Suzaku identifies the true nature of an old friend in the Galactic center — Sgr D —

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Abstract

Sagittarius D (Sgr D) is one of the oldest known objects from the dawn of the radio astronomy in the Galactic center (GC). It has been considered a complex of H\textsubscript{II} regions. However, recent radio-continuum and infrared studies indicate that several components at various distances are projected along the same line of sight. In this presentation, we report the Suzaku discovery of a supernova remnant in the Sgr D complex, overturning the long-standing view of the object for 30 years (Sawada et al. 2009, PASJ). Our work is a nice illustration of the Suzaku’s superb sensitivity for faint diffuse sources, which continues to revise our view of the GC region.

Key words: ISM: H\textsubscript{II} regions — ISM: individual (Sgr D) — ISM: supernova remnants

1. Introduction

Sagittarius D (Sgr D; Downes et al. 1979) is a twin of an H\textsubscript{II} region (Sgr D H\textsubscript{II} region) and a supernova remnant (SNR; Sgr D SNR) in the Galactic center (GC). Interferometric radio images resolved the H\textsubscript{II} region into several substructures (figure 1a; Mehringer et al. 1998). This complex (Sgr D H\textsubscript{II} complex) had been considered to be a single H\textsubscript{II} region and its environment. However, the latest radio-continuum/infrared studies indicate that objects at various distances are projected along the same line of sight (Blum & Damineli 1999; Law et al. 2008).

In order to reveal the true nature of the complex, we conducted X-ray observations of the Sgr D H\textsubscript{II} complex using X-ray Imaging Spectrometer (XIS) on board Suzaku (Sawada et al. 2009). Here we report a significant detection of diffuse X-ray emission, which renews our understanding of the complex.

2. Results

2.1. Images

The Sgr D H\textsubscript{II} complex is accompanied by both diffuse and point-like X-ray emission (figure 1a). In the narrowband (2.4–2.5 keV) image tracing the SXV K\textalpha emission line (figure 1b), the diffuse emission emerges. Thus the diffuse X-ray emission is likely to be thermal emission of plasma with the temperature of \( \sim 1 \text{ keV} \).

2.2. Spectrum

Figure 2 shows XIS spectrum of the diffuse X-ray emission. XIS spectrum was characterized by emission lines from highly ionized atoms. Observed spectrum was well reproduced by a thin-thermal plasma model attenuated by interstellar matter (table 1).

3. Discussion

3.1. Origin of the diffuse X-ray emission

No stellar distributions similar to the morphology of the diffuse X-ray emission nor bright X-ray point sources significantly contaminating to the diffuse emission were found. We therefore conclude that the X-ray emission is a new X-ray object and truly extended source in nature.
The Energetic Cosmos: from Suzaku to ASTRO-H

Fig. 2. XIS spectrum of the diffuse X-ray emission

Table 1. Best-fit parameters of the diffuse X-ray emission

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (90% error)</th>
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</thead>
<tbody>
<tr>
<td>$N_H$ (10$^{22}$ cm$^{-2}$)</td>
<td>8.5 (7.3–9.7)</td>
</tr>
<tr>
<td>$kT$ (keV)</td>
<td>0.91 (0.74–1.08)</td>
</tr>
<tr>
<td>$Z_S$ (solar)</td>
<td>1.6 (1.2–2.1)</td>
</tr>
<tr>
<td>$Z_{Ar} = Z_{Ca}$ (solar)</td>
<td>1.8 (0.9–2.9)</td>
</tr>
<tr>
<td>$L_X$ (10$^{35}$ erg s$^{-1}$ at 8 kpc)$^*$</td>
<td>1.4</td>
</tr>
</tbody>
</table>

$^*$Absorption corrected value in 0.7–8.0 keV.

The large extinction ($N_H \sim 8.5 \times 10^{22}$ cm$^{-2}$) indicates the X-ray object is located in or beyond the GC region. The apparent size of the object is about 9 pc $\times$ 16 pc at the GC distance of 8 kpc. The XIS spectrum is akin to those of SNRs discovered in the GC region (Mori et al. 2008). Thus we conclude that the origin of the diffuse X-ray emission is a new SNR in the GC region.

Fig. 3. Intensity maps of 3.5-cm and 6.0-cm bands and the spectral indices between the two bands along the slice (figure 4a).

In cm-band, spectra of SNRs are generally nonthermal synchrotron emission. We then studied the radio spectrum around the diffuse X-ray emission using the 100-m Green Bank Telescope (GBT) dataset. The spectral index was derived from background-subtracted intensity maps of 3.5-cm and 6.0-cm emission (figure 3) along the slice around the diffuse X-ray emission (figure 4a). We found the spectral index is consistently about $-0.5$. Therefore the radio emission across the diffuse X-ray emission is dominated by nonthermal synchrotron emission. This result provides another evidence of the diffuse X-ray emission being an SNR.

Fig. 4. Multiwavelength view of Sgr D: (a) GBT 6.0 cm with black contours and Spitzer 24 $\mu$m with gray ones. The slice for the radio spectral study is shown with a vector. (b) CO J=3–2 at 100±5 km s$^{-1}$ with gray contours (Oka et al. 2007) and CS J=1–0 at $-15 \pm 5$ km s$^{-1}$ with black ones (Tsuboi et al. 1999).

3.2. Structure of the Sgr D HII complex
The "tail" is the new SNR and a part of it is bright in X-ray (figure 4a; G1.2$-$0.0). We found a 100 km s$^{-1}$ giant molecular cloud (GMC) at the GC distance anti-correlates with the diffuse X-rays (figure 4b). This indicates that the lack of X-ray emission in other parts of the "tail" is due to the absorption by intervening GMC. Thus, the new SNR is behind the GC. The "core" is associated with a $-15$ km s$^{-1}$ GMC on the near side of the GC (Blum & Damineli 1999). Therefore the new SNR is located behind the Sgr D HII region. It is now clear that an SNR and an HII region are projected along the same line of sight, not a HII region and its environment.

4. Summary
XIS detected diffuse X-ray emission toward the Sgr D HII complex for the first time. Spectral study of the emission in X-ray as well as cm-radio revealed its origin as a new SNR in the GC region. By assembling images across the wavelengths, we proposed a new view of the Sgr D HII complex: it is a projection of an SNR in or beyond the GC and an HII region in front of it. This revises a long-standing view of the object for 30 years.

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References
Mori, H. et al. 2008, PASJ, 60, S183