



Long Term X-ray Spectral Variability of PDS 456 with Suzaku, XMM-Newton and NuSTAR



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PDS 456 is the most luminous ($L_{bol}=10^{47}$ ergs/s^[1]) radio quiet quasar in the local ($z=0.184$) universe, its high luminosity making it more reminiscent of $z=2-3$ at the peak of the quasar luminosity function, with a powerful outflow ($L_{kin}>0.05L_{edd}$ ^[2]). This work is focused on the broadband spectral variations in the Suzaku and XMM/NuStar campaigns.

Suzaku

There are currently 5 observations of PDS456 in the Suzaku archive between 2007 and 2013, during which we see a change in flux of a factor of 2.5 in the 2.0-10.0 keV band (High: 3.6×10^{-12} ergs/cm²/s, Low: 1.5×10^{-12} ergs/cm²/s), see Figure 1 for lightcurves. Most of this variability is seen in the soft (0.5-2 keV) band as is seen in Figure 3. Due to their low flux the 2011 and 2013 observations are not detected with the HXD

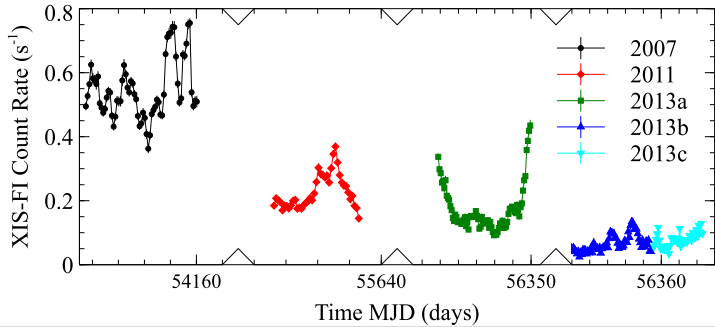


Fig.1: The Suzaku lightcurves in the 0.5-10keV of Front-Illuminated (FI) detectors (xis0 and xis3) for each of the 2007-2013 observations.

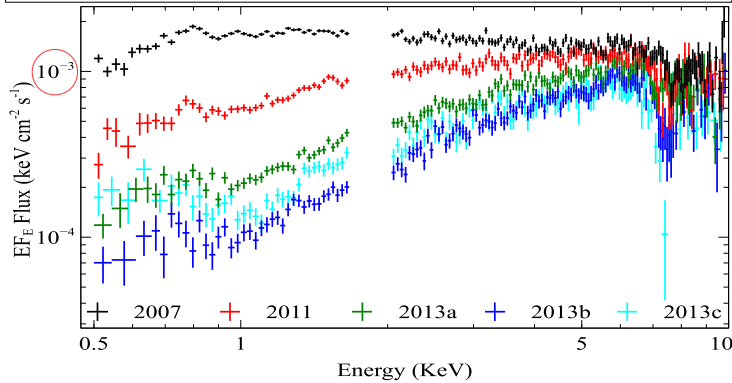


Fig.3: The Time averaged spectra of the FI Detectors onboard Suzaku, the spectra has been binned to the detectors HWHM. This shows the progression from a high(soft) state to a low (hard) state from 2007 to 2013, with little change in the hard band 5-10keV – excluding the blueshifted absorption feature of the wind.

XMM/NuSTAR

The XMM/NuStar campaign in August and September 2013, observed PDS 456 in a higher flux state than the Suzaku 2013 observations (taken in February and March), in these observations we see a change in flux of 2.4 between 2-10 keV (Obs1 6.6×10^{-12} ergs/cm²/s, Obs2 2.7×10^{-12} ergs/cm²/s), see Figure 1 for lightcurves. Unlike Suzaku the variability is not confined to the soft, much of the variability is in the hard band between Obs1 and Obs2 in Fig. 4.

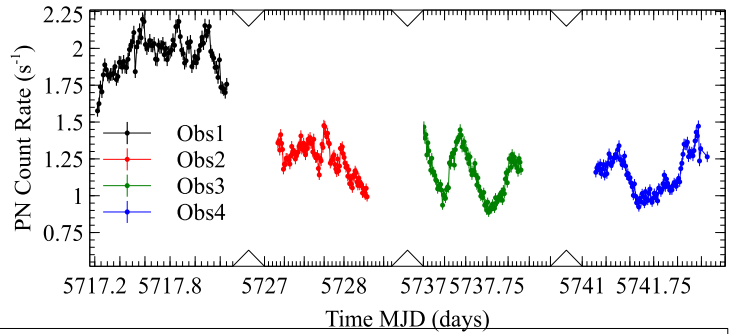


Fig.2: The XMM lightcurve of PN detector in the 0.5-10keV band for each of the 2013 observations.

