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On the Origin of the 6.4 keV line from the GRXE

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Abstract. The Galactic Ridge X-ray Emission (GRXE) spectrum has strong iron emission lines at 6.4, 6.7, and 7.0 keV, each corresponding to the neutral (or low-ionized), He-like, and H-like iron ions. The 6.4 keV fluorescence line is due to irradiation of neutral (or low ionized) material (iron) by hard X-ray sources, indicating uniform presence of the cold matter in the Galactic plane. In order to resolve origin of the cold fluorescent matter, we examined the contribution of the 6.4 keV line emission from white dwarf surfaces in the hard X-ray emitting symbiotic stars (hSSs) and magnetic cataclysmic variables (mCVs) to the GRXE. In our spectral analysis of 4 hSSs and 19 mCVs observed with Suzaku, we were able to resolve the three iron emission lines. We found that the equivalent-widths (EWs) of the 6.4 keV lines of hSSs are systematically higher than those of mCVs, such that the average EWs of hSSs and mCVs are 180^{+50}_{-10} eV and 93^{+20}_{-3} eV, respectively. The EW of hSSs compares favorably with the typical EWs of the 6.4 keV line in the GRXE of 90–300 eV depending on Galactic positions. Average 6.4 keV line luminosities of the hSSs and mCVs are 9.2×10^{39} and 1.6×10^{39} photons s^{-1}, respectively, indicating that hSSs are intrinsically more efficient 6.4 keV line emitters than mCVs. We estimated required space densities of hSSs and mCVs to account for all the GRXE 6.4 keV line emission flux to be 2×10^{-7} pc^{-3} and 1×10^{-6} pc^{-3}, respectively. We also estimated the actual 6.4 keV line contribution from the hSSs, which is as much as 30% of the observed GRXE flux, and that from the mCV is about 50%. We therefore conclude that the GRXE 6.4 keV line flux is primarily explained by hSSs and mCVs.

Keywords. Galaxy: disk — stars: binaries: symbiotic — stars: novae, cataclysmic variables — X-rays: stars

1. Introduction

Presence of the seemingly extended hard X-ray emission from the Galactic Ridge has been known since early 1980's (Galactic Ridge X-ray Emission; GRXE: Worrall *et al.* (1982), Warwick *et al.* (1985), Koyama *et al.* (1986). The nature and origin of this emission is yet to be settled. However, there is a strong argument in favor of collection of faint point sources as opposed to the diffused emission (e.g., Revnivtsev *et al.* (2006), Krivonos *et al.* (2007), Revnivtsev *et al.* (2009), Revnivtsev *et al.* (2010 and references therein), although the question remains "what are these Galactic point sources?"

We study origin of the 6.4 keV emission line in the GRXE using 4 hSSs and 19 mCVs observed with Suzaku, examining if this emission could be fully resolved by collection of point sources.

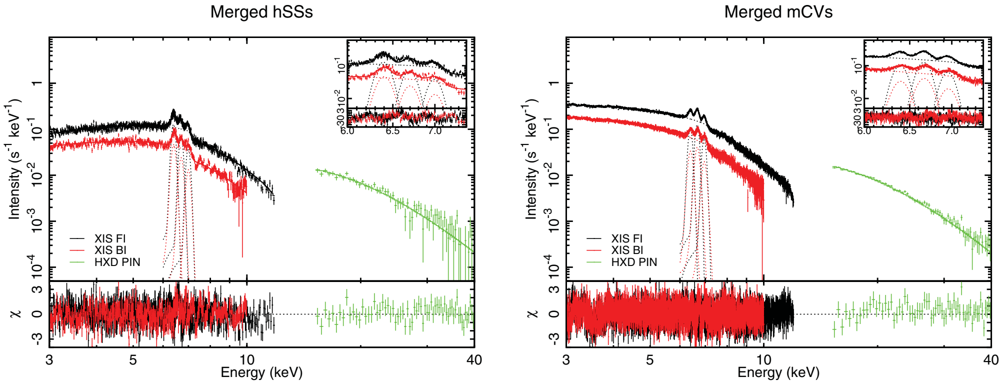

Figure 1. Spectra of the average symbiotic stars(left) and the average magnetic cataclysmic variables(right). In the upper panel, the data and the best-fit model are shown by crosses and solid lines, respectively. In the lower panel, the ratio of the data to the best-fit model is shown by crosses. The inset in the upper panel is an enlarged view for the Fe Kα complex lines.

2. Spectral Analysis and Results

Spectral analysis of all observations were performed using XSPEC version 12.7. We modeled the spectrum using absorbed bremsstralung model with three Gaussian lines for the three Fe Kα emission lines to measure the iron line fluxes. We assumed two types of absorption by full-covering and partial covering matter. The three Fe lines, neutral or low ionized (6.4 keV), He-like (6.7 keV), and H-like (7.0 keV) ions, were clearly resolved in all the sources except in one mCVs, where we were unable to detected the H-like (7.0 keV) significantly but the other two lines were detected.

We used `addascaspec` to average the spectra of hSSs and mCVs (as well as responses). The spectra for the average hSSs and average mCVs were presented in figure 1. We detected strong 6.4 keV iron line emission in the average hSSs spectrum with an equivalent width (EW) of 180^{+50}_{-10} eV and in the average mCVs spectrum with 93^{+20}_{-3} eV. We have found that the 6.4 keV line EW is much stronger in hSSs than in mCVs, which suggests that hSSs can be strong candidates of the GRXE 6.4 keV line emission. For comparison, 6.4 keV iron line EWs of the GRXE are of 90–390 eV, depending on the Galactic locations (Yamauchi *et al.* 2009).

In our rough estimate, as much as $\sim$30% of the GRXE 6.4 keV line flux may be from hSSs, and $\sim$50% from mCVs. We therefore conclude that the GRXE 6.4 keV line flux is primarily explained by hSSs and mCVs.

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