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NGC 3516: SPECTRAL FEATURES AND THEIR RELATION WITH X-RAY VARIABILITY IN TIME

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RESUMEN

La galaxia NGC 3516, Seyfert 1.5, presenta una variabilidad de rayos X compleja temporalmente. Analizamos todos los espectros de 2006 de los telescopios XMM-Newton y Chandra en el intervalo 0.3–10 keV. Se encontró un modelo aceptable que consiste en la emisión del continuo variable, absorbida por 3 fases ionizadas –absorbedores tibios– con diferentes grados de ionización. Una de las fases absorbedoras está respondiendo a la variabilidad de la emisión del continuo. Presentamos nuestros resultados más importantes.

ABSTRACT

The 1.5 Seyfert galaxy, NGC 3516, presents a complex time variability in X-rays. We analysed the 2006 XMM-Newton and Chandra spectra in the band 0.3–10 keV. We found an acceptable fitting model which consists of a variable continuum emission absorbed by three ionized phases –warm absorbers– in outflow, with different ionization degrees. One of the absorption phases is responding to the continuum emission variability. We present our most oustanding results.

Key Words: galaxies: individual (NGC 3516) — galaxies: Seyfert

1. INTRODUCTION

NGC 3516 is a Seyfert 1.5 galaxy (at $z = 0.00886$; Keel 1996) which presents an extreme X-ray flux variability (Turner et al. 2008; Markowitz et al. 2008). The X-ray spectrum of NGC 3516 was fitted with a multicomponent model: The power law, the narrow fluorescence Iron emission line Kα and the absorption lines FeXXV and FeXXVI –Fe complex– the soft excess, several absorption features attributed to the presence of warm absorbers –WA– and some emission lines of distinct ion species.

In the literature the flux variability is explained in several ways. Markowitz et al. (2008) using Suzaku data presented a model with discrete cold clouds or filaments, located within few light years of the black hole, traversing the line of sight during the observation. Turner et al. (2008) proposed that only one parameter varied among the observation, the covering factor of one ionized absorber, they used medium resolution XMM-Newton and Chandra high resolution spectra. Instead, Mehdipour et al. (2010) found a continuum variation, but they did not find change in the cov. fac., neither opacity changes in the WA, the analysis was made with XMM-Newton high and low resolution data.

Here, we present an alternative model: The continuum emission is varying in time and one WA is responding to this change and no variation in the cov. fac. was found. We used high and medium resolution XMM-Newton spectra and high resolution Chandra spectra performed in 2006.

2. DATA REDUCTION

XMM-Newton: EPIC PN [0.3, 10 keV] and RGS [8, 38 Å: 0.33, 1.55 keV] spectra of medium and high resolution respectively were analyzed. All XMM-Newton data were processed using SAS software (v8.0.1). To filter high background events of PN spectra we used the method developed by Piconcelli et al. (2004). PN spectra were grouped to 20 counts per bin and RGS spectra in two channels per bin.

Chandra: HEG [1.57, 15 Å: 0.83, 7.9 keV] and MEG [2, 25 Å: 0.5, 2 keV], of high and medium resolution, data from HETGS grating (ACIS-S) were used in this analysis. We extracted the spectra with CIAO (Chandra Interactive Analysis of Observations) software (v. 3.4). The spectra were grouped in two channels per bin.

3. ANALYSIS RESULTS

We started the analysis with XMM-Newton observations using the PN and RGS detectors simultaneously. All spectra were analyzed with Sherpa package of the CIAO software.

Statistically, our best model consist of a continuum emission (power law + black body) absorbed by three different ionized phases. One of intemediate ionization degree –*phase 1*– (log $U \sim 0.3$),

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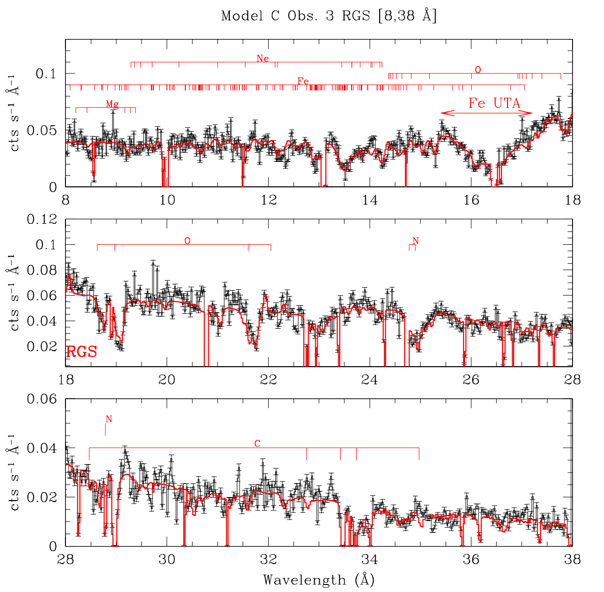

