-wing of the line between $8.5-9$ keV, whilst the line equivalent width is extremely large at $\sim$ 4 keV (Table 1, fit 3). This line energy is much larger than the maximum energy corresponding to H-like iron (6.97 keV), therefore this could indicate a significant outflow of the medium producing the line, i.e. 0.3–0.4 c (90 000–120 000 km s^{-1}), for H-like or neutral iron respectively. As an alternative model, we free the disk inclination angle, but instead fix the rest energy of the iron line emission at 6.97 keV, i.e. corresponding to H-like iron. This then requires a large disk inclination of 67^{+5}_{-4} degrees in order to fit the blue-wing of the line, although the fit is equally acceptable (Table 1, fit 4). Thus either a substantial outflow of the line emitting matter is required, or the disk has to be highly inclined to the line of sight.

Given the evidence for a very strong broad line in PG 1402+261, we tested whether the spectrum could be fitted with an ionized disk reflection model. We use the model XION from Nayakshin, Kazanas, & Kallman (2000) in the simplest lamppost configuration to model the emission above 2 keV, together with a soft featureless power-law component to model the steep soft X-ray excess in PG 1402+261. We fixed the height of the source above the disk to $10R_g$, the inner and outer disk radii to $4R_g$ (the minimum the model allows) and $100R_g$ respectively. The accretion rate was fixed to 50% of Eddington, whilst the ratio of X-ray to disc (UV) luminosity was set to 10% (Porquet et al. 2004). We find the reflection model fits the spectrum well with $\Gamma_{\rm soft}$=$3.11^{+0.09}_{-0.08}$ and $\Gamma_{\rm hard}$=$1.70^{+0.17}_{-0.44}$ for the continuum photon indices and a fit statistic of $\chi^2/dof = 397/379$. The unfolded spectral fit is shown in Figure 3. Although the model produces mainly He and H-like Fe emission (at 6.7 keV and 6.97 keV respectively), a high disk inclination of greater than >60° is required to model the extreme blue-shift of the line. In addition, a high iron abundance of 5× solar (the maximum permitted value) is required, whilst in order to model the extreme strength of the line, the hard emission component is required to be *reflection dominated*, i.e. the illuminating hard power-law component cannot be directly observed.

3.3. Highly Ionized Absorption in PG 1402+261?

As an alternative interpretation, we have investigated whether the strong iron K feature can be modeled with a highly ionized absorber. One can fit the spectrum reasonably well with a continuum modeled by two power-laws ($\Gamma_{\rm soft} = 3.0 \pm 0.2$ and $\Gamma_{\rm hard} = 0.9 \pm 0.5$), although the hard power-law has to be very flat to model the hard excess above 5 keV. The addition of an absorption edge at 9.0 ± 0.2 keV, with a depth of $\tau = 1.1 \pm 0.5$, models the sharp drop at 9 keV in the rest frame (Figure 2), with a fit statistic of $\chi^2/dof = 395/378$. The energy of the K-shell edge then either corresponds to H-like iron (at 9.27 keV) or He-like iron (at 8.75 keV).

We then proceed to fit the data with the xspec warm absorber model ABSORI (Done et al. 1992). The model is applied so that the soft X-ray power-law (which may for instance originate directly from the disk) is unattenuated, but so the hard X-ray power-law is modified by the absorber (i.e. a partial coverer). In order to model the depth of the edge a large column density of $N_H \sim 2 \times 10^{24}$ cm^{-2} is required. Formally, the 90from this model is $\log \xi > 3.5$ erg cm s^{-1}, with an outflow velocity of < 20000 km s^{-1}, whilst the column density must exceed $N_{\rm H} > 3 \times 10^{23}$ cm^{-2} (assuming 5× solar abundance). The best fit model is shown in Figure 4, whilst the fit obtained is equally as good as the disk reflection model ($\chi^2/dof = 396/378$). Inclusion of the warm absorber results in there now only being a requirement for a *narrow* iron Kα emission line, with an equivalent width of ~ 600 eV. The line centroid energy is 7.4 ± 0.1 keV, which indicates that there may still be some blue-shift of this component; e.g., ~ 18000 km s^{-1} compared to the rest-frame energy of H-like Fe at 6.97 keV.

