LUMINOSITY FUNCTION OF X-RAY SOURCES IN THE GALACTIC BULGE

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ABSTRACT

We studied the luminosity function of X-ray sources in the Galactic bulge using a flux-limited sample selected from the *ROSAT Bright Source Catalogue* (hereafter *RBSC*). By using the spectral colors, 78 sources were picked up from the Galactic bulge. From the 78 selected sources, we constructed the luminosity function of the Galactic bulge sources with a luminosity of $> 10^{34}$ erg s^{-1}. Most of the X-ray sources are likely Low-Mass X-ray Binaries (hereafter LMXBs). Compared with the luminosity functions of LMXBs in the bulges in other galaxies, we found that there is a good correlation between the number of LMXBs and the B-band luminosity in the host bulges. The luminosity function of the LMXBs over the wide luminosity range of $10^{34} - 10^{40}$ erg s^{-1} can be commonly represented by the power-law with three indices (0.4, 0.8, and 1.8) and two break luminosities of $\sim 10^{36}$ and 5×10^{38} erg s^{-1}.

Key words: Bulge, Luminosity function, LMXBs.

1. INTRODUCTION

The galactic bulge is a spherical structure surrounding the galactic center over ~ 3 kpc. The bulge is considered as a vestige of galaxy evolution (e.g., Gilmore 1999). Therefore the galactic bulge is believed as a key to understand the galaxy evolution. Since the bulge is old, its stars with relatively large masses had already ended their lives and evolved into compact stars, such as a neutron star (hereafter NS) or a black hole (hereafter BH). Hence the X-ray wavelengths provide us new insights into the bulge that are sensitive to the stellar population with higher masses. For this aim, we selected the Galactic bulge. There have been many past studies on the Galactic LMXBs (e.g., Grimm et al. 2002), however no attention had been paid to the Galactic bulge, mainly due to the poor detection limit of a non-imaging instruments. In order to pick up the LMXBs in the Galactic bulge, we used the *RBSC* sample (Voges et al. 1999), which enables us to determine the positions of the X-ray sources with high accuracy and

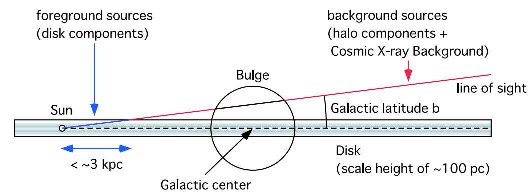

Figure 1. Schematic view of the cross section of our Galaxy

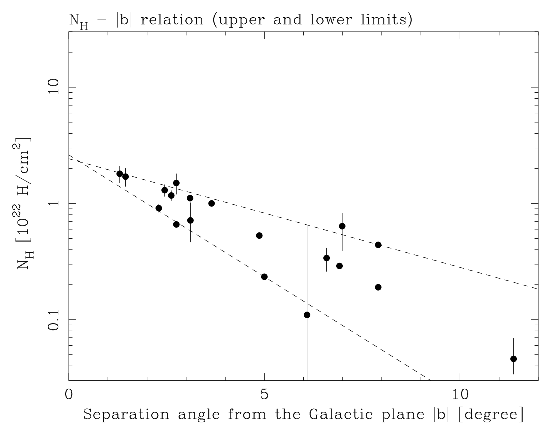

Figure 2. Column densities towards the Galactic bulge LMXBs dependent on their Galactic latitude $|b|$

to perform an unbiased population study of the Galactic bulge.

2. X-RAY SOURCES IN THE GALACTIC BULGE

Fig. 1 shows a schematic view of our Galaxy, which consists of the Galactic disk and bulge. The Galactic bulge is a gas-less spheroid with a scale angle of ~ 12 degrees from the Galactic center. As shown in Fig. 1, the Galactic bulge sources are contaminated along a line of sight by foreground sources in the Galactic disk and background ones in the Galactic halo or extragalaxies. Since the Galactic absorption is attributed to interstellar medium (hereafter ISM) which mainly distributes along the Galactic disk, the foreground sources are suffered from relatively low absorption. We can thus remove the foreground sources by testing if their low-energy absorption columns are large enough for the disk ISM in the line of sight or not. The *RBSC* provides us with two hardness ratios designated as HR1 and HR2. The spectral colors (HR1, HR2) serve as a good measure of absorption column if we assume an appropriate spectral model.

