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AN XMM-NEWTON OBSERVATION OF THE BRIGHT SEYFERT 2 GALAXY NGC 6300

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RESUMEN

Presentamos resultados preliminares de la observación con *XMM-Newton* de la galaxia brillante, cercana (18 Mpc), tipo Seyfert 2 NGC 6300. Observamos emisión difusa de rayos X suaves (0.1–2 keV) extendida sobre una escala de $\sim$ 2 arcmin, correspondiente a la escala de la galaxia anular huésped. Se encuentran 2 fuentes de rayos X suaves a menos de 80 arcsec del núcleo. Podrían ser fuentes de rayos X compactas ultraluminosas, similares a las descubiertas en otras galaxias cercanas. El mas débil de los dos objetos corresponde a una fuente de emisión UV que se observa con el monitor óptico de *XMM-Newton*. Coincide con una fuente azul compacta en una imagen en la banda B del *HST*. Si está asociada con la galaxia, su rango de luminosidad de 0.2–10 keV es $0.7\text{–}1.2\times10^{39}\,\mathrm{erg\,s^{-1}}$. El espectro en rayos X del núcleo activo es típico de una galaxia Seyfert 2 delgada en Compton. Consiste de una componente dura fuertemente absorbida y variable que domina la banda de 3–10 keV, y una componente suave que domina la banda de 0.17–2 keV band. En la banda dura el espectro se ajusta bien por una ley de potencias ($\Gamma_{hard} \simeq 1.8$) visto a traves de un medio delgado en Compton ($N_H \simeq 2.1 \times 10^{23}\,\mathrm{cm^{-2}}$). Confirmamos la presencia de una línea de fluorescencia de hierro neutro, $K\alpha$, con un centroide a $E_{Fe} = 6.41$ keV y un ancho equivalente de $EW_{Fe} \simeq 148$ eV. La energía de la línea de hierro está marginalmente resuelta. El flujo observado en la banda de 2–10 keV es $F \simeq 9 \times 10^{-12}\,\mathrm{ergs\,cm^{-2}\,s^{-1}}$. El espectro en la banda suave se ajusta bien por una ley de potencias ($\Gamma_{soft} \simeq 1.7$) atenuada únicamente por el gas de nuestra galaxia.

ABSTRACT

We present preliminary results from an *XMM-Newton* observation of the bright, nearby (18 Mpc) Seyfert 2 galaxy NGC 6300. We observe diffuse soft (0.1–2 keV) X-ray emission extended on a scale of $\sim$ 2 arcmin, corresponding to the scale of the host ring galaxy. Two soft X-ray sources within 80 arcseconds of the nucleus were found. They may be ultraluminous compact X-ray sources, similar to those discovered in other nearby galaxies. The fainter of the two objects corresponds to a source of UV emission observed by the *XMM-Newton* optical monitor. It also matches a blue compact source in a B band image from the *HST*. If associated with the galaxy, its 0.2–10 keV luminosity range is $0.7\text{–}1.2\times10^{39}\,\mathrm{erg\,s^{-1}}$. The X-ray spectrum of the active nucleus is a rather typical one for a Compton-thin Seyfert 2 galaxy. It consists of a heavily absorbed, strongly-variable hard component dominating the 3–10 keV band, and a soft component dominating the 0.17–2 keV band. In the hard band, the spectrum is well fitted by a power-law model ($\Gamma_{hard} \simeq 1.8$) seen through a Compton-thin ($N_H \simeq 2.1 \times 10^{23}\,\mathrm{cm^{-2}}$) absorber. We confirm the presence of a $K\alpha$ fluorescence neutral iron line with a centroid at $E_{Fe} = 6.41$ keV and an equivalent width $EW_{Fe} \simeq 148$ eV. The iron line energy may be marginally resolved. The observed flux in the 2–10 keV band is $F \simeq 9 \times 10^{-12}\,\mathrm{ergs\,cm^{-2}\,s^{-1}}$. The spectrum in the soft band is well fitted by a power-law ($\Gamma_{soft} \simeq 1.7$), attenuated only by the gas in our Galaxy.

Key Words: **GALAXIES: INDIVIDUAL (NGC 6300) — GALAXIES: SEYFERT — X-RAYS: GALAXIES**

1. INTRODUCTION

NGC 6300 is a nearby (18 Mpc, z=0.0037), ringed, barred, spiral galaxy, identified as bright Sy 2. It was first detected in hard X-rays in 1991 during a *Ginga* maneuver (Awaki 1991). It has been observed in the 3–24 keV band by *RXTE* in

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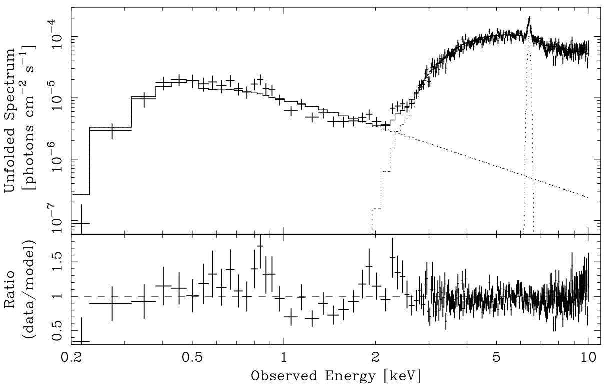

Fig. 1. TOP: Unfolded photon spectrum from the PN with the model and its components superimposed. BOTTOM: Ratio of the data to the model.