4. Discussion and Conclusions

The X-ray spectrum of PG 1402+261 shows a strong excess in the iron K-shell band between $6 - 9$ keV. If this is due to a relativistic disk line, then its parameters are rather extreme. The line equivalent width is ~ 2 keV, even stronger than the broad iron line observed in MCG -6-30-15 (Tanaka et al. 1995; Wilms et al. 2001; Vaughan & Fabian 2004). Such a strong iron Kα emission line can only be produced if the hard X-ray emission in PG 1402+261 is dominated by the disk reflection component, with little of the direct hard power-law being observed. Furthermore the rest-energy of the line, peaking above 7 keV and extending up to 9 keV, implies that the accretion disk is likely to be observed at large inclination angles, i.e. $> 60°$. Such a high inclination would be appear unusual for a type I AGN in the context of AGN unification schemes (Antonucci 1993).

It is possible that large density perturbations in the disk could explain the strong reflection dominated emission above 2 keV. Variations of up to $\times 100$ in density have predicted from simulations of highly turbulent disks (Turner, Stone & Sano 2002). Thus a natural geometry could occur whereby the direct hard X-ray emission (e.g. from compact coronal flares) is obscured by dense, turbulent clouds within the disk surface layers, the same clouds then reflect the X-rays into the line of sight (Guilbert & Rees 1988). A similar geometry was applied by Fabian et al. (2002) to the Narrow Line Seyfert 1, 1H 0707-495, which shows an unusually strong iron K edge at 7.1 keV. Fabian et al. (2002) propose that the hard X-rays could be emitted within low density cavities between dense rings of matter on the disk surface; the ring surfaces then reflect the X-rays into the observers line of sight, whilst the direct emission is obscured. In PG 1402+261, the direct X-rays are more likely to be obscured if the disk was viewed at large (side-on) inclination angles, as is inferred from our accretion disk fits. The soft X-ray (and EUV) excess emission may not be obscured however, if this is the Comptonized thermal emission from the extended inner disk region (Malkan & Sargent 1982; Czerny & Elvis 1987).

One other possibility is that the disk reflection is enhanced by the effects of gravitational light bending of the hard X-ray emission *towards* the disc, i.e. returning radiation (Cunningham 1975). This effect will be strongest when the X-rays are concentrated within $2 - 3R_g$ around the spin axis of a maximally rotating black hole (in the so-called "lamp-post" configuration). Indeed it has been suggested that the strong, redshifted iron line in MCG -6-30-15 may be boosted by this process (Martocchia, Matt & Karas 2002; Fabian & Vaughan 2003). However in the case of PG 1402+261, it may be difficult to explain the observed blueshift of the iron line in this scenario, as one would expect the emergent line profile to be gravitationally redshifted below 6 keV.

Alternatively, the spectrum of PG 1402+261 can also be modeled by a high column density, high ionization absorber, where the sharp drop at 9 keV in the spectrum can be fitted by a high ionization (He or H-like) K-shell edge of iron. Both the column density and ionization of the absorber have to be rather extreme ($N_H > 3 \times 10^{23}$ cm^{-2} and log $\xi >$ 3.5 erg cm^{-1} s^{-1} respectively), to produce a $\tau \sim 1$ iron K-shell edge at 9 keV. However other high column density iron K-shell absorbers, with similar absorber parameters, have recently been observed in *XMM-Newton* and *Chandra* observations of several high luminosity AGN; in particular PDS 456 (Reeves, O'Brien & Ward 2003), PG 1211+143 (Pounds et al. 2003), PG 1115+080 (Chartas, Brandt & Gallagher 2003) and APM 08279+5255 (Chartas et al. 2002; Hasinger, Schartel, & Komossa 2002). The outflow velocities inferred in these absorbers were generally found to be extreme, of up to 0.1c. One possibility is that the absorber arises from the innermost part of an high velocity accretion disk outflow, within a few $(10 - 100R_g)$ radii of the black hole. Indeed as noted by King & Pounds (2003), high velocity, large column density disk winds may be a natural consequence of accretion at a high fraction of the Eddington rate; in PG 1402+261 the accretion rate is $\sim 50\%$ of Eddington (Porquet et al. 2004).

