The Long Term X-Ray Spectral Variability of NGC1365 with SWIFT

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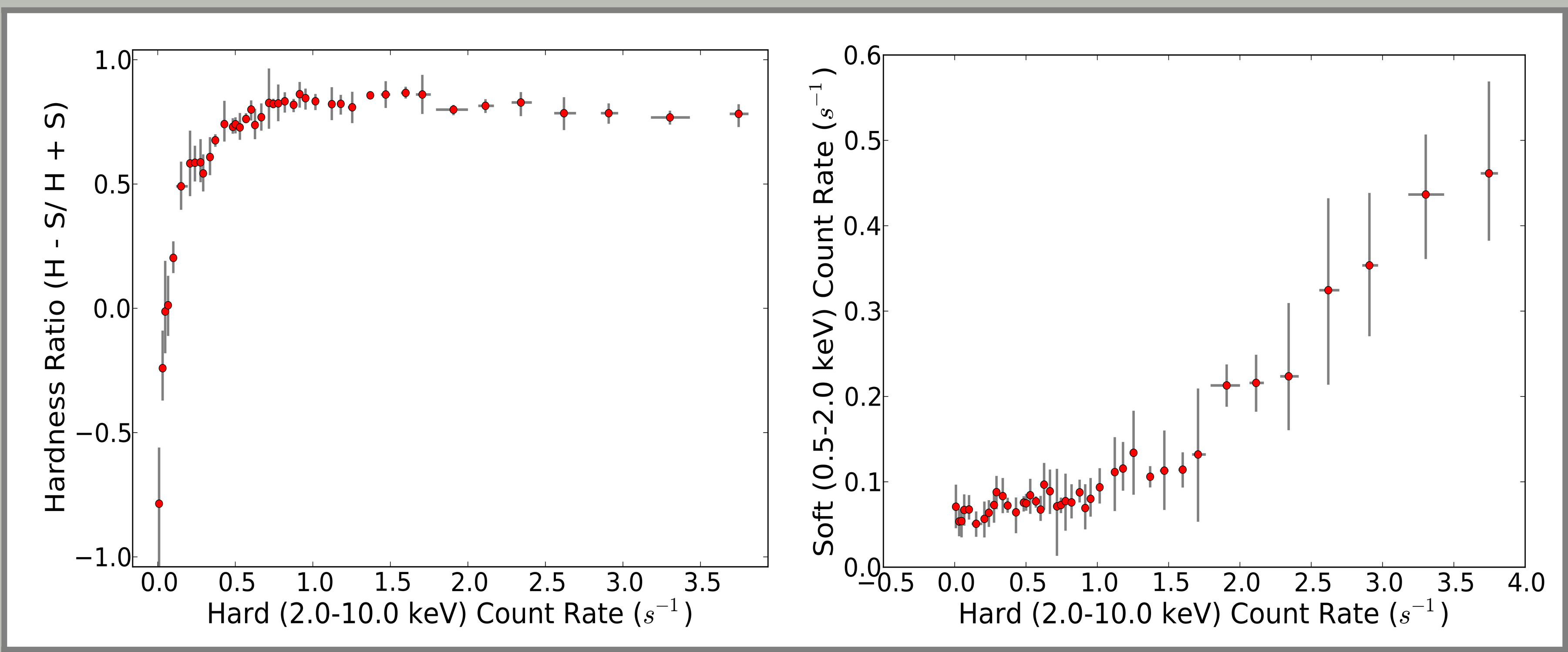
Abstract

We present long-term spectral variability in SWIFT data of the Seyfert galaxy NGC1365. The data cover both a large time period (six years) and a very wide flux range. The spectra have been fitted using a variety of models, in order to discover the nature of and reasons for the observed variation. It has been found that variation in the degree of absorption is the most likely cause of spectral changes. The primary cause of the variation in absorption is found to be most likely due to changes in the column density of the absorbing material; changes in the ionisation state of the absorbing material alone are found to be insufficient to account for the spectral changes observed. Furthermore, spectral fits seem to show that the degree of absorption decreases with increasing source flux, implying varying obscuration of the source.

1. Introduction

The Seyfert galaxy NGC1365 is known to be a highly variable X-ray source [1]. Previous observations have seen large changes in the column density of absorbing material, causing significant spectral variation on time scales of weeks to years [2]. In this work, we use six years of SWIFT data to study long term trends in the spectral variability of NGC1365 and to investigate the relationship between X-ray flux and the observed X-ray spectrum.

