Suzaku Observations of Unidentified X-Ray Sources Towards the Galactic Bulge

Hideyuki Mori[1], Yoshitomo Maeda[1], Manabu Ishida[1], Yoshihiro Ueda[2]

[1] Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency
[2] Kyoto University
E-mail(HM): mori@astro.isas.jaxa.jp

Abstract

We present the Suzaku observations of two unidentified sources discovered with ROSAT towards the Galactic bulge. We obtained the wide-band spectra of these sources above 2 keV, for the first time. The X-ray spectrum of 1RXS J165256.3−264503 showed a Kα emission line from He-like Ne and was well reproduced by two thin-thermal plasma components with temperatures of 0.7 and 2.4 keV, which is reminiscent of a spectrum of an active binary. On the other hand, the spectrum of 1RXS J174459.5−172640, extending up to 20 keV, was well represented with a cut-off powerlaw model with a photon index of 2.2 and a cut-off energy of 17 keV, or a multi-color disk blackbody ($kT \sim 0.2$ keV) plus Comptonized blackbody model, where the electron temperature is 19 keV. Therefore, we inferred that the former is a RS-CVn type binary and the latter is a low-mass X-ray binary (LMXB) with a luminosity of $\sim 10^{35}$ erg s^{-1}, at which the X-ray emission mechanism of the LMXB has seldom been studied systematically.

Key words: Galaxy: bulge — X-rays: stars — stars: binaries: general

1. Introduction

A galactic bulge is a gravitationally-relaxed spheroidal rotator surrounding the galaxy. Since the bulge is presumed to be an old ($\sim 10^9$ yr) galactic component, the primordial stars in the bulge with a mass over $8M_\odot$ have already evolved into compact objects such as neutron stars or black holes. These compact objects should form binary systems together with slowly evolving low-mass stars and emit X-rays via accretion flow from their companions. We picked up the X-ray source candidates located in the Galactic bulge from the ROSAT Bright Source Catalogue, using the absorption estimated from the X-ray spectral color for each source. In order to reveal the nature of these unidentified bulge sources, we conducted the observations of 1RXS J165256.3−264503 and 1RXS J174459.5−172640 with Suzaku.

2. Analysis and Results

2.1. 1RXS J165256.3−264503

The XIS image showed that no point-like and/or diffuse sources except for 1RXS J165256.3−264503 within the XIS field of view. Then, we accumulated the XIS photons from a 4.′3 circle centered on the RBSC source position. We chose the background region as an annulus surrounding the source region. Since no variability was found in the background-subtracted XIS lightcurve, we extracted the XIS spectra during the whole time interval. On the other hand, we found no significant signals from the HXD PIN data.

We show the XIS spectra obtained with FI and BI CCDs in figure 1 (left). We can see a Kα emission line at 1 keV from highly-ionized Ne in both spectra. Thus, we first tried to fit the spectra with a thin thermal plasma model in collisional ionization equilibrium (CIE) affected by photoelectric absorption. However, the fit was statistically unacceptable ($\chi^2 = 545/241$ d.o.f.). Since the residual indicated a marginal emission-line feature and an excess above 3 keV, we fitted the spectra by two CIE plasma components with the same absorption column density (N_H). We set the elemental abundances to be free parameters but tied them between the two plasma components. We obtained an acceptable fit ($\chi^2 = 179/238$ d.o.f.). The temperatures of the plasma were 0.7 and 2.4 keV. The elemental abundances were $\sim 30\%$ relative to the solar values except for Mg and Ne; Ne was overabundant in these plasma. We superposed the best-fit model on the data, together with each CIE plasma component in figure 1 (left).

Since the absorption column density of $N_\mathrm{H} \sim 1 \times 10^{21}$ cm^{-2} is consistent with the HI column density in the line sight of the source (Dickey and Lockman 1990), the source is probably located in our Galaxy. The temperature combination (0.7 and 2.4 keV) suggests that the origin of the X-ray emission is a coronal plasma associated with an active star binary (e.g., Swank et al. 1981). Fur-