Determining which model (reflection vs absorber) is the most plausible explanation for the iron K profile in PG 1402+261 is not possible with the current short *XMM-Newton* observation. However a high column density absorber may impart discrete spectral features that could be detected with a longer observation (with *XMM-Newton*) or with much improved spectral resolution (e.g. with the calorimeter-based XRS detector on Astro-E2, due for launch in 2005). For instance, resonant K-shell absorption lines from Fe XXV or Fe XXVI may be produced, whilst strong absorption lines may also be detected from other elements (e.g. Mg, Si and S), making it possible to constrain the kinematics of the outflow. Indeed strong, blue-shifted (by up to 0.1c) absorption line were detected in the XMM-Newton observations of PG 1211+143 (Pounds et al. 2003), whilst resonant absorption lines may even affect the iron line profiles of some nearby Seyfert 1 galaxies; e.g., NGC 3783 (Reeves et al. 2004). Alternatively if the spectrum of PG 1402+261 can be explained by disk reflection, then it would be highly desirable to determine how the strong iron line changes with flux, in a much longer observation.

REFERENCES

Antonucci, R. 1993, ARA&A, 31, 473

Boller, T., et al. 2002, MNRAS, 329, L1

Boller, T., Tanaka, Y., Fabian, A.C., Brandt, W.N., Gallo, L., Anabuki, N., Haba, Y., & Vaughan, S. 2003, MNRAS, 343, L89

Chartas, G., Brandt, W.N., Gallagher, S.C., & Garmire, G.P. 2002, ApJ, 579, 169

Chartas, G., Brandt, W.N., & Gallagher, S. 2003, ApJ, 595, 85

Cunningham, P.T. 1975, ApJ, 202, 788

Czerny, B., & Elvis, M. 1987, ApJ, 321, 305

Done, C., Mulchaey, J.S., Mushotzky, R.F., & Arnaud, K.A. 1992, ApJ, 395, 275

Fabian, A.C., Ballantyne, D.R., Merloni, A., Vaughan, S., Iwasawa, K., & Boller, T. 2002, MNRAS, 331, L35

Fabian, A.C., & Vaughan, S., 2003, MNRAS, 340, L28

Guilbert, P.W., & Rees, M.J. 1988, MNRAS, 233, 475

Hasinger, G., Schartel, N., & Komossa, S. 2002, ApJ, 573, L77

King, A.R., & Pounds, K.A. 2003, MNRAS, 345, 657

Laor, A. 1991, ApJ, 376, 90

Malkan, M.A., & Sargent, W. 2003, ApJ, 254, 22

Martocchia, A., Matt, G., & Karas, V. 2002, A&A, 383, L23

Mineo, T., et al. 2000, A&A, 359, 471

Nayakshin, S., Kazanas, D., & Kallman, T.R. 2000, ApJ, 537, 833

Porquet, D., Reeves, J.N., O'Brien, P., & Brinkmann, W. 2004, A&A, in press (astro-ph/0404385)

Pounds, K.A., Reeves, J.N., King, A., Page, K., O'Brien, P.T., & Turner, M.J.L. 2003, MNRAS, 345, 705

Reeves, J.N., O'Brien, P.T., & Ward, M. 2003, ApJ, 593, L65

Reeves, J.N., Nandra, K., George, I.M., Pounds, K.A., Turner, T.J., Yaqoob, T. 2004, ApJ, 602, 648

Schmidt, M., & Green, R.F. 1983, ApJ, 269, 352

Strüder, L., Aschenbach, B., Bruninger, H., et al. 2001, A&A, 365, L5

Tanaka, Y., et al. 1995, Nature, 375, 659

Turner, M.J.L., et al. 2001, A&A, 365, L27

Turner, N.J., Stone, J.M., & Sano, T. 2002, ApJ, 566, 148

Vaughan, S., & Fabian, A.C. 2004, MNRAS, 348, 1415

Wilms, J., Reynolds, C.S., Begelman, M.C., Reeves, J., Molendi, S., Staubert, R., & Kendziorra, E. 2001, MNRAS, 328, L27