2. Spectral Hardness



Left: Hard flux (x) against hardness ratio (y). Right: Hard flux (x) against soft flux. (Data binned)

The hardness ratio shows the spectrum to be extremely soft at low fluxes. The small amount of scatter implies that the shape of the spectrum can be assumed to be similar at a given flux level independent of time. This allowed spectra observed at a similar flux, but in different epochs, to be combined; 52 spectra were binned according to the X-ray flux at the time of observation and combined, resulting in a set of spectra representing the spectral shape at each flux level.

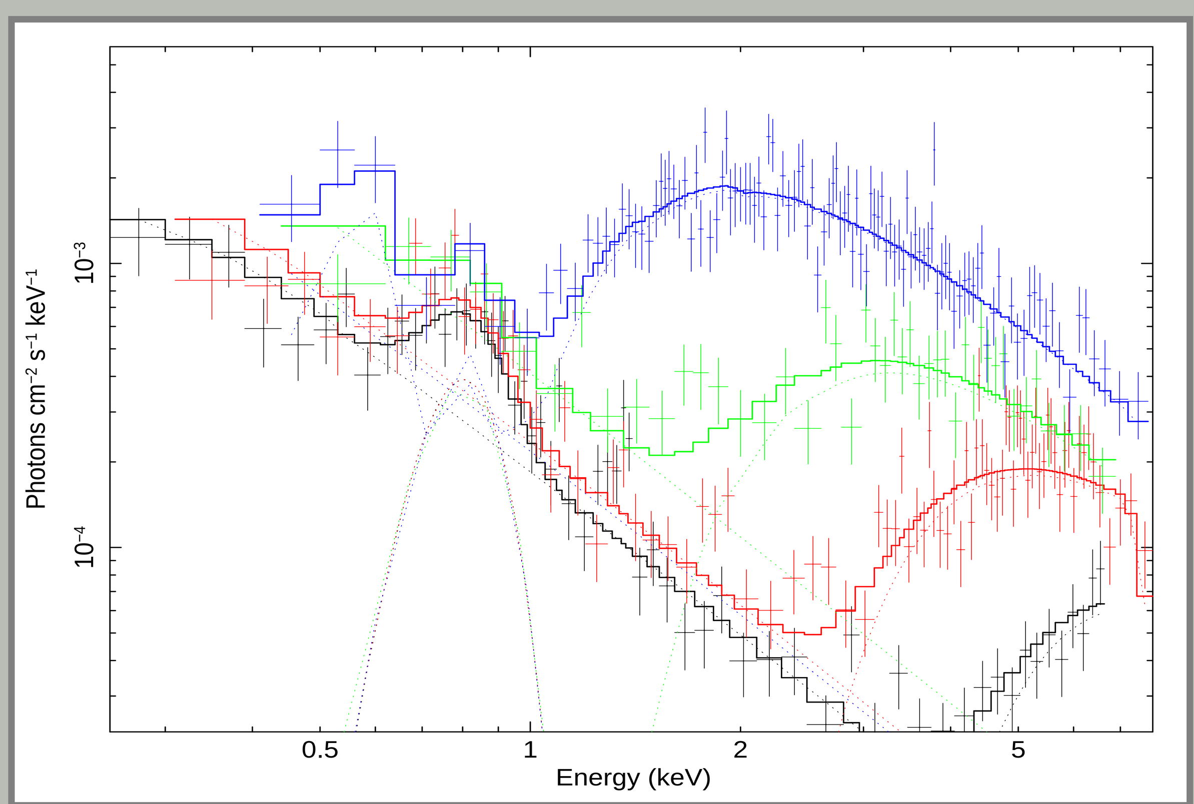
3. Spectral Modelling

Model	Parameters			χ^2_{Red}	DoF
	Fixed	Tied	Free		
Absorbed and unabsorbed power laws	spectral index	-	column density, ionisation	1.56	1077
Absorbed and unabsorbed power laws	spectral index	ionisation	column density	1.56	1087
Absorbed and unabsorbed power laws	spectral index	column density	ionisation	2.61	1087
Single, absorbed power law	-		column density, spectral index, ionisation	1.52	1077
Absorbed and unabsorbed power laws	-	column density	spectral index, ionisation	2.20	1077

χ^2_{Red} values and no. of degrees of freedom (DoF) of five models fitted to the average spectra.

Spectral fits show that the model which best describes the data consists of two power laws, one unabsorbed and one undergoing absorption with a varying column density. In each case, the spectral index was assumed to be constant, at the value found by Risaliti et. al (2013) [3].

