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THE X-RAY VIEW OF THE IONIZATION CONE IN NGC 5252

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RESUMEN

Presentamos los resultados de las observaciones realizadas con *Chandra* en rayos-X suaves del espectacular cono de ionización de la galaxia cercana Seyfert-2 NGC5252. Como se observa invariablemente en los AGN oscurecidos, la emisión de rayos-X suaves exhibe una marcada coincidencia en morfología con el cono de gas ionizado trazado por el HST en las imágenes de O[III]. Imágenes resueltas en energía y espectroscopía de alta resolución sugieren que el gas emitido en rayos-X es fotoionizado por el AGN, al menos en escalas tan grandes como las del gas más interno y el anillo estelar ($\leq$3 kpc). Suponiendo que el cono en su totalidad es fotoionizado por el AGN, nosotros reconstruimos los últimos $\sim$$10^5$ años de la historia del núcleo activo.

ABSTRACT

We present the results of a *Chandra* soft X-ray observation of the spectacular ionization cone in the nearby Seyfert 2 galaxy NGC 5252. As almost invariably observed in obscured AGN, the soft X-ray emission exhibits a remarkable morphological coincidence with the ionized gas cone as traced by HST O[III] images. Energy-resolved images and high-resolution spectroscopy suggest that the X-ray emitting gas is photoionized by the AGN, at least on scales as large as the innermost gas and stellar ring ($\leq$3 kpc). Assuming that the whole cone is photoionized by the AGN, we reconstruct the history of the active nucleus in the last $\sim$$10^5$ years.

Key Words: galaxies: active — galaxies: individual (NGC 5252) — galaxies: nuclei — galaxies: Seyfert — X-rays: galaxies

1. INTRODUCTION

The Seyfert 2 galaxy NGC 5252 hosts one of the most spectacular ionization cones ever observed in an Active Galactic Nucleus (AGN). Line emission exhibits a bi-conical morphology (Tadhunter & Tsvetanov 1989) extending out to $\simeq$20 kpc either side of the active nucleus. Optical studies have suggested that O[III] emission is due to photoionization by the active nucleus. On smaller scales ($\simeq$3 kpc) a gas disk (Tsvetanov et al. 1996) is probably due to the combination of three dynamical components: an inclined ($\simeq$40°) stellar disk, and two gas disks associated with it and rotating in opposite directions. It has been suggested that the gas of this inner structure is also photoionized by the AGN (Morse et al. 1998).

Recent *Chandra* high-resolution observations have revealed at large scales (hundreds of parsecs to kilo-parsecs) soft X-ray emission in almost all nearby obscured AGN with Extended Narrow Line Regions (ELNRs) where this measurement is technically possible (Bianchi et al. 2006). Soft X-rays show a remarkable morphological coincidence with high-resolution O[III] HST images. High-resolution spectra taken with the Reflection Grating Spectrometer on-board XMM-Newton confirm that the soft X-rays carry the unmistakable signatures of photoionized gas: "narrow" ($\delta E \simeq 1$–10 eV) Radiative Recombination Continua, and large ratios between the forbidden component of the He-like Hα triplets and the H-like Lyα (Sako et al. 2000; Sambruna et al. 2001; Kinkhabwala et al. 2002; Guainazzi & Bianchi 2007). The large intensity of higher-order transitions with respect to the K_α are indicative of an important role played by resonant scattering.

In this paper, we briefly discuss the soft X-ray properties of NGC 5252. At its distance (92 Mpc) the spatial scale is: $1'' = 450$ pc.

The soft X-ray (0.2-1 keV) *Chandra*/ACIS emission in NGC 5252 is extended on scales as large as $\simeq$11 kpc (Figure 1).

The hard X-ray (1–10 kpc) image is instead unresolved. There is a good morphological coincidence between the X-rays and the optical (O[III]) emission, taking into account the different spatial resolutions. The agreement extends also to the diffuse soft X-ray emission overlapping with the smaller scale ($\simeq$3 kpc) stellar and gaseous disks. On this small scale X-rays are mostly due to He-like and H-like Oxygen recom-

