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 (Log$_{10}L_{\text{bol}}=10^{47}$ erg/s) 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 ($L_{\text{kin}}>0.05L_{\text{edd}}$). 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: $3.6\times10^{-12}$ ergs/cm$^2$/s, Low: $1.5\times10^{-12}$ ergs/cm$^2$/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.

**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 $6.6\times10^{-12}$ ergs/cm$^2$/s, Obs2 $2.7\times10^{-12}$ ergs/cm$^2$/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.

**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\% (77\%)
    - Low column:
      - < 10 (19\%)

Due to the large change in ionisation (Log($E_i$)) 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 Blurred Disk reflection (relxill[3]) case:
- Single layer of ionised partial covering ($\log(E_i) = 2.5 \pm 0.05$)
  - $N_H = 2.5 \pm 0.25 \times 10^{23}$ cm$^{-2}$
  - Obs1(Obs2)
- Covering fraction:
  - 32\% (77\%)
- Photon Index:
  - 2.27 (2.07)
- Chi$^2$/dof:
  - 4443.3/4185

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

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

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.

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