Unresolved Soft X-Ray Emissions from the Galactic Plane

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Abstract

Previous studies on the soft X-ray diffuse background below 1 keV suggest an existence of an unresolved soft X-ray emission in the Galactic plane. Systematic studies using \textit{Suzaku} demonstrate that the "bump-like" excess emission peaked at 0.9 keV as observed in a Galactic plane region is widely distributed over the whole Galactic plane. Spectral analysis reveals that these components are represented well by a thin thermal plasma model with temperatures of 0.5–1.3 keV. Their intensities show larger variation by a factor of 10 and its scale height is 6 ± 1 degrees. To clarify the origin, X-ray and infrared observations are needed.

Key words: the galaxy: disk — X-rays: diffuse background

1. Introduction

The soft X-ray diffuse background (hereafter SXDB) below 1 keV is spatially uniform after subtracting the local structure in the Galaxy. In high latitude regions of the Galaxy, 40% of an emission is attributed to an emission from faint extragalactic individual sources, i.e., the cosmic X-ray background (CXB) (McCammon et al. 2002). Since a mean free path of X-ray photons below 1 keV is about 1 kpc in the Galactic plane due to a dense material (\(>10^{21} \text{ cm}^2\)), a soft X-ray emission from extragalactic sources is totally blocked in midplane. Thus, it is naturally expected that an intensity below 1 keV decreases by 40% in midplane compared to high-latitude regions. However, the reduction is smaller than the expectation, suggesting an unknown emission in the Galactic plane (e.g., McCammon et al. 1990). Masui et al. (2009) discovered "bump-like" emission peaked at 0.9 keV in the spectrum of a Galactic plane region approximated by a thin thermal plasma with \(kT = 0.8\) keV.

2. Analysis & Results

To answer the question whether the observed "bump-like" emission can be a solution for the unresolved emission in the Galactic plane, we conducted a systematic study using \textit{Suzaku} (Mitsuda et al. 2007) which is optimum for such faint diffuse emission considering its lowest and stable background. One criterion that count rate in the ROSAT R45 band \((0.4–1 \text{ keV})\) is below \(200 \times 10^6 \text{ counts s}^{-1} \text{ arcmin}^{-2}\) was imposed to search for a blank-sky region in the Galactic plane efficiently. Consequently, we selected 16 blank-sky regions where no contamination from a specific X-ray astronomical object was confirmed in its image and energy spectrum mainly above 2 keV. For all the 16 blank-sky regions, we fitted broadband spectra including below 1 keV and confirmed that an excess emission is required to make up for a residual around 0.9 keV. In the spectral analysis, we assumed that an emission from the Galactic halo was completely blocked by a dense material distributed in the Galactic plane and adopted a thin thermal plasma model to represent the excess emission. Spectrum shape of the excess emissions is similar to that of the "bump-like" excess emission as observed in Masui et al. (2009), suggesting that the "bump-like" excess emission is widely distributed in the Galactic plane. The observed spectra is shown in Figure 1.

Next, we discuss their spectral features. The resultant temperatures range from 0.5 keV to 1.3 keV and its fluctuation is within a factor of 3, while the intensity show larger variation by a factor of >10. The temperature and intensity distributions are shown in Figures 2 and 3. This result may indicate that main contributor(s) to the excess emission is the same but shows variation in its spatial distribution. We investigated the intensity distribution as functions of Galactic latitude and longitude. Figure 4 exhibits Galactic latitude dependence and negative correlation is found toward a high
Fig. 1. The observed “bump-like” excess emissions in the Galactic plane with Suzaku overlaid on the RASS R45 map. The resultant spectra fitted with LHB+SWCX (blue), the CXB (orange), and “bump-like” excess emission (red) in 16 blank-sky regions of the Galactic plane are also shown. To emphasize each position where an excess emission is detected, a radius of a green circle is set to be 1.5 degrees. An emission from the Galactic halo was assumed to be blocked completely by a dense neutral material in the Galactic plane.

Galactic-latitude region, while no correlation is seen between Galactic longitude and the intensities. The scale height is calculated to be $6 \pm 1$ degrees at a 90% confidence level, which suggests that the main contributor(s) is widely distributed also along the Galactic latitude direction. A combined analysis of X-ray and infrared is needed to constrain the origin of the excess emission.

References
McCammon et al. 1990 ARA&A, 28, 657
Masui et al. 2009 PASJ, 61, 115
Mitsuda et al. 2007 PASJ, 59, 1

Fig. 2. Histogram of the observed temperatures of the excess emissions. The emission measure (EM) integrated over the line of sight is defined as $\int n_e n_{\text{H}} \, ds$.

Fig. 3. Histogram of the observed intensities of the “bump-like” excess emissions.

Fig. 4. Resultant intensities of the “bump-like” excess emissions as a function of Galactic latitude. The emission measure (EM) integrated over the line of sight is defined as $\int n_e n_{\text{H}} \, ds$. 