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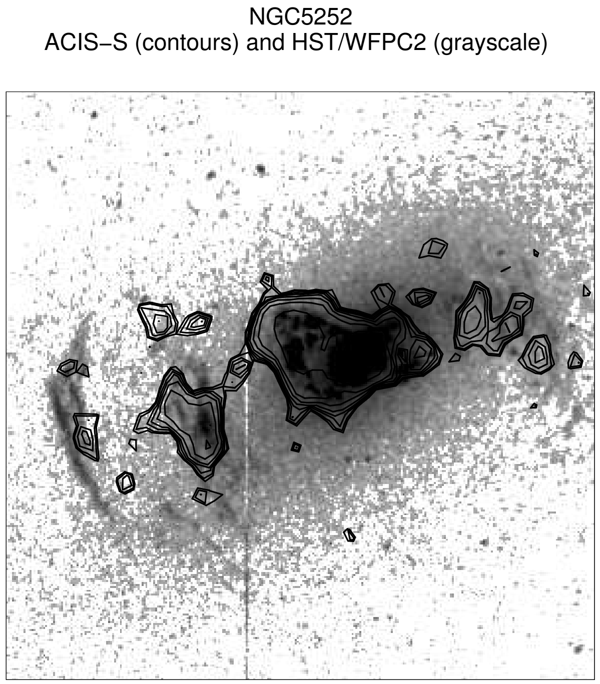

Fig. 1. O[III] HST/WFC2 (*greyscale*) and 0.2–1 keV Chandra/ACIS (*smoothed contours*) images of NGC 5252. The image is 35″ aside.

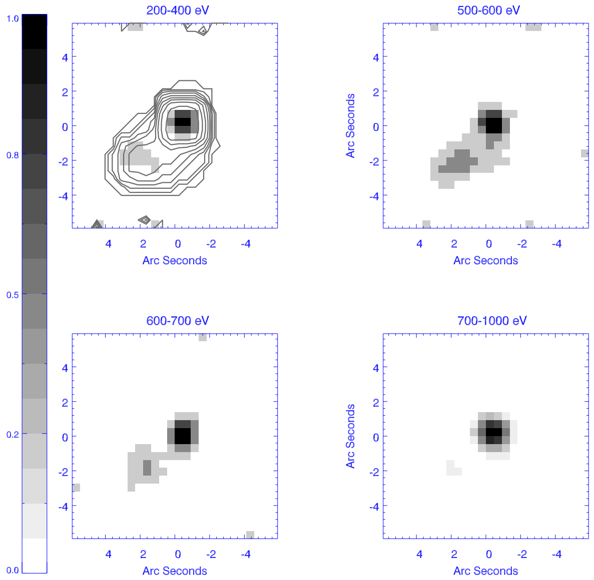

Fig. 2. Energy resolved *Chandra*/ACIS images of NGC 5252. The coordinate reference system is centered on the position of the X-ray active nucleus (Cappi et al. 1996).

bination transitions, with a smaller contribution by CVI and by the Fe-L complex (Figure 2).

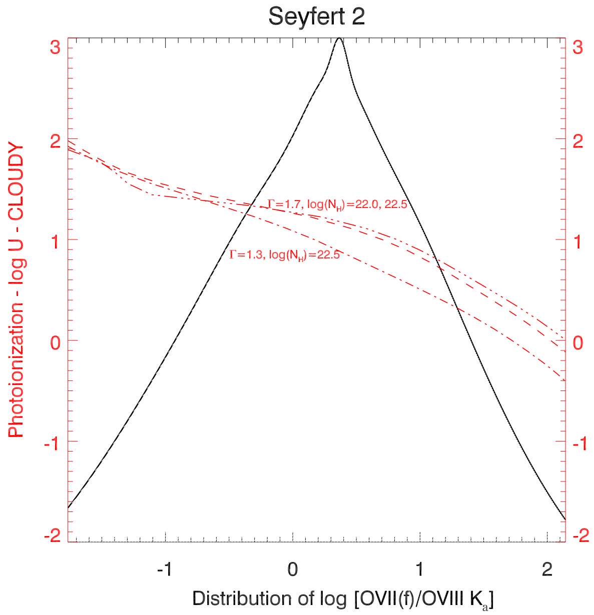

Fig. 3. *Solid line*: Distribution of the observed values of the flux logarithmic ratio between the OVII Heα forbidden component and the OVIII Lyα; *dashed and dotted lines*: CLOUDY predictions as a function of the ionization parameter U (y-axis) for different values of the gas column density and ionizing continuum X-ray photon index Γ.

The measured flux ratio between the counts in the OVII and OVIII bands, once corrected for the energy dependence of the ACIS effective area (2.3 ± 0.4), is typical of AGN-photoionized sources (Guainazzi & Bianchi 2007). This correspond to ionization parameters $\log(U) \sim 1$ [4] (see Figure 3).