Woo, J. & Urry, C.M. 2002, ApJ, 579, 530

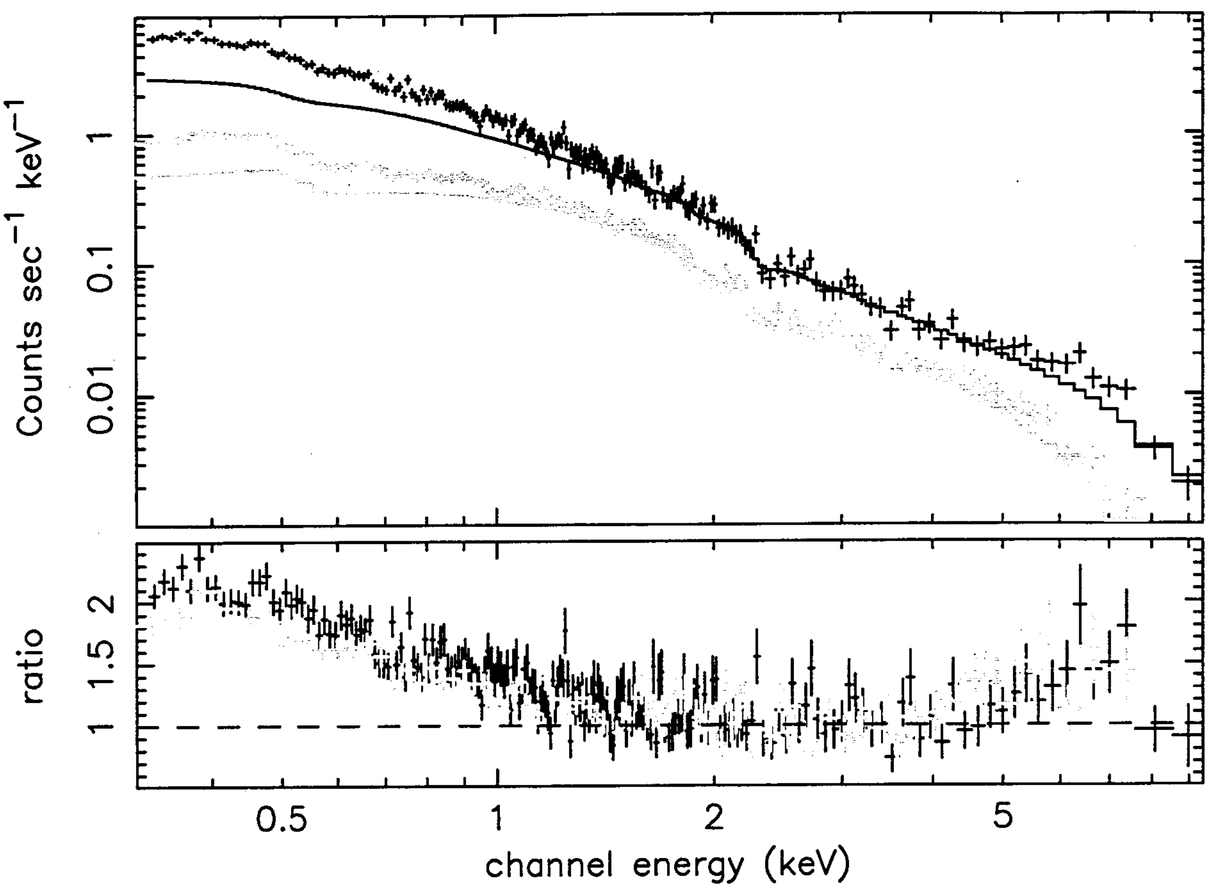

Fig. 1.— XMM-Newton EPIC-pn (black) and EPIC-MOS (grey) spectrum of PG 1402+261. Energy is plotted in the observers frame. The top panel shows the datapoints (crosses) and the model fitted to the data (solid line), folded through the detector response. The bottom panel shows the ratio of the data to a power-law continuum model, fitted between 2-5 keV, of index $\Gamma = 2.2$. A soft X-ray excess is clearly seen below 1.5 keV, whilst an excess of counts is observed in both detectors above 5 keV in the iron K-shell band.