4. Two-Component Spectral Variability

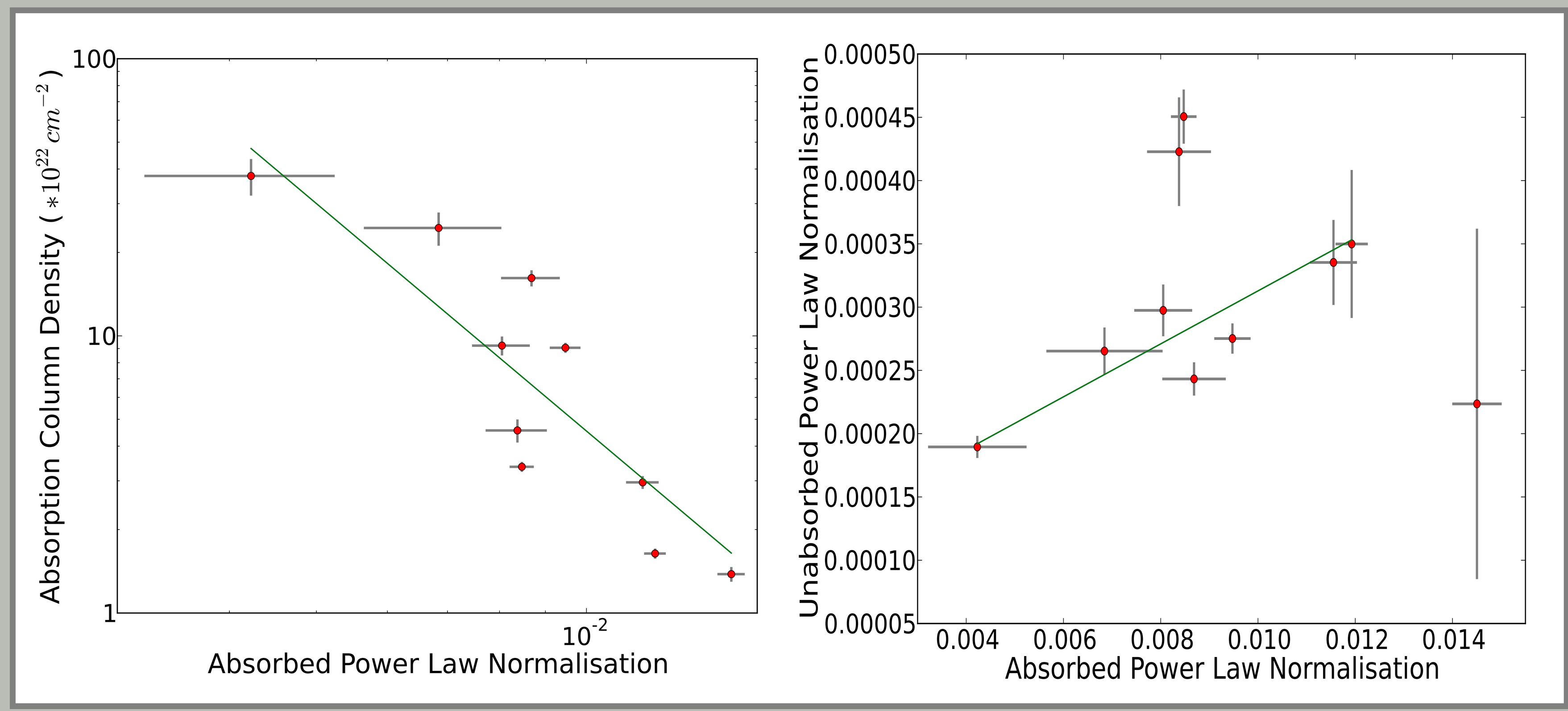


Sample of the average spectra produced by combining spectra in the same flux range.

Here we show plots from the best fitting model, described above. In this case, the spectrum is composed of a weakly varying unabsorbed component and a strongly varying absorbed component, whose absorption varies inversely with luminosity. The spectral variability observed cannot be accounted for by changes in ionisation, requiring a change in the amount of absorbing material between the observer and the X-ray source.

5. A Possible Link Between Source Flux and Column Density

The best-fitting model requires the normalisations of the power laws to vary; these are approximately correlated, as would be expected if the emission were from the same source. In this case, the two components could correspond to direct, absorbed emission and unabsorbed emission which is direct and/or scattered.

