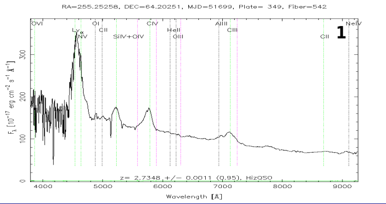
Relativistic outflow or absorption edge in the z=2.73 QSO HS 1700+6416?

G. Lanzuisi[1]; M. Giustini[1]; M. Cappi[1]; M. Dadina[1]; G. Malaguti[1]; C. Vignali[2]

[1] INAF/IASF-BO; [2] Università di Bologna

Abstract We present the detection of **broad absorption features** in the X-ray spectrum of the quasar HS 1700+6416, indicating either the presence of high velocity out-flowing gas or a huge absorption edge from Fe. HS 1700+6416 is a high-z (z=2.735), high luminosity quasar, classified as a Narrow Absorption Line (NAL) QSO. One broad absorption feature is clearly visible in the 50ks Chandra observation taken in 2000, while two similar features, at different energies, are visible when the 8 contiguous Chandra observations carried out in 2007 are merged together. The XMM-Newton observation taken in 2002, despite strong background flares, shows an hint of such a feature at lower energies.

HS 1700+6416 (z=2.735) is one of the most luminous quasar in the SDSS. It is classified as a NAL-QSO, showing narrow CII, CIV, SiIII and Si IV absorption lines in the SDSS spectrum (Fig. 1, from SDSS_DR3), blueshifted at mildly (~0.1c) relativistic velocities (Misawa et al. 2007).



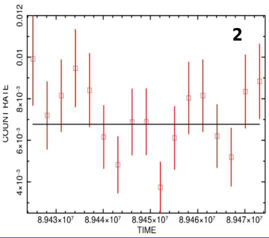
X-ray coverage

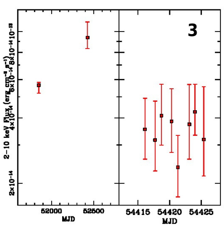
The source lies in the same field of 2 clusters (Abell 2246 z=0.225; V1701+6414, z =0.45) and a proto-cluster at z=2.3 (Digby-North et al 2010) and therefore have very good X-ray coverage available. In particular: One 50 ks Chandra observation in 2000; one 30 ks XMM observation in 2002 and 8 x 15-30 ks Chandra observations in 2007.

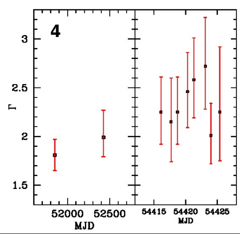
Short and long term X-ray variability

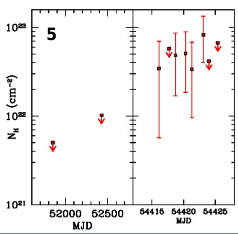
Given the exposure times, and the flux level of the source, the study of short term variability is feasible only for the long, 50 ks Chandra observation.

Fig. 2 shows the 0.5-8 keV light-curve of HS 1700+6416 with a bin size of 3 ks (at least 20 net counts per bin). When fitted with a constant, the resulting count rate is 6.8×10^{-3}. The source results to be **marginally variable on time scales of few ks** ($P(X^2/v)=0.25$). We also studied the long term variability of the continuum parameters (F(2-10), Γ and NH, fig 3,4,5). A **long term variability** is clearly detected in the 2-10 keV flux, that varies of a factor 3, from 9×10^{-14} to 3.5×10^{-14} erg s^{-1} cm^{-2}, and in the amount of neutral absorption, that is $<10^{22}$ cm^{-2} in 2000 and 2002 data, and become consistent with $4\text{-}8 \times 10^{22}$ cm^{-2} in 2007. For the photon index the error bars are too large to draw any firm conclusion. In the 8 observations of 2007, the source spectral parameters remain almost constant, thus we added together these spectra to increase the statistics.









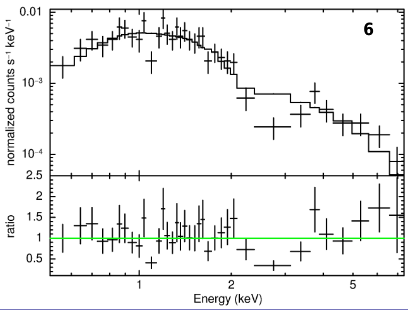
50 ks Chandra spectrum (2000)

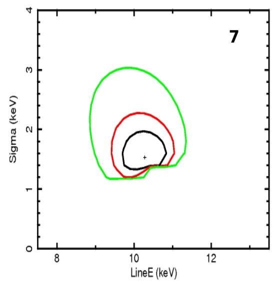
Fig. 6 shows the spectrum of HS1700+6416 obtained from the 50 ks Chandra observation. The counts are binned to a minimum significant detection of 3σ, for plotting purpose (we applied the Cash statistic). The fit to a simple absorbed power-law model shows significant residuals around ~**3 keV**, suggesting the presence of a strong absorption feature. When adding an absorption Gaussian line, the **ΔC-stat is 20.3 for 3 additional parameters**.