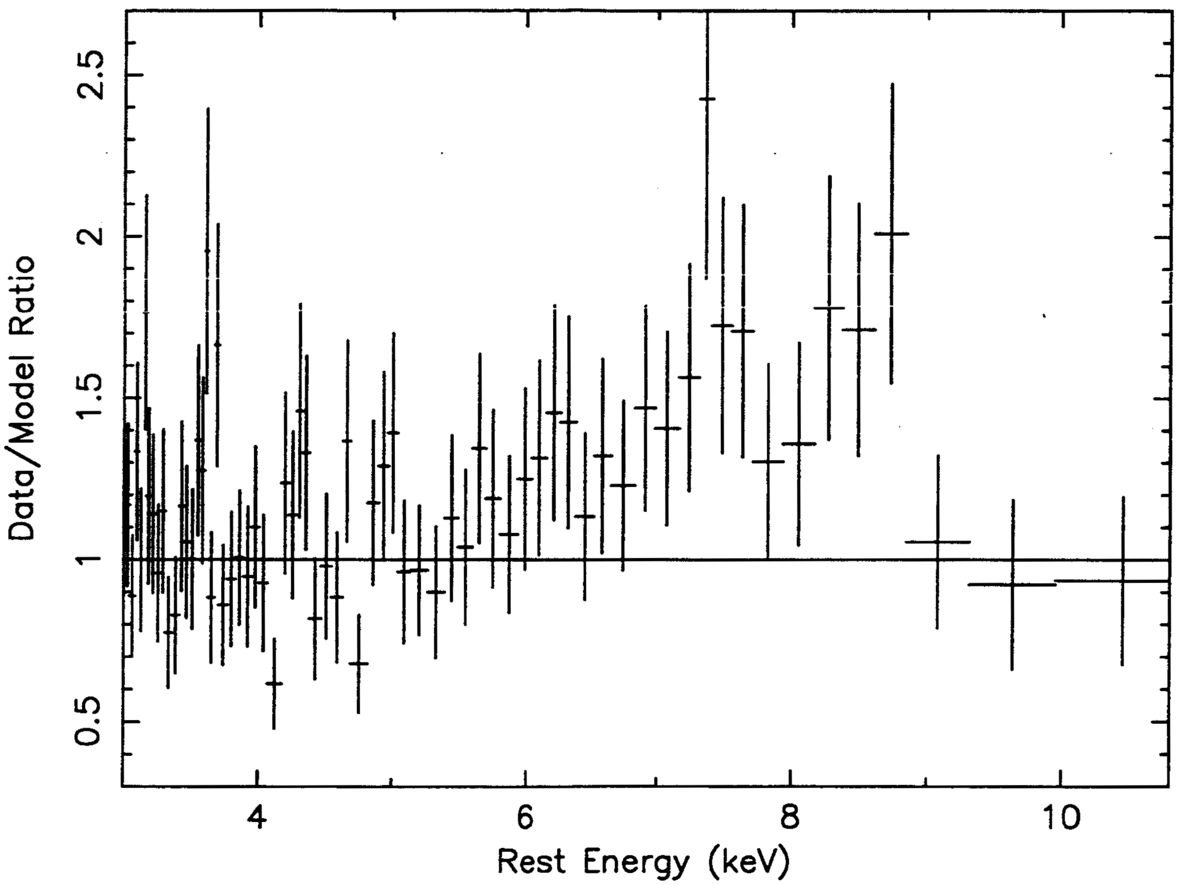

Fig. 2.— The iron line profile of PG 1402+261, showing the ratio of the EPIC-pn data to a broken power-law continuum fit, as described in the text. Energy is plotted in the quasar rest frame. An excess of counts, which can be modeled as a broad, but blue-shifted, iron K-shell line is observed between 6-9 keV, whilst a sharp drop is observed in the data at 9 keV.

