Discovery of the ~0.8 keV emission component from the Galactic disk with Suzaku

Shunsuke Kimura[1], Kensuke Masui[1], Kazuhisa Mitsuda[1], Noriko Y. Yamasaki[1] and Dan McCammon[2]

[1] ISAS/JAXA, 3-1-1, Yoshinodai, Sagamihara, Kanagawa, 229-8510, Japan
[2] Department of Physics, University of Wisconsin - Madison, 1150 University Avenue, Madison, WI 53706, USA
E-mail(SK): kimura@astro.isas.jaxa.jp

Abstract

We report the discovery of a ~0.8 keV emission component from the Galactic disk with Suzaku. Using two Suzaku observations and re-analysis of ROSAT All Sky map, we conclude that the emission component exists over the entire galactic plane. This is likely an answer to the long standing mystery of the "M-band problem" identified in the early 1980's. Since high pressure is required to explain the 0.8 keV emission, diffuse gas is unlikely an explanation of the emission. Instead, we constructed a model which assumes that the emission originates from unresolved faint M dwarf (dM) stars in the Suzaku field of view. This model successfully represents the energy spectrum, the absolute intensity, and the latitude dependence of the emission.

Key words: X-rays: diffuse background, stars: early-type

1. Introduction

1.1. M-band problem

The Soft X-ray Diffuse Background (SXDB) is spatially smooth except for local Galactic structures, such as Loop I. About 40 % of the emission in the 0.4 − 1 keV band (= ROSAT R45 band) is totally blocked by the Galactic disk in midplane. This is of extragalactic origin (CXB). Nevertheless, the SXDB brightness at midplane is approximately 80 % of the high latitude value. This is called the "M-band problem" (e.g. Cox et al. 2005) and it indicates that unknown "excess emissions" exist in the Galactic disk within ~1 kpc (absorption length of a 0.9 keV photon) from the Earth.

1.2. The answer from Suzaku

Masui et al. (2009) observed a midplane direction which has no special features ($\ell = 235°, b = 0°$), in order to study the X-ray spectrum of the "excess emission". They found that a narrow bump-like emission, which peaked at ~ 0.9 keV, was compensating the decrease of the CXB by absorption. The emission was well represented by a thin thermal plasma model of $kT = 0.8$ keV.

If the 0.8 keV emission is from diffuse hot gas, its pressure must exceed the total pressure of the Galaxy (Cox et al. 2005). Thus Masui et al. (2009) considered point source origins. Faint dM stars were Thought to be the most likely source of emission because of its spectrum, X-ray brightness, and high spatial density. Masui et al. (2009) constructed a dM star emission model. They successfully reproduce both the X-ray spectral shape and the absolute flux.

Does the 0.8 keV emission exist over the entire Galactic disk? This is an essential question to examine whether if the 0.8 keV component is the answer of the M-band problem, and to determine the origin of the emission. In this paper, we try to answer the question by two means; a new Suzaku observation and a re-analysis of the ROSAT All Sky Survey data.

2. Observation and Analysis

2.1. New Suzaku observation

We observed another midplane direction in which there is also no special features; ($\ell = 123°, b = 0°$). We clearly detected bump-like emission features (fig.1) that can be represented by a thin-thermal emission of kT ~ 0.8 keV. The best fit parameters are shown in Table.1.

2.2. Re-analysis of ROSAT All Sky Survey

The midplane spectrum at ($\ell = 235°, b = 0°$) is harder than the high latitude spectrum in North Ecliptic Pole in 0.4–1 keV (= R45) band (See figure 2 in Yoshino et al. 2009). Such a difference is also noticeable in the ROSAT All Sky Map. There has been no analysis of ROSAT data to evaluate this difference so far. We thus re-analyzed the ROSAT R4 and R5 map. First we calculated the contribution of the extragalactic component assuming the

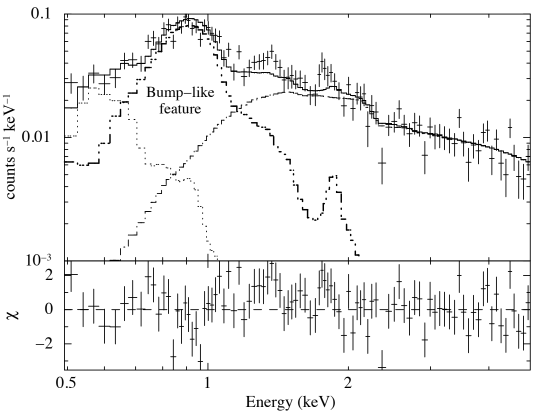

Fig. 1. Spectrum of $(\ell, b) = (123°, 0°)$ and the best-fit model function convolved with the telescope and the detector response functions.