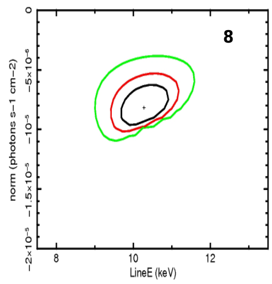
The significance is >4σ with F-test, confirmed with extensive Monte-Carlo simulations. The rest frame line energy is E_line=10.26±0.75 keV, the line width σ=1.6±0.5 keV and the equivalent width EW=-0.83 keV (rest frame). Fig 7, 8 show the 68, 90, 99% confidence contours of E_line vs. σ and E_line vs. Normalization, respectively. If the absorption feature is due Fe XXV or Fe XXVI Kα, the observed E_line translates in an outflowing velocity **v_out=0.38±0.10 c**. If modeled with the ionized absorber model XSTAR (Kallman & Bautista 2001), we have to add two ionized gas shells, with slightly different v_out, and both with high Nh and ξ (**Nh>4x10^{23} cm^{-2}, Logξ>3.3**) and turbulence velocity **v_turb=5000 km/s**, to reproduce the huge width of the feature.

If modeled with an absorption edge, the rest frame edge energy is **E_edge=8.95±0.30 keV** and the absorption depth is τ=1.85±0.83. E_edge is consistent with K shell ionization thresholds of Fe XVI-FeXXVI with 0 v_out (Hasinger et al. 2002).

For all the 3 models, the ΔC-stat is similar, i.e. the quality of the data do not allow to distinguish between the different scenarios.

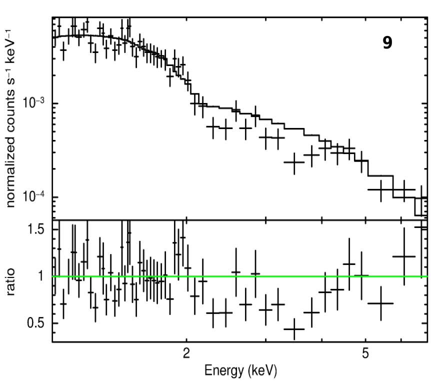


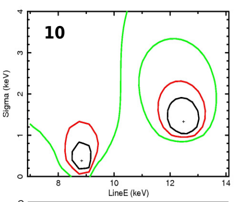


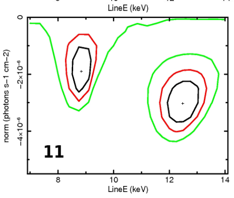


Merged Chandra Spectrum (2007)

The merged spectrum has ~1000 counts above 1 keV, and shows two features at ~2.2 and ~3.2 keV (fig. 9). The detection for two Gaussian lines, with EW1=-0.14 and EW2=-0.50 keV, and v_out 0.25±0.05c and 0.55±0.08c, has **significance of ~2σ and >3σ**, respectively. Fig 10, 11 show the confidence contours for the absorption lines parameters. From the XSTAR model results column densities **Nh=3-5x10^{23} cm^{-2}**, and high ionization parameters (**Logξ>3.2**) in both cases. In the edge model the two edges have E_edge1=8.14±0.52 and E_edge2=11.20±0.60 keV, the latter consistent with a **Fe XXVI edge with v_out of 0.18c**.



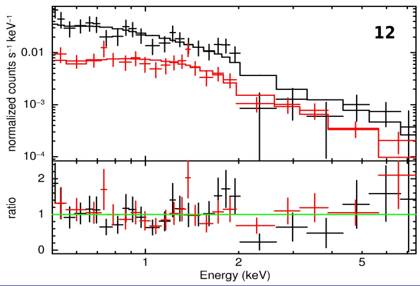




XMM spectrum (2002)

The 30 ks XMM observation of 2002 is affected by strong background flares. The resulting net exposure is only ~10 ks for pn and MOS cameras (~300 counts).

Despite the bad data Quality, an hint of the presence of an absorption feature around ~ 2 keV can be seen in the residuals (fig. 12). The **ΔC is 15.7** and the confidence level is **~2.5σ**. The E_line=8.05 ±0.30 KeV, implies **v_out~0.14c**.



Conclusions: We clearly detected 'at least' 2 strong absorption features, at variable energies, in different X-ray spectra of NAL QSO HS 1700+6416. They can be due to highly ionized (Logξ>3.2) nearly Compton thick gas with nearly-relativistic outflowing velocities (v_out = ~0.4-0.5c), or to absorption edges at energies consistent with mildly ionized Fe at lower velocities. The source may be one of the few known X-ray BAL QSO with nearly-relativistic v_out. The quality of present data do not allow to draw stronger conclusions, and a long look observation is needed to better constrain the absorption features, and check for variability of their properties on short time scales (few ks).

X-ray Universe, Berlin, 27-30 June 2011