Fig. 1. Three-phase absorbed model (red) plotted over RGS spectum of the first XMM-Newton observation. Absorption transitions are marked in the top (red).

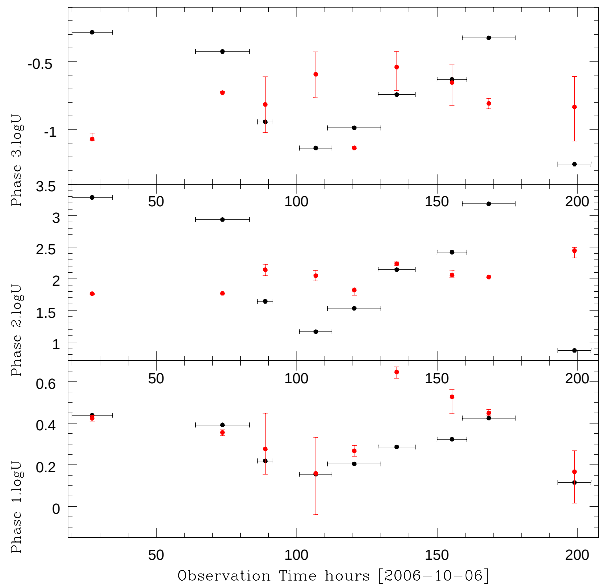

Fig. 2. Log of the ionization parameter of each phase as a function of time (red). For an easy comparison, the black points represent the flux [1, 7 keV] scaled.

the second with a low ionization degree –*phase 2*– ($\log\ U \sim -1$), and the last one –*phase 3*– of high ionization degree ($\log\ U \sim 1.7$). For all phases, the absorbing gas is in outflow but with velocities from 500 km s^{-1} to 2500 km s^{-1}. Also, our model contains the FeKα line, the Fe complex and nine emission lines in the soft X-ray band. Figure 1 shows the model fit and the RGS spectra in the first observation of XMM-Newton. We used the PHASE photoionization code of Krongold et al. (2003) to fit the WA. The ionization paremeter is defined as $U = \frac{Q}{4\pi R^2 n_e c}$, where Q is the ionizing photons luminosity in 0.013-100 keV range, R the distance between the black hole and the accretion disk system to WA location, n_e the electronic density and c the light speed. The model was successfully applied in the Chandra contemporary spectra. With this analysis we have the spectral components of nine observations performed in a time variability study of six days.

The flux variation can be explained by a variable continuum emission among the nine observations. We discovered that *phase 1* is responding to this continuum variation throught its ionization degree, as it can be saw in Figure 2, where the flux is scaled to compared its change with the ionization degree evolution.

Phase 1 response is very usefull to estimate the electronic density n_e and the distance R. We have two timescales to constrain these parameters, the first one is the photoionization equilibrium –PE– time, it can be estimated from Figure 2, the WA responds in PE during obs 2 to 4 –in chronological order– $t_{\mathrm{eq},1} = 126$ ksec. The second timescale occurs when the WA lost PE, among the obs 6 and 7 $t_{\mathrm{eq},2} = 72$ ksec. Using the relation between t_{eq} and n_e proposed by Nicastro et al. (1999), we estimated the electronic densities $n_{e,1} \sim 2.41 \times 10^6$ cm^{-3} and $n_{e,2} \sim 4.22 \times 10^6$ cm^{-3} for both timescales, therefore the WA distance is in the range 5.61×10^{15} cm to 1.04×10^{16} cm (2.2–4 light days).

We did a deeper analysis to study the spectra response to the continuum change with different flux states of XMM-Newton observations. This work will be presented in a forthcoming paper (Huerta, E. M., et al., 2011 in preparation).

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