Perseus in Sicily: From Black Hole to Cluster Outskirts
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Chandra view on the active nucleus of CGCG 292−057: Jet-ISM interactions

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Abstract. We present the analysis of the 93 ksec *Chandra* ACIS−S data for the galaxy CGCG 292−057 ($z = 0.054$), with complex radio structure indicative of the intermittent jet activity. In order to characterize precisely the spectrum of the unresolved low-luminosity active nucleus in the source, we performed detailed MARX/PSF simulations and studied the radial profile of the source region surface brightness. In this way, we have detected an additional X-ray component extending from a few up to ~ 10 kpc from the unresolved core, which could be associated with the hot gaseous medium compressed and heated (up to 0.9 keV) by the expanding inner lobes of the radio galaxy. We modeled the X-ray spectrum of the unresolved nucleus assuming various emission models, including an absorbed power-law, a power-law plus thermal emission component, and a two-temperature thermal plasma. The best fit was however obtained assuming a power-law emission scattered by a hot ionized gas, giving rise to the 6.7 keV iron line.

Keywords. galaxies: active — X-rays: galaxies — X-rays: Individual (CGCG 292−057)

1. Introduction

CGCG 292−057 ($z = 0.054$) is a particularly interesting example of a post-merger starforming galaxy (Singh *et al.* (2015)), hosting two pair of radio lobes: the outer lobes are believed to have formed during the previous, long-terminated cycle of the jet activity, while the inner coaxial lobes are considered as a manifestation of a new episode of the enhanced jet production in the system, triggered by a sudden increase in the central black hole accretion rate (Kozieł-Wierzbowska *et al.* (2012)). We have imaged CGCG 292−057 in X-rays with the ACIS instrument onboard the *Chandra* X-ray Observatory for a total of 93 ks, and here we highlight some selected results of the data analysis, which will be presented in full in Balasubramaniam et al. (2018, in prep.).

2. Chandra data analysis

The *Chandra* data analysis was carried out with CIAO version 4.9 software, CALDB version 4.7.7, using standard procedure. Spectral fitting was carried out with Sherpa using Cstat, due to the low photon statistics. First we performed 100 MARX simulations of the PSF at the position of the active nucleus in CGCG 292−057, and found out that the 2σ fraction of counts radius for the simulated PSFs ranges from 2.5 px up to 5 px. For this reason, for the spectral analysis of the nucleus described below, we adopted the circular source (AGN) extraction region with the radius of 5 px $\simeq 2.5''$; at the source redshift, this correspond to the physical scale of $\simeq 2.5$ kpc.

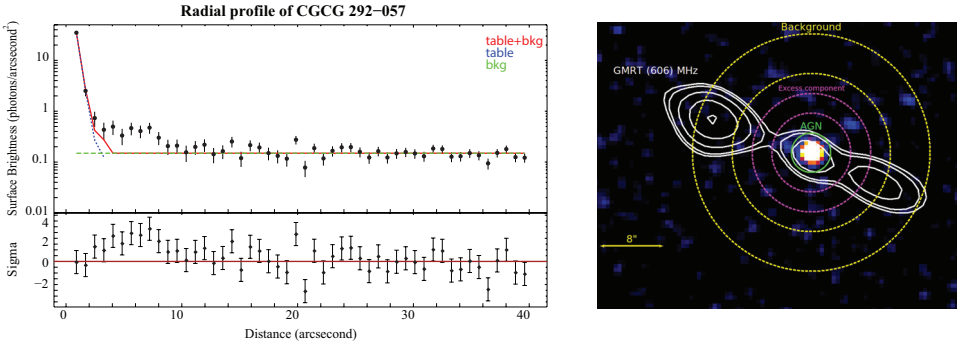

Figure 1. Left: the X-ray surface brightness profile centred on the CGCG 292−057 nucleus, along with fit including the table model for the PSF (based on the merged simulated PSF images) and a constant background. Right: ACIS-S image of CGCG 292-057 system, with the overlaid 606 MHz GMRT contours.

The X-ray surface brightness profile of the source, centred on the CGCG 292−057 nucleus, along with fit including the table model for the PSF (based on the merged simulated PSF images) and a constant background, is presented in Figure 1, left panel. As shown, positive residuals are seen within the range from about 2.5″ up to roughly 10″, signalling an additional X-ray emission component located at distances between a few kpc up to about 10 kpc from the core. In the following spectral analysis of this excess component, we adopted the annular region from 5″ to 7.5″, and the annular region from 10″ to 15″ for the constant background. The right panel in Figure 1 presents the *Chandra* image of the central parts of the CGCG 292−057 galaxy, with the 606 MHz GMRT contours of the inner radio lobes superimposed, and the source extraction regions as described above. As shown, the excess X-ray emission component is seen around the edges of the innermost parts of the radio structure, and hence we identify this feature with the diffuse phase of the ISM compressed and heated by the expanding jets/lobes.

First, we modelled the spectrum of the excess ISM component ($5'' - 7.5''$) simultaneously with the background ($10'' - 15''$), assuming an absorbed Apec model (with solar metallicity) for the former, and a single power-law (PL) for the latter. The best-fit parameters are $kT_{\rm ism} \simeq 0.88$ keV, $N_{\rm H,\,ism} \simeq 0.45 \times 10^{22}$ cm^{-2}, and $\Gamma_{\rm bcg} \simeq 0.9$. Next we modelled the spectrum of the AGN ($\leq 2.5''$), considering a variety of models. Our fits favour however the model consisting of a power-law emission scattered by a hot ionized gas giving rise to the 6.7 keV iron line. For such, the implied power-law photon index $\Gamma = 1.73 \pm 0.16$ and the 0.5–7.0 keV luminosity of 5×10^{41} erg/s, are consistent with the LINER classification of the active nucleus in CGCG 292-057, while the position of the line, $E_{line} = 6.75 \pm 0.09$, and the calculated $EW_{line} \simeq 241 \pm 77$ eV, are both, in principle, consistent with the FeXXV emission arising due to an X-ray reflection on a photoionized circumnuclear matter with the column density of $\sim 6 \times 10^{22}$ cm^{-2}.

Recently, ionized iron lines have been also detected in the X-ray spectra of the two other compact radio galaxies, namely 0710+439 (Siemiginowska *et al.* (2016)), and PMN J1603-4904 (Krauss *et al.* (2018)). This may suggest that such features are common in the systems hosting newly-born jets propagating through, and interacting with the multiphase ISM.

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