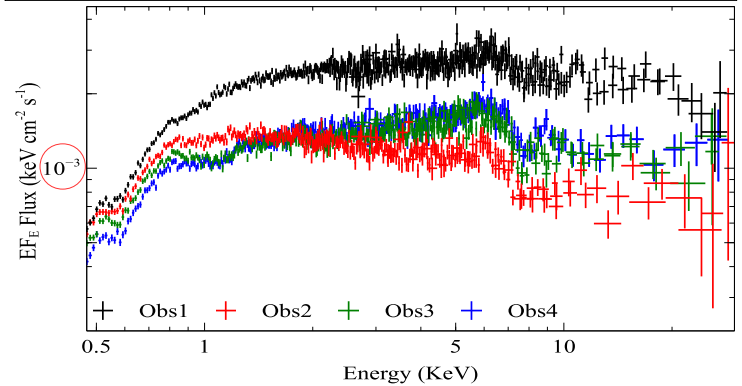


Fig.4: The spectra of XMM's PN detector and NuSTARs FPMA and FPMB for each of the observations.

Please note that Fig 3 and Fig 4 are on different flux scales.

What causes the spectral variability, Partial Covering changes or changes in Disk Reflector?

For the partial covering case:
• 2 layers neutral partial covering
• high column (low column)
• $N_H = 9.7 \times 10^{22} (8 \times 10^{21}) cm^{-2}$
2007 (2013b) observation covering fractions
• High column:
• $12^{+13}_{-7} (77^{+11}_{-7})\%$
• Low column:
• $< 10 (19 \pm 3.5)\%$

For Blurred Disk reflection (relxill^[3]) case:
2007 (2013b)
• Reflection Fraction:
• $1.05 \pm 0.05 (32.4^{+0.8}_{-0.6})$
• Log(ξ):
• $3.9 \pm 0.1 (< 0.1)$

Due to the large change in ionisation (Log(ξ)) between 2007 and 2013b, we rule out the reflection model, as this would require a factor of 10^4 decrease in the hard X-ray ionising luminosity, which is not observed for any of the spectra.

For the partial covering case:
• Single layer of ionised partial covering ($Log(\xi) = 2.9^{+0.03}_{-0.04}$,
 $N_H = 2.5^{+0.4}_{-0.25} \times 10^{23} cm^{-2}$)
• Obs1(Obs2)
• Covering fraction:
• $32.04^{+1.73}_{-4.95} (45.24^{+1.71}_{-6.79})$
• Photon Index
• $2.27^{+0.036}_{-0.027} (2.70^{+0.050}_{-0.055})$
• Chi2/dof
• 4443.38/4185

For Blurred Disk reflection (relxill^[3]) case:
Obs2(Obs4) observation
• Source Height:
• $< 3.6 (18.25^{+17}_{-8}) GM/c^2$
• Log(ξ):
• $3.34^{+0.04}_{-0.02} (3.33^{+0.05}_{-0.02})$
• Photon Index
• $2.32 \pm 0.01 (1.98 \pm 0.01)$
• Chi2/dof
• 4658.14/4185

For the reason to the right we conclude that during the Suzaku observations the transition from 2007 and 2013b is due to absorption changes.

While Blurred reflection has not yet been ruled out in the XMM/NuSTAR campaign the partial covering model is a better fit.

[1] Reeves, J. N., O'Brien P. T. & Ward, M. J. A massive X-ray outflow from the quasar PDS 456. *Astrophys. J.* 593, L65–L68 (2003).
[2] Gofford, J. et al. Revealing the location and structure of the accretion disk wind in PDS 456. *Astrophys. J.* 784, 77 (2014)
[3] Garcia, J. et al. Improved reflection models of black hole accretion disks: treating the angular distribution of X-rays. *Astrophys. J.* 782, 76 (2014)