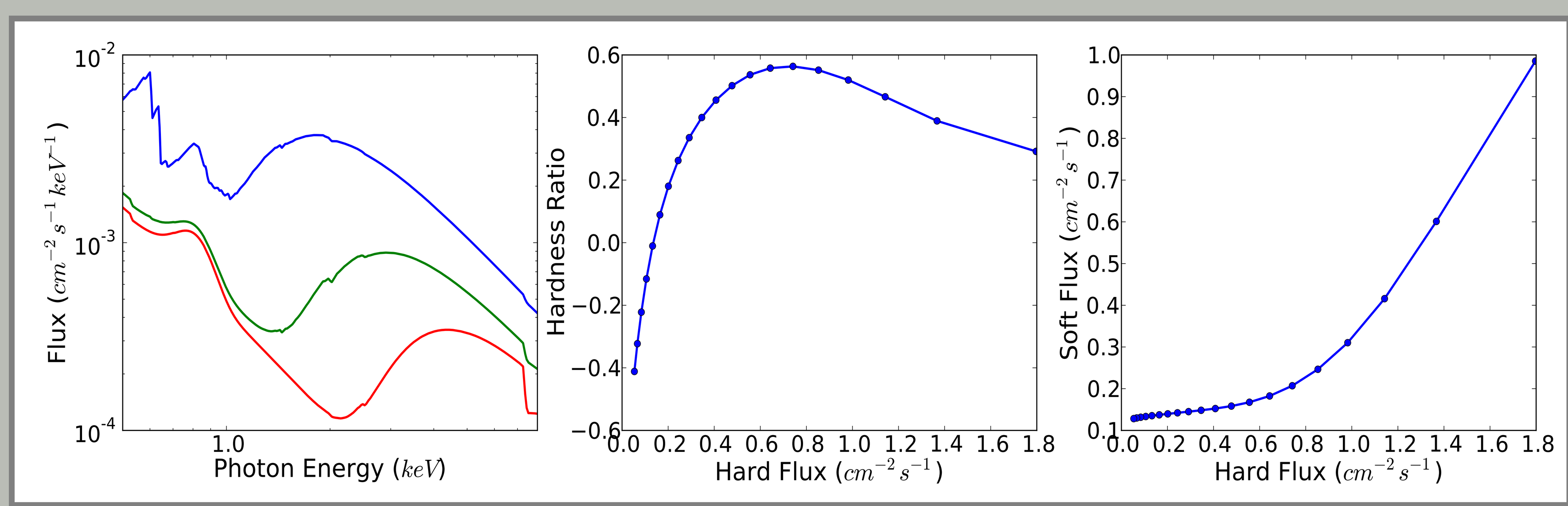


The normalisation parameter of the absorbed power law (x) against the column density of the absorbing material (y) in the model described above.

A possible link between the normalisation of the absorbed power law and the column density of the aborbing matter is revealed by plotting thise two paramaters, showing a decreasing column density with increasing source flux.

As models involving varying ionisation do not fit the data well, it seems that there is an actual change in the amount of material between the observer and the source. In the AGN wind model proposed by Elvis (2000) [4], absorbing material arises from a narrow range of disc radii. A higher accretion rate in this model leads to both a higher disk temperature and a greater X-ray luminosity, causing the wind to arise at larger radii. It is possible that this could lead to less obscuration of the X-ray source, giving a physical mechanism for the oberved decrease in column density with increased flux.

6. Modelling Hardness Variation with Flux



Top: A sample of many simulated spectra with a varying absorbing column density. Middle: The corresponding hard flux (x) against hardness (y) plot. Bottom: The corresponding hard flux (x) against soft flux (y) plot.

Artifical spectra, created using each model, show that the hardness ratios seen in the data can only be accurately reproduced by the model described above.

7. Conclusions

The SWIFT spectra of NGC1365 show large variation, the cause of which is found to be changes in the column density of absorbing material. Furthermore, the column density appears to decrease with increasing X-ray flux.

References: (1) Risaliti, G., Miniutti, G., Evlis, M., Fabbiano, G., Salvati, M., Baldi, A., Braito, V., Bianchi, S., Matt, G., Reeves, J., Soria, R., Zezas, A., 2009, ApJ,696,160. (2) Brenneman, L.W., Risaliti, G., Evlis, M., Nardini, E., 2013 MNRAS, 429, 2662. (3) Risaliti, G., Harrison, F.A., Madsen, K.K., Walton, D.J., Boggs, S.E., Christensen, F.E., Craig, W.W., Grefenstette, B.W., Hailey, C.J., Nardini, E., Stern, D., Zhang, W.W., 1013, Nature, 494, 449. (4) Elvis, M., 2000, ApJ, 545, 63.