# RADIO AND X-RAY EMISSION ASSOCIATED WITH THE SUPERNOVA REMNANT G352.7-0.1

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## ABSTRACT

We report on new VLA radio and XMM-Newton X-ray observations of the SNR G352.7-0.1. These high sensitivity, high resolution data reveal that G352.7-0.1 belongs to the thermal composite morphological class. Small scale structures in radio and X-ray emission are not always correlated and are different for the different X-rays bands examined. The distance to G352.7-0.1 can be constrained between 6.6 and 8.4 kpc. The study of the HI suggests that G352.7-0.1 is located within a cavity probably created by the stellar wind of the precursor star.

Key words: X-rays; Radio continuum; Supernova remnants; G352.7-0.1; ISM.

## 1. INTRODUCTION

G352.7-0.1 is a supernova remnant (SNR) classified as a shell-like type, with a size of $8' \times 6'$. The high resolution VLA image at 1.4 GHz obtained by Dubner et al. (1993) shows the presence of two overlapping ring structures and an unresolved bright spot over the eastern limb, whose origin is unclear. Kinugasa et al. (1998) presented an ASCA X-ray image that is described as a shell which roughly coincides with the inner radio shell. They proposed that G352.7-0.1 is a middle-age (2200 years) SNR located at 8.5 kpc, evolving in a pre-existing cavity.

We present the comparison between high spatial resolution radio data and XMM-Newton X-ray data of G352.7-0.1, carried out to investigate the origin of the observed morphologies, analysing also their X-ray spectra. In addition, based on HI data taken from the SGPS survey (McClure-Griffith et al., 2001) and CO data from the CfA CO survey (Dame & Thaddeus, 2001) we investigate the atomic and molecular gas in the direction to G352.7-0.1 to set constraints on its distance.

## 2. RADIO AND X-RAY OBSERVATIONS

The radio image at 4.8 GHz was produced from VLA archival data corresponding to observations carried out in its DnC configuration. The data were processed under the Miriad software package following standard procedures. The angular resolution of the final image is $12'' \times 9''$ and the noise is 0.2 mJy/beam.

X-ray images and spectra were obtained from EPIC data of an XMM-Newton observation of G352.7-0.1 performed on October 3, 2002. The public data were extracted from the XMM-Newton Science Archive and processed using version 6.5.0 of the XMM-Newton Science Analysis System. The MOS and pn cameras were operated in FULL FRAME mode with the Medium filter. Net exposure times were 25 ks and 20 ks for the MOS and pn cameras, respectively. The astrometry of the resulting images was confirmed to be accurate to about 5 arcsec.

## 3. RESULTS

Fig.1 (*Left*) shows G352.7-0.1 at 4.8 GHz. The overall appearance of this image resembles that at 1.4 GHz, but the higher angular resolution of these data reveal clumpy structures on small scales. The largest angular scale structures, however, have not been fully recovered because of the incomplete sampling in the visibility plane.

Fig. 1 (*Right*) shows the broadband (0.15 - 8.0 keV) EPIC image of G352.7-0.1 overlaid with the VLA radio contours at 1.4 GHz as taken from Dubner et al. (1993). The X-ray emission is confined within the inner radio shell, filling it almost completely. The emission is characterized by the presence of several knots of emission. The brightest radio spot has not counterpart in the X-ray range and vice-versa. These new observations reveal that G352.7-0.1 belongs to the composite morphological class, i.e. shell-like in radio, filled- centre in the X-ray regime. Narrowband images centered at the Si, S, Ar and Fe emission lines are displayed in Fig. 2 (a), (b), (c) and (d) respectively. The distribution of the emission in the

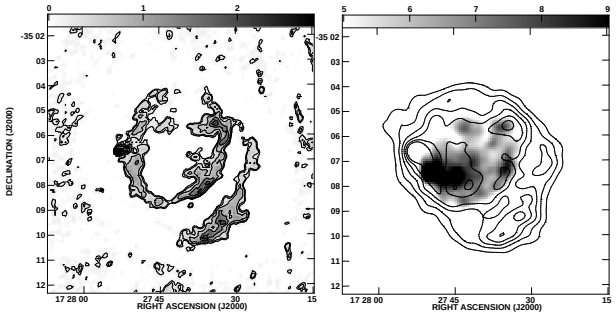


*Figure 1. Left: Gray-scale and contour image of G352.7-0.1 at 4.8 GHz. Right: XMM-Newton X-ray data in the range 0.15 to 8.0 keV (gray-scale) overlaid with the VLA radio contours at 1.4 GHz (from Dubner et al. 1993).*