1997 and in the 0.5–200 keV band by *BeppoSAX* in 1999. *RXTE* measured a flat continuum spectrum ($\Gamma \simeq 0.68$) with a superimposed $K\alpha$ neutral iron emission line of huge equivalent width ($EW_{Fe} \simeq 920$ eV). These spectral properties reveal the presence of a Compton thick absorber surrounding the nucleus (Leighly et al. 1999). Two and a half years later, *BeppoSAX* detected a spectrum brighter in the whole 3–20 keV band, seen through a Compton thin absorber ($N_H \simeq 3 \times 10^{23}\,\mathrm{cm}^{-2}$), but with an iron line of same intensity as the *RXTE* line (Guainazzi et al. 2002). The spectral differences between the two observations are most likely associated with the transient behavior of the Seyfert nucleus, which was probably caught in a high activity stage during the *BeppoSAX* observation. We present preliminary spectral, imaging, and timing results of the 2001 *XMM-Newton* observation of NGC 6300.

2. NGC 6300 NUCLEUS

In order to avoid contamination from the two serendipitous sources within 80″ from the nucleus of NGC 6300, and supress contamination from diffuse emission, PN, MOS1, and MOS2 spectra in the 0.2–10 keV band were extracted from circular regions of 16″ in radius. Background spectra for each detector were extracted from source-free circular regions of 120″ in radius. The spectra were modeled between 0.2 and 10 keV with a soft X-ray power-law attenuated only by gas in our Galaxy, plus a hard X-ray power-law seen through a Compton-thin absorber, with a superimposed iron emission line. Figure 1 shows the PN spectrum and the data-to-model ratio. The results from the simultaneous spectral fitting are summarized in Table 1. The fit is statistically acceptable. Weak excess emission near 0.9 keV may be Fe L emission lines or O VIII recombination edge, and weak emission near 2 keV may be Si and S K features. The observed flux is intermediate between that obtained by *RXTE* (Leighly et al. 1999) and that obtained by *BeppoSAX* (Guainazzi et al. 2002). The next step in the spectral analysis involves modeling the hard X-ray band with a power-law reflected from neutral material. NGC 6300 showed rapid, rather high amplitude variability during the *XMM-Newton* observation (Figure 2). Spectral variability was also observed. This is demonstrated by plotting the variance of light curves compiled from PN and MOS data such that the number of photons is the same in each light curve. Around 2 keV, the variance is low, because the variability of the absorbed hard X-ray component is diluted by the non-variable soft emission. Larger continuum variance around 4 keV may imply that the intrinsic spectrum is softer when it is brighter. The variability drops around 6.4 keV, indicating a non-variable iron line, probably originating from an extended emission region.

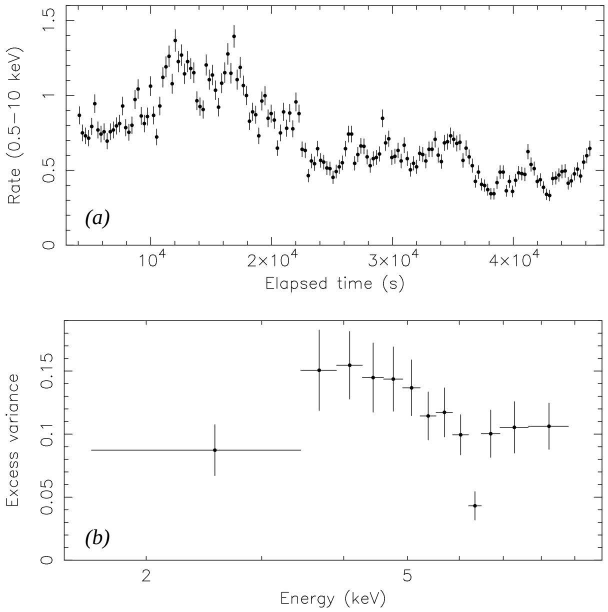

Fig. 2. TOP: Light curve accumulated between 0.5 and 10 keV from MOS and PN detectors. BOTTOM: Variance as a function of energy for light curves constructed to have equal number of photons in each. Significant spectral variability is observed; noteworthy is the significant decrease in variance at the position of the iron line.

3. ULTRALUMINOUS X-RAY SOURCE

Simultaneous near-UV and X-ray images were made with the *XMM-Newton* optical monitor and EPIC MOS1+MOS2, respectively (Figures 3a and

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TABLE 1

SPECTRAL FITTING RESULTS.

