EXTREME X-RAY VARIABILITY AND ABSORPTION IN NGC 1365

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ABSTRACT

We present multiple Chandra and XMM-Newton observations revealing extreme X-ray absorption properties in the Seyfert Galaxy NGC 1365. We observe changes from reflection-dominated ($N_H > 10^{24}$ cm^{-2}) to transmission - dominated ($N_H \sim 10^{23}$ cm^{-2}) states in time scales as short as three weeks; moreover, we clearly measure column density variations in the Compton thin states of $\sim 10^{23}$ cm^{-2} in time scales of $\sim 20,000$ sec.

Key words: Galaxies: X-rays.

1. INTRODUCTION

NGC 1365 (z=0.0055) is an optically type 1.8, X-ray absorbed, Seyfert Galaxy, which has shown in the past extreme variations of its spectral state: it was observed in a reflected-dominated state by ASCA in 1995 (Iyomoto et al. 1995), then in a Compton-thin state by BeppoSAX in 1998 (Risaliti et al. 2000).

Given the long time interval between the two observations, it was not possible to understand whether the variations were due to switching on and off of the central source, or to column density variations $\Delta(N_H) > 10^{24}$ cm^{-2} (Guainazzi et al. 2005).

In order to further investigate this issue, NGC 1365 has been the target *Chandra* and XMM-*Netwon* observational campaign during the years 2002-2004. The source was caught in a Compton-thick state by Chandra, then in a Compton-thin state by XMM-*Newton* three weeks later, and again in a Compton-thick state three more weeks later. This rapid variability implies the presence of a clumpy absorber on a smaller scale (of the order of that of the Broad Line Region or slightly larger) than usually assumed for the circumnuclear torus (a few parsecs). These results are discussed in detail in Risaliti et al. 2005a. These three observations are all relatively short (~ 10 ksec), therefore a variability analysis of the single observations is not possible. Two, longer (~ 60 ksec) XMM observations were obtained in 2004, allowing an analysis of the intra-day variability. Here we summarize the results regarding the variability studies. Another interesting result obtained from these two observations is the detection of four strong absorption lines in the 6.7-8.3 keV spectral range, identified as FeXXV and FeXXVI $K\alpha$ and $K\beta$. These lines imply the presence of a highly ionized, compact absorber with a column density of several 10^{23} cm^{-2}, and are discussed in Risaliti et al. 2005b.

2. ANALYSIS OF THE ABSORPTION VARIABILITY

In order to search for column density variations within the single observations, we performed a two-steps analysis. We first calculated a hardness-ratio (HR) light curve, which is sensitive to variations in spectral shape. A non-constant HR light curve can be due to several different phenomena: column density variations, changes in the continuum slope, flux variability of a spectral component in a multi-component spectrum. As a second step, a complete spectral analysis of the single HR states is needed in order to distinguish between these cases. We show in Fig. 1 the HR light curve for the first of our two long XMM observations. Three different spectral states are clearly present. We extracted the spectrum from each of these three intervals, and performed three fits to a multi-component model, consisting of an absorbed power law, a cold reflection component, an iron emission line, and a soft thermal component. In each fit all the parameters were left free, therefore any of the above-mentioned variation mechanisms could be investigated. We obtained a good fit for all the single spectra, with all the parameters compatible with a constant value, except for the column density, which was found to vary with a significance higher than 99% (Fig. 2).