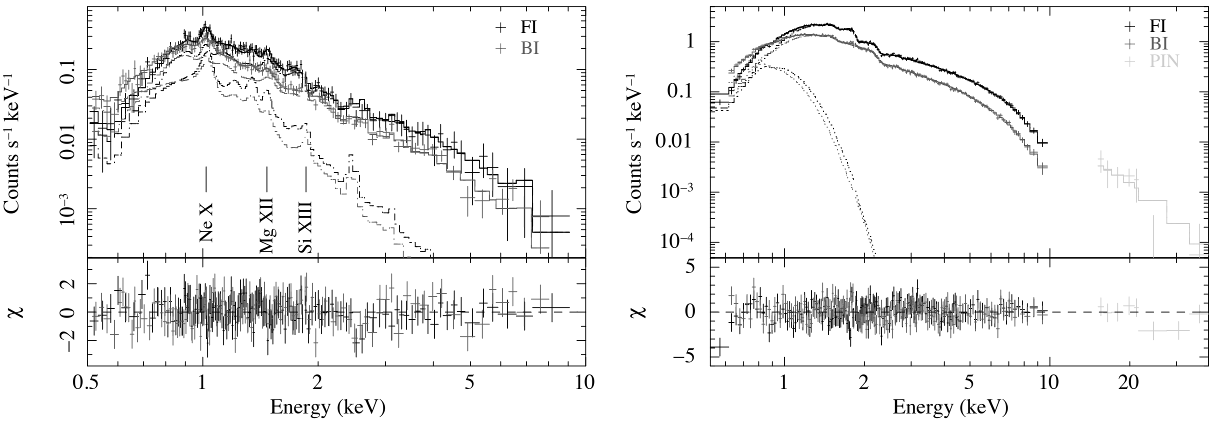

Fig. 1. Spectra of 1RXS J165256.3−264503 (left) and 1RXS J174459.5−172640 (right). The data obtained with FI CCD, BI CCD, and HXD PIN are indicated with black, red, and green crosses. We superposed the best-fit model on the data, together with each component.

thermore, using the SIMBAD database, we found a RS-CVn type star, HD 152178 (Fekel et al. 1999), located $\sim$ 4" away from 1RXS J165256.3−264503. This position coincidence also supports our identification. Since the distance to HD 152178 is estimated to be 472 pc from its parallax, we can infer the X-ray luminosity of 6.0×10^{31} erg s^{-1}, an order of magnitude brighter than that of a typical RS CVn star.

2.2. 1RXS J174459.5−172640

We first made the background-subtracted lightcurves in the XIS and HXD PIN energy bands. For the XIS data, the source and background extraction regions were chosen to be a 6.′1 circle and its surrounding annulus, respectively. For the HXD-PIN spectra, we estimated the contribution of the Galactic Ridge X-ray Emission (GRXE; Koyama et al. 1986) within the HXD-PIN field of view to be 4.9×10^{-13} erg s^{-1} cm^{-2}, which is lower than the detection limit at $> 3\sigma$ confidence. Hence, we only generated the CXB spectrum followed by Boldt (1987) and then subtracted it, together with the NXB spectrum, from a raw HXD spectrum.

We show the X-ray spectra of 1RXS J174459.5−172640 extending up to $\sim$ 20 keV in figure 1. Since the XIS spectra show no line feature, we fitted the spectra with an absorbed power-law model. This model well reproduced the overall spectral shape, however, there was a subtle deviation above 8 keV between the data and the model. We then included an exponential cutoff in the power-law model. The fit was significantly improved ($\chi^2 = 386/336$ d.o.f.). The best-fit parameters were as follows: $N_{\rm H} = (3.51^{+0.05}_{-0.03}) \times 10^{21}$ cm^{-2}, $\Gamma = 2.17 \pm 0.06$, and $E_{\rm cut} = 17^{+7}_{-4}$ keV.

We also tried to fit the spectra with some two-component models which have a physical or observational basis. We used a multi-color disk blackbody model (`diskbb` in `XSPEC`; Mitsuda et al. 1984) from an accretion disk to explain the soft X-ray emission. For the hard X-ray emission, we tried to fit the spectrum with a blackbody, power-law, or a Comptonized blackbody model. We tied an absorption column density between the two components. We obtained an acceptable fit by the disk blackbody plus the Comptonized blackbody model ($\chi^2 = 315/330$ d.o.f.). The temperature at the innermost disk radius was $kT_{\rm in} = 110^{+2}_{-3}$ eV. The temperature of the Comptonized blackbody component was $kT = 188^{+10}_{-3}$ eV and the electron temperature of the hot plasma was $kT_{\rm e} = 19.7^{+0.7}_{-0.4}$ keV, which is slightly larger than the cutoff energy described above. In the two component model, we obtained the higher absorption column density of $N_{\rm H} = (5.3 \pm 0.2) \times 10^{21}$ cm^{-2}.

The X-ray spectrum dominated by continuum emission suggests that the source is an X-ray binary including a compact object. Furthermore, the XIS and HXD lightcurves show no pulsation and flux variability. Thus, we infer this source to be a low-mass X-ray binary (LMXB). In the SIMBAD database, 1RXS J174459.5−172640 is identified with a near-infrared (NIR) source, 2MASS J17445953−1726397. Using the Galactic absorption towards the source and its apparent colors, we inferred the color excess of the source to be $(J - H)_0 = 0.27 \pm 0.03$ mag and $(H - K)_0 = 0.02 \pm 0.03$ mag, which is consistent with that of an F-type main sequence star. The result strengthens that the system would be a LMXB class.

References

Bold, E. 1987, Observational Cosmology, 124, 611
Dickey, J. M., & Lockman, F. J. 1990, ARA&A, 28, 215
Fekel, F. C. et al. 1999, A&AS, 137, 369
Koyama, K. et al. 1986, PASJ, 38, 121
Mitsuda, K., et al. 1984, PASJ, 36, 741
Swank, J. H., et al. 1981, ApJ, 246, 208