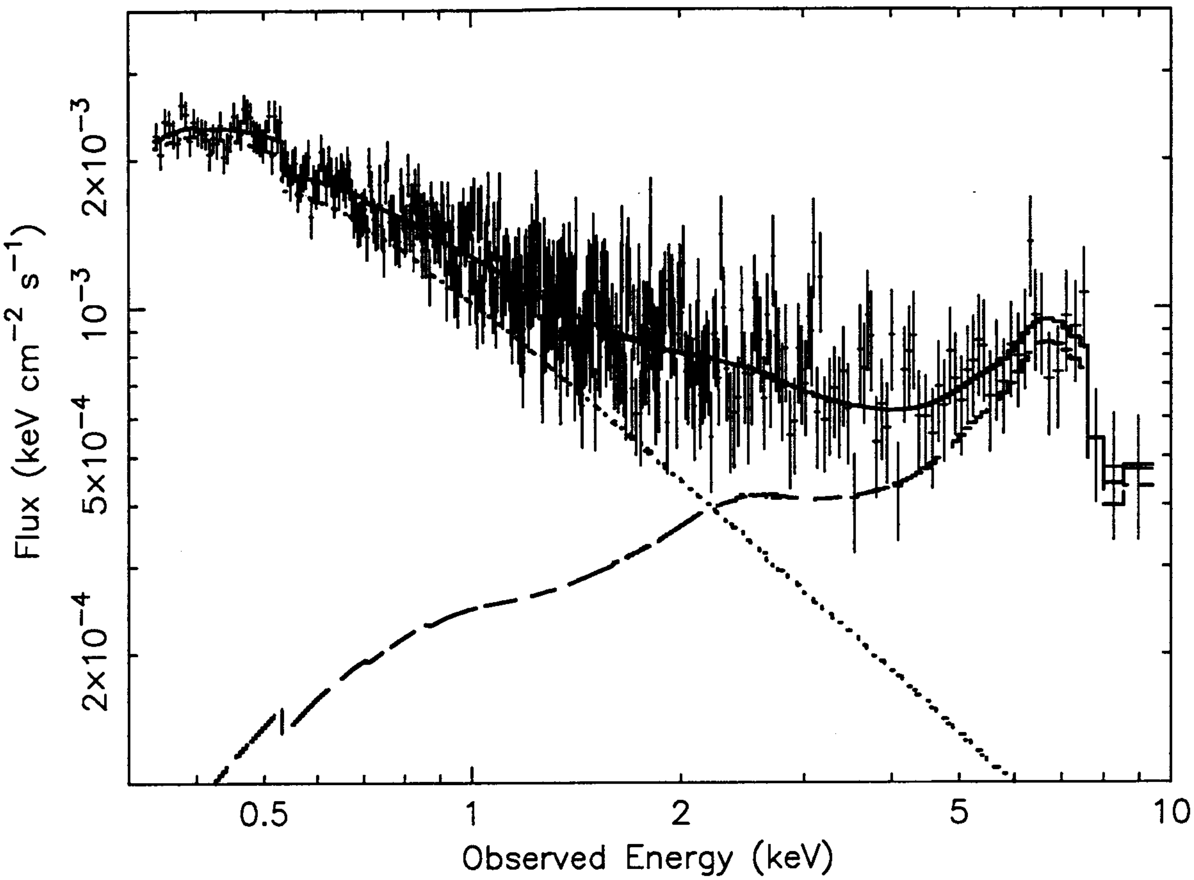

Fig. 3.— An ionized disc reflection model (XION), fitted to the spectrum of PG 1402+261. The crosses show the (unfolded) data-points, the solid line the total model emission, the dotted line the soft X-ray power-law and the dashed line the ionized reflection component. In order to model the extreme blue-wing of the line, the disc must be highly inclined at $> 60°$. The reflection component must also dominate the emission in the iron K-band (i.e. the illuminating hard X-ray power-law is not directly observed), in order for the very strong iron line to be observed.