Table 1. Best fit spectral parameters

Parameter	New observation	Masui et al. (2009)
$(\ell,\ b)$	$(123.0°, 0.0°)$	$(235.0°, 0.0°)$
Exposure	59.3 ksec	89.6 ksec
Cosmic X-ray Backgound (Powerlow)		
$N_{\rm H}^{*}$	0.74	0.90
Γ	1.4 (fixed)	1.4 (fixed)
Norm†	$13.7^{+0.7}_{-0.6}$	11.1 ± 0.9
LHB+Heliospheric SWCX (Apec)		
kT [keV]	0.07 ± 0.021	$0.11^{+0.05}_{-0.03}$
Norm‡	82^{+420}_{-64}	14^{+6}_{-10}
Bump-like feature (Apec)		
kT [keV]	0.75 ± 0.03	0.77 ± 0.04
O abund$^{\natural}$	3.1 ± 0.1	$3.1^{+1.3}_{-1.2}$
Norm‡	$5.8^{+0.3}_{-0.4}$	3.8 ± 0.4
χ/d.o.f	132/90	77/84

* The unit is $[10^{22}\ {\rm cm}^{-2}]$.
† The unit is photons ${\rm s}^{-1}\ {\rm cm}^{2}\ {\rm keV}^{-1}\ {\rm sr}^{-1}$@ 1 keV.
‡ $(1/4\pi) \int n_{\rm e} n_{\rm H} d\ell$ in units of $10^{14}\ {\rm cm}^{-5}\ {\rm sr}^{-1}$.
$^{\natural}$ Solar abundance by Anders and Grevesse (1989).

surface brightness corrected for the galactic absorption is constant. Then we subtracted the extragalactic emission from the R4 and R5 band, respectively. Then the hardness ratio was calculated as R5/R4. It is shown in Figure 2. Even though the map is contaminated by the long-term enhancement (Snowden et al. 1994), we can see that the emission is harder in midplane than in high latitude.

3. Discussion – Latitude Dependence

In Figure 3, we plot the residuals of R45 band flux latitude profile and CXB profile of a constant surface brightness was absorbed by $N_{\rm H}$ for $\ell = 235°$. Yoshino et al.

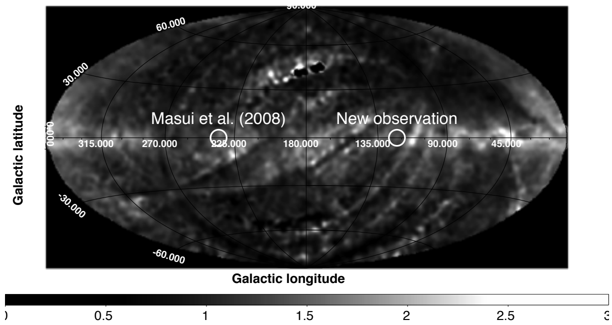

Fig. 2. All sky map of the ratio, (R5 band - extragalactic) / (R4 band - extragalactic). Notice the anti Galactic center direction is at the center of the map.

(2009) detected a 0.8 keV emission component in the spectrum of $(\ell = 96.6°, b = 10.4°)$. The intensity of the 0.8 keV component in this direction is comparable to the residuals in the $\ell = 235°$. Masui et al. (2009) showed that a latitude profile of the dM star emission did not reproduce the latitude dependency of the residuals. However, by using a more updated star density profile along the Galactic vertical direction (Robin et al. 2003), we obtained a good fit to the data. Therefore, we concluded that the emission from dM stars is likely the origin of 0.8 keV emission that solves the M-band problem.

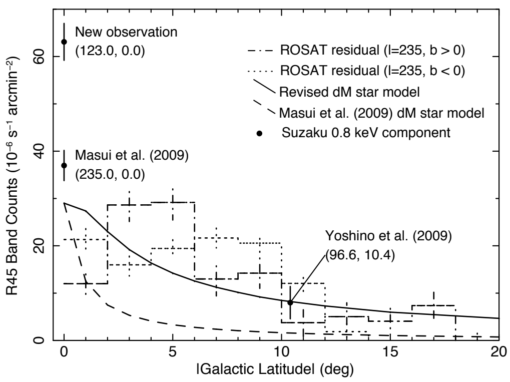

Fig. 3. Residuals of R45 band surface brightness from the CXB and unabsorbed constant emission (blue), the 0.8 keV component (red) and expected X-ray fluxes from faint dM stars (black) as functions of the galactic latitude, $|b|$, along $\ell = 235°$.

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