In Figure 4 we show the O[III] to soft X-ray flux ratio as a function of the radius along the ionization cone. The ratio is calculated at the position of optically bright knots and filaments along the cone. On the same plot, we compare the predictions of simple, homogeneous and time-independent photoionization models, following the method described in Bianchi et al. (2006). An almost constant ionization parameter along the cone is required, implying a radial decrease of the electronic density as: $n(r) \propto r^{-(1.8-2.0)}$. Similar trends had been observed in other obscured AGN with ENLRs (Bianchi et al. 2006). Such a decrease is steeper than required by optical diagnostics of space resolved NLRs (Bennert et al. 2006), and may suggest that a local photoionizing source contribute to

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[4] U is defined as $\Phi(H)/n(H)c$, where $\Phi(H)$ is the surface flux of ionizing photons, and $n(H)$ is the total hydrogen density.

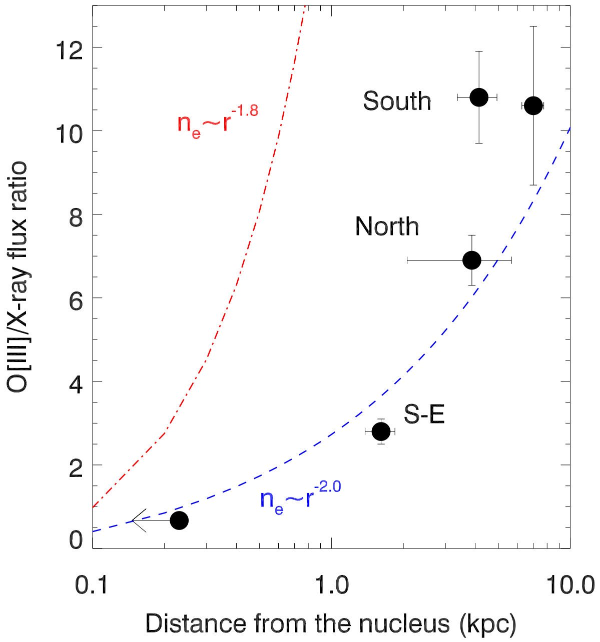

Fig. 4. O[III] to soft X-ray flux ratio along the ionization cone (the x-axis is the distance from the optical position of the active nucleus). The lines represent the predictions of a CLOUDY-based (Ferland et al. 1998) model in thermal and ionization equilibrium, where the AGN is responsible for photoionizing the cone gas. The AGN Spectral Energy Distribution has: $\alpha_{ox} = -1.4$, $\alpha_U V = -0.50$, and $\alpha_X = 2.0$. An X-ray to bolometric luminosity correction of 1/0.03 is assumed (Elvis et al. 1994).

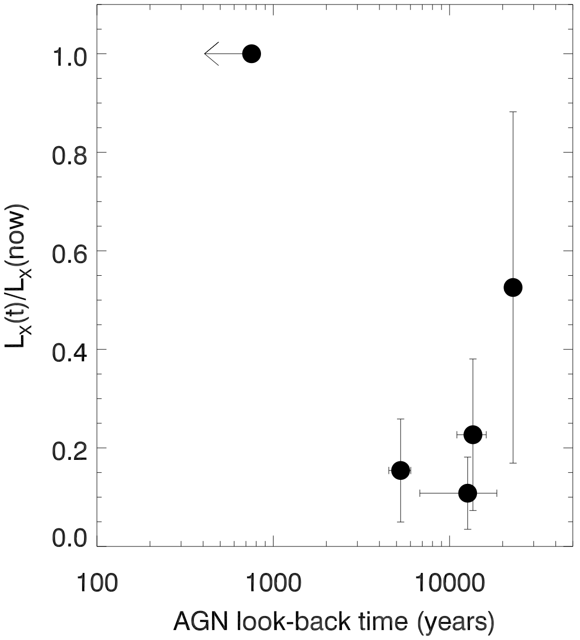

Fig. 5. History of the ionizing flux responsible for the ionization cone in NGC 5252. See details in text.

the soft X-ray emission. Shocks heating of the hot gas by stellar winds or interaction with a feeble jet are possible culprits.

If AGN photoionization is still responsible for the bulk of the ionization equilibrium in the gas, one can derive from the results in Figure 4 and the known geometry of the cone knots and filaments the history of the active nucleus responsible for the ionization cone observed nowadays (Figure 5).

A more detailed description of the observations and of their implications will be the subject of a subsequent paper (Guainazzi et al., in preparation).

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