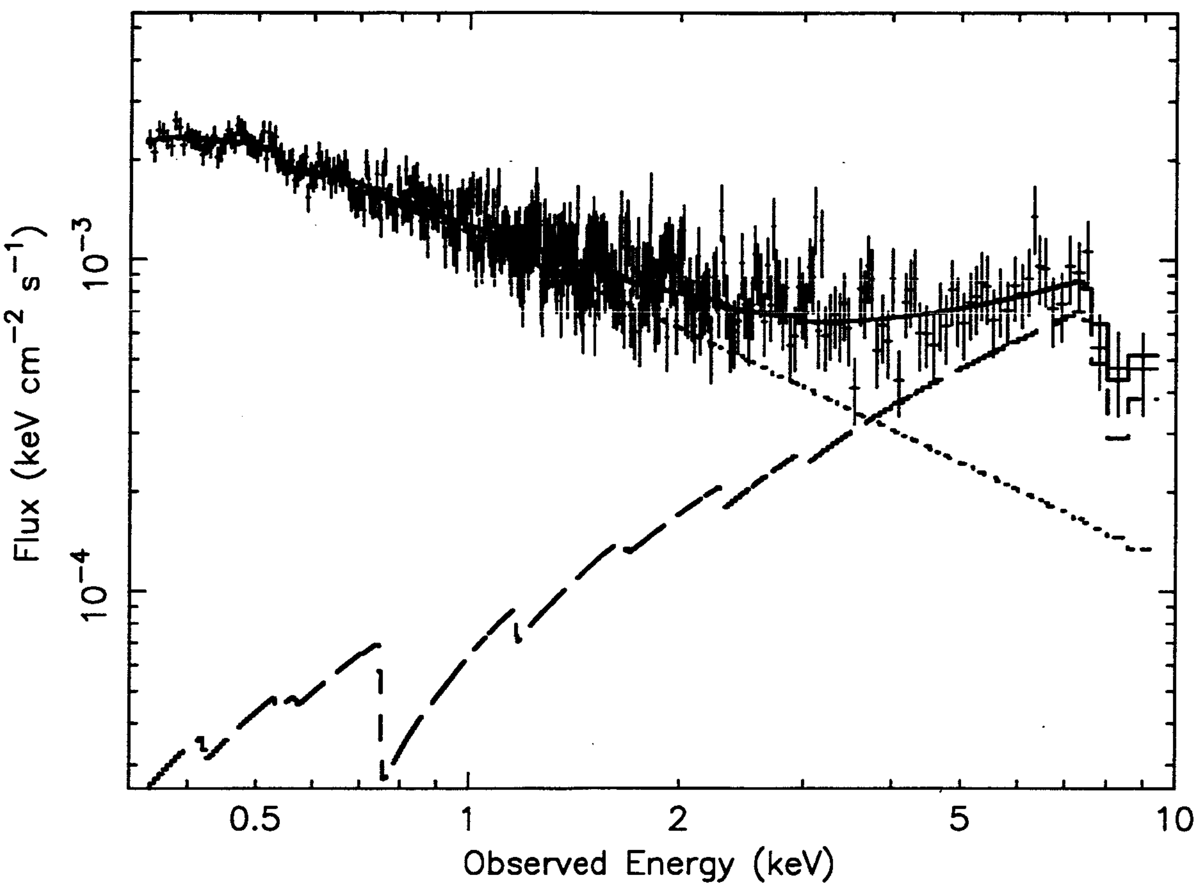

Fig. 4.— An ionized partial covering absorber model fit to the spectrum of PG 1402+261. The dotted line shows the unabsorbed soft X-ray power-law, whilst the dashed line shows the hard X-ray power-law, modified by the ionized absorber. A high column density of $> 3 \times 10^{23}$ cm^{-2} is required to model the deep absorption edge present in the spectrum of PG 1402+261 at 9 keV.

Table 1. Table of iron line spectral fits with relativistic line profiles. The underlying continuum is a broken power-law.

Fit	E^{a}	σ^{b}or q^{c}or θ^{d}	EW^{a}	χ^2/dof
GAUSSIAN	$7.3^{+0.4}_{-0.5}$	$1.2^{+0.6}_{-0.4}$	$2.0^{+1.3}_{-0.8}$	390.5/377
GAUSSIAN$^{(e)}$	$7.2^{+0.4}_{-0.6}$	$0.8^{+0.7}_{-0.4}$	$1.0^{+1.1}_{-0.5}$	404.2/361
LAOR	$8.5^{+0.3}_{-0.2}$	$3.3^{+0.6}_{-0.4}$ 30° (f)	$4.4^{+2.0}_{-1.7}$	389.6/377
LAOR	6.97 (f)	$2.3^{+0.6}_{-0.3}$ $67^{+5\circ}_{-4}$	$2.1^{+0.8}_{-0.7}$	388.2/377

[a]Rest frame energy of line in units of keV.

[b]Velocity width (σ) in units of keV.

[c]Emissivity power-law of the accretion disk.

[d]Inclination of the accretion disk in degrees.

[e]Fit performed with ASCA data

[f]Parameter value is fixed.