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AGN activity and the extended hot ISM in the compact radio elliptical NGC 4278

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Abstract. With a deep *Chandra* ACIS pointing of the compact radio elliptical NGC4278, representative of the less explored class of low/medium mass ellipticals, we studied the origin of the very sub-Eddington nuclear emission, the radiative and mechanical accretion energy outputs, and the unusual sharp increase of the gas temperature at the center. Extended hot gas was also detected, misaligned with the stars and aligned with the ionized gas and dust, an effect possibly due to accreting cold gas triggering the hot gas cooling.

Key words. galaxies: elliptical and lenticular, CD – galaxies: individual: NGC 4278 – galaxies: active – galaxies: nuclei — X-rays: galaxies — X-rays: ISM

1. Introduction

High angular resolution *Chandra* observations allowed us to investigate in detail for the first time the connection between the central supermassive black hole (MBH) and the surrounding hot interstellar medium (ISM), with important implications for the building of a complete picture of the host galaxy–MBH coevolution. Previous studies concentrated on X-ray bright and massive ellipticals, though, with few exceptions (Pellegrini et al. 2007). We present here two 2010 *Chandra* pointings of the medium-mass elliptical NGC4278 (d = 16.1 Mpc, $1'' = 78$ pc, and $L_B = 1.7 \times 10^{10} L_{B,\odot}$), that merged with 6 previous pointings give an exceptionally deep observation (579 ks). Low surface brightness hot gas could be detected out to a radius of $\sim$ 5 kpc, and studied with high accuracy, thanks also to the careful subtraction of the stellar emission. A significant dimming of the nucleus in 2010 allowed us to study the hot gas down to the central $\sim$ 150 pc.

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2. Results

2.1. The nuclear region

The nuclear X-ray emission is very sub-Eddington, consistent with that of a low ra-

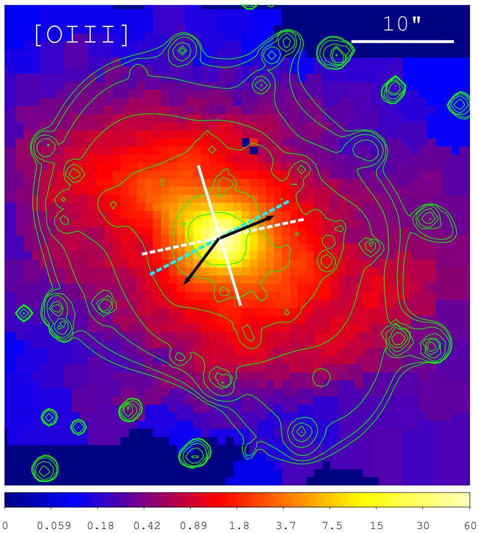

Fig. 1. The 0.3–0.9 keV emission (green contours) superimposed on the ionized gas map, from the SAURON survey. White solid and dashed lines: major axis of optical light and rotation axis of the stars in the inner galaxy; cyan dashed line: rotation axis of the ionized gas; black arrows: pc-scale radio jet directions (Pellegrini et al. 2012a).

diative efficiency accretion flow; for the Bondi mass accretion rate $\dot{M}_B$, this flow produces $L_{bol} \approx 10\dot{m}_B\dot{M}_B c^2$ ($\dot{m}_B = \dot{M}_B/\dot{M}_{Edd}$), and $L_{0.5-8keV} \lesssim 5 \times 10^{40}$ erg s^{-1}. If the accretion rate is lowered as a possible consequence of rotation in the flow, then $L_{0.5-8keV}$ comes close to the observed value of 2.5×10^{39} erg s^{-1}. NGC4278 hosts a radio loud nucleus, made of a central compact component plus a pc-scale jet that could be interacting with the circumnuclear medium. The total radio luminosity ($P_{1.4GHz} = 10^{21.7}$ W Hz^{-1}) is $>$ 2 orders of magnitude lower than in powerful radio-loud AGN. The nuclear jet power, from observed scaling relations, is $P_{jet} \approx 10^{42}$ erg s^{-1} $\sim 0.01\dot{M}_B c^2$. Thus the accretion rate cannot be largely reduced with respect to $\dot{M}_B$, as concluded from the observed AGN luminosity. The hot gas temperature at the nucleus is significantly larger ($kT = 0.75$ keV) than in the surrounding region, and this central peak could be due to: a) gravitational MBH heating, which is ruled out by specifically tailored hydrodynamical simulations; b) a recent AGN outburst at high $\dot{m}$, after which a low density central region is predicted (Pellegrini et al. 2012b), but not observed here; c) the interaction with the parsec-scale jets, which seems more likely, especially if the jets remain confined and heat the nuclear region frequently. A high central temperature may be a typical feature of the activity cycle of low-power objects, when the jet cannot bore out of the nucleus surroundings, but it can heat them (Pellegrini et al. 2012a).

2.2. The galactic scale

In a galaxy like NGC4278, for standard assumptions concerning the type Ia supernova (SNIa) heating, the mass losses from evolving stars originate an outflow on the galactic scale. This explains the low observed hot gas content (a few$\times10^7$M$_\odot$) and X-ray luminosity ($L_{0.5-8keV} = 2.4 \times 10^{39}$ erg s^{-1}). Hydrodynamical simulations also show that, on the galactic scale, the model temperature is larger than observed ($kT \sim 0.3$ keV). This discrepancy could be due to the interaction between the hot and the colder gas phases. NGC4278 is surrounded by a massive ($M_{HI} = 6.9 \times 10^8$M$_\odot$), extended and regular HI disk, whose kinematical structure is consistent with that of an ionized gas disk (Fig. 1). The accreting HI could be triggering the cooling of the hot gas, thus producing 1) an enhancement of the X-ray gas emission, and the unusual hot gas elongation and misalignement; 2) a decrease of the gas temperature, due to the heat flux from the hot to the cold phase; 3) a contribution (of $L_{H\alpha} \sim 10^{39}$ erg s^{-1}) to the ionized gas emission, that in fact cannot be explained entirely by photoionization. Interestingly, the heat flux would be comparable to the power injected by SNIa's. Alternatively, the lower-than-expected gas temperature could be due to an efficiency of SNIas heating lower than usually adopted (Pellegrini et al. 2012a).

References

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