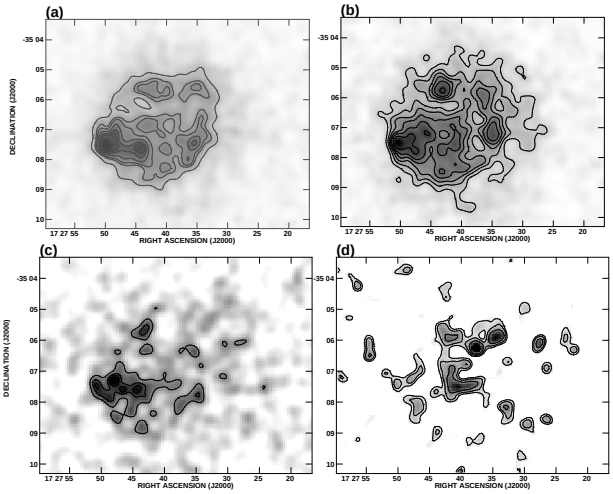


*Figure 2. XMM-Newton EPIC images in the bands centered in: (a) the Si XIII/XV line (1.7-2 keV), (b) the S XIII/XV line (2.3-2.6 keV), (c) the Ar XVII line (3.1-3.3 keV) and (d) the Fe K$\alpha$ line (6.3-6.7 keV).*

energy bands centered at Si and S lines are quite similar to the broadband image. The image centered in the Ar line, instead, outstands only near the southeastern X-ray maximum. The distribution of the Fe emission line band is more clumpy and anti-correlated with the other bands.

EPIC X-ray spectra were obtained from a circular region with a radius $2.5'$ and were background subtracted using an annular region surrounding the SNR. The data were simultaneously fit in the 0.5 -7.5 keV band with a non-equilibrium ionization collisional plasma model (Borkowski et al., 2001), assuming a constant temperature and single ionization parameter, combined with ISM absorption. The best fit requires significant overabundance of Si, S, Ar and Ca with respect to the solar values of Anders & Grevesse (1989). An additional component is needed to model the Fe K$\alpha$ emission at 6.4 keV. The values obtained are *k*T $\sim 1.7$ keV, $\tau \sim 4.7 \times 10^{10}$ s cm$^{-3}$ and $N_{\rm H} \sim 2.6 \times 10^{22}$ cm$^{-2}$.

To estimate the distance to G352.7-0.1, we analized HI profiles in the direction to the bright eastern spot in G352.7-0.1. These profiles reveal an absorption HI feature around $V_{\rm LSR} \sim$ -85 km/s. A flat rotation curve of the Galaxy produces for this radial velocity a near distance of $\sim$ 6.6 kpc and a far distance of $\sim$ 10.2 kpc. Since no absorption features are observed at more negative velocities, 6.6 kpc can be confidently set as the lower limit for the distance. An upper limit is the tangent point at $\sim$ -189 km/s, corresponding to the kinematical distance of 8.4 kpc. Based on CO and HI observations we estimated the cumulative absorbing column density in direction to G352.7-0.1. The obtained value is in good agreement with the $N_{\rm H}$ derived from the XMM-Newton spectrum if the SNR is located at a distance between 6.6 and 8.4 kpc. On the other hand, the analysis of the distribution of the HI emission near 7 kpc reveals the presence of an open shell surrounding G352.7-0.1. It is possible that this shell represents the walls of the wind-blown cavity suggested by Kinugasa et al. (1998).

In summary, from the radio and X-ray study of the SNR G352.7-0.1 and its environs it can be concluded that: (a) This SNR belongs to the thermal composite morphological class; (b) the bright radio spot seen to the east of the SNR has not counterpart in the X-ray emission; (c) the distance to G352.7-0.1 is set between 6.6 and 8.4 kpc; (d) G352.7-0.1 is located within a cavity, probably created by the stellar wind of its precursor star.

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