Fig. 2 shows the column densities to the known Galactic bulge sources. The column densities can be modelled by a simple exponential function of the Galactic latitude $|b|$ (for details, Mori et al. 2005). Using this $|b|$-dependent model of the Galactic absorption, we estimated the colors of the *RBSC* sources when they are located in the Galactic bulge. We considered the power-law spectrum with indices of 0.5–3.0 (see Schulz 1999). In total, the colors of 78 *RBSC* objects are consistent within 90% confidence level that they are not located in front of the Galactic bulge. Since only 17% of these sources are likely extragalactic origin (see Miyaji et al. 2000), the 78 sources mainly inhabit in the Galactic bulge.

3. LUMINOSITY FUNCTION

Since the distances to the Galactic bulge sources are expected as nearly constant (8.5 ± 1.7 kpc), we can make the luminosity function of the 78 Galactic bulge sources as shown in Fig. 3. The error box corresponds to the uncertainties of the distances, and the absorption columns and photon indices in spectra when we convert the source count rates to the unabsorbed X-ray fluxes. We also corrected the incompleteness of the source detection below the luminosities of 10^{35} erg s^{-1}. The extragalactic component was also subtracted using the high latitude data.

Over the luminosity range of $10^{35} - 10^{38}$ erg s^{-1}, we fit the luminosity function by a single power-law model. The best fit parameter of the power-law index is ~ 0.4. Since the Galactic bulge is old and the X-ray luminosities of each source are larger than 10^{34} erg s^{-1}, most of the Galactic bulge sources are considered to be LMXBs.

4. DISCUSSION

We compared the cumulative luminosity function of the LMXBs in the Galactic bulge with those in the M31 bulge (Kong et al. 2002) and elliptical galaxies (Kim & Fabbiano 2004). Fig. 4 shows these luminosity functions where the number of LMXBs is normalized by the B-band luminosity of its host bulge. As seen in Fig. 4, the normalized luminosity functions are consistent with each others in the overlapped luminosity ranges. This result indicates that the number of LMXBs in the galactic bulges is well proportional to their size, and that the luminosity

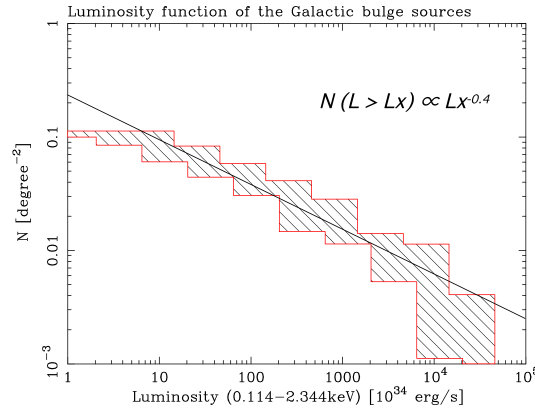

Figure 3. Cumulative luminosity function of the X-ray sources in the Bulge

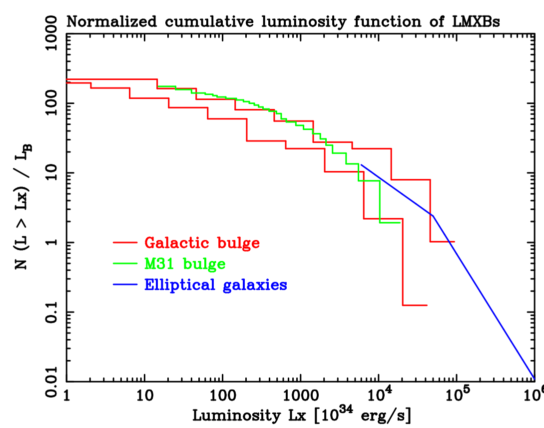

Figure 4. Luminosity function of the LMXBs normalized by the B-band luminosities of the host bulges

function of the LMXBs over the wide luminosity range of $10^{34} - 10^{40}$ erg s^{-1} is represented by the power-law model, whose slope becomes steeper (0.4, 0.8, and 1.8) as the luminosity increases.

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