Parameter	Value
Γ_{soft}	1.70 ± 0.14
Γ_{hard}	1.76 ± 0.07
N_H ($10^{23}\,\mathrm{cm}^{-2}$)	2.12 ± 0.7
Iron line energy (E_{Fe}; keV)	6.41 ± 0.01
Iron line width (σ_{Fe}; keV)	0.06 ± 0.02
Iron line flux (F_{Fe}; $10^{-5}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$)	2.35 ± 0.3
Iron line eq. width (EW_{Fe}; eV)	152 ± 19
$F_{2-10\mathrm{keV,\,obs.}}$ ($10^{-12}\,\mathrm{erg\,cm}^{-2}\,\mathrm{s}^{-1}$)	8.9
$L_{2-10\mathrm{keV,\,intr.}}$ ($10^{42}\,\mathrm{erg\,s}^{-1}$)	1.3
χ^2/d.o.f.	741/660

b). The X-ray image shows two point sources within $\sim 1'$ of the nucleus. One is coincident with a UV source on the galaxy ring. It also matches a blue compact source found in a B-band *HST* WFPC2 image that is apparently a young star cluster (Figure 3). The other source does not lie on the ring, has no optical/UV counterpart, and may be a background AGN. We have done some preliminary X-ray analysis of the first source. Due to the uncertainty in the background, we attempt to bracket the parameters of the spectrum by extracting background spectra from several regions equidistant from the AGN. Reasonable fits were obtained by using a disk blackbody model with Galactic absorption. The background regions nearest the source yield a temperature for the inner edge in the range of $0.8-1.6$ keV and a $0.2-10$ keV luminosity range of $0.7-1.2\times10^{39}$ ergs^{-1}, making it an ultraluminous X-ray source (ULX) such as has been found in other nearby galaxies (Makishima et al. 2000). Due to the small number of photons, we were unable to detect variability from it. Diffuse X-ray emission, which seems to follow the ring with hints of weak sources, is also observed. This emission is reduced over the portion of the galaxy that appears to have prominent dust lanes. Bright UV sources $\sim 20''$ from the nucleus are foreground stars. In progress are quantitative analysis of the UV and optical images, as well as the infrared images from 2MASS and archived radio data from the ATCA.

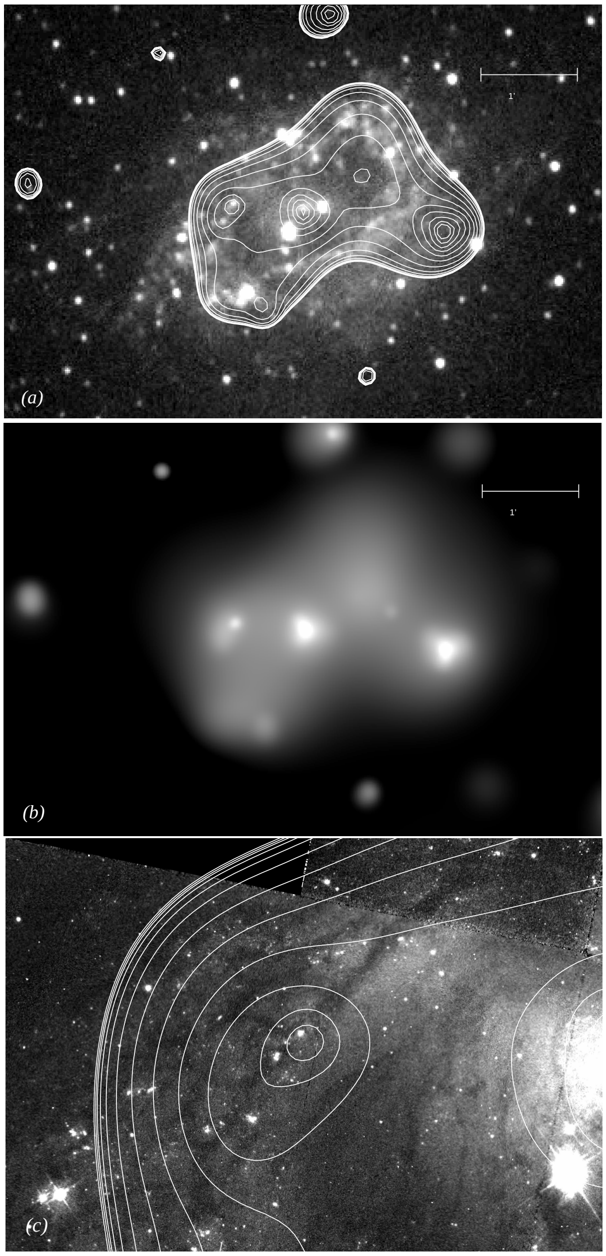

Fig. 3. (a) Near-UV image with overlayed soft (0.1–2 keV) X-ray contours. (b) Smoothed soft X-ray image. (c) Zoom of *HST* B-band image with overlayed soft (1–2 keV) contours.

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