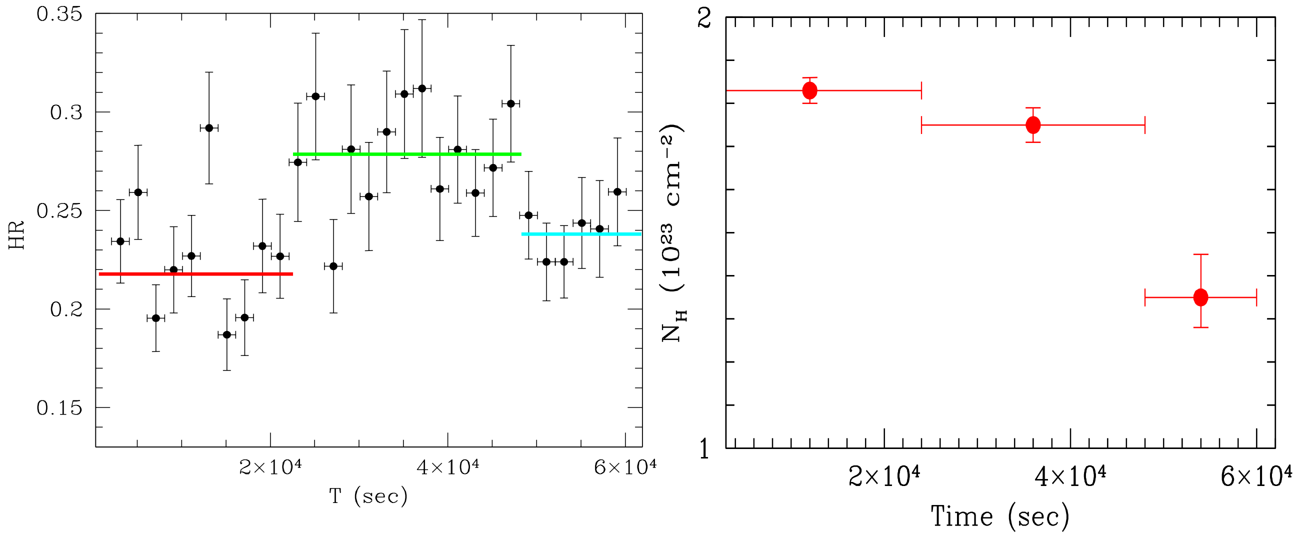

Figure 1. Left panel: hardness ratio light curve for a 60 ksec XMM observation of NGC 1365. The three intervals labeled with the three horizontal lines have been separately analyzed. The best fit column density values for the three spectra are shown in the right panel.

Our results put strong constraints on the location of the X-ray absorber. Assuming that the absorption is due to clouds moving with Keplerian velocity, $v_K = \sqrt{GM_{BH}/R}$, we can derive a relation between the cloud density ρ and its distance R from the central source simply identifying the linear dimension of the cloud, $D = N_H/\rho$, with the distance covered by the cloud in the typical variation time scale, $\Delta(T)$. The limits put by our observations are shown in Fig. 2. A parsec scale torus is completely ruled out, unless unphysically high densities ($\rho > 10^{12}$ cm^{-3}) are allowed.

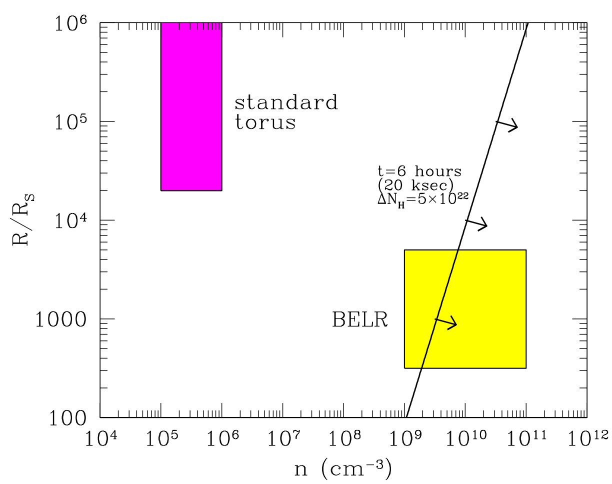

Figure 2. Distance of the absorber from the central source versus its density. Our observations exclude a parsec-scale torus, and suggest that the absorber is located at the Broad Line Region scale.

This result is in agreement with the studies performed by our group on other bright Seyfert Galaxies, such as NGC 4151 (Puccetti et al. 2004) and NGC 4388 (Elvis et al. 2004) and suggests that the X-ray absorber is located as close to the center as the Broad Line Region.

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