Suzaku Observation of the Iron Absorption Lines in the Dipping Low-Mass X-ray Binary XB1323–619

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Abstract

We report Suzaku observation of the dipping, bursting low-mass X-ray binary XB 1323–619 focusing on the iron absorption lines in the energy spectra. The source was found to be dim, 1.5×10^{36} ergs/s (1-10 keV, 10 kpc), during the Suzaku observation in 2007 contrary to the brightening trend continued between 1985 and 2003. Clear absorption lines of He/H-like iron ions were detected in the persistent and dip spectra of the Suzaku data. In spite of the luminosity difference of a factor of 4, the equivalent widths (EWs) of the absorption lines and their changes in the dip were not very different from those observed by XMM-Newton in 2003. We considered the cause of similarity in EWs in the framework of the standard disk model.

Key words: accretion disk — X-rays:general — X-ray:individual (XB1323-619)

1. Introduction

XB1323-619 is the dipping, bursting low-mass X-ray binary with an orbital period of 2.93 hr. It shows periodical dips synchronus to the orbital motion, and regular type-1 X-ray bursts. Its X-ray luminosity gradually increased from 1.3×10^{36} ergs/s to 5.4×10^{36} ergs/s between 1985 and 2003. Absorption lines due to highly ionized ions were detected with XMM-Newton (Church et al. 2005) and Suzaku. In this paper, we study the change of the line-forming absorber with the source luminosity, which varied by a factor of 4 between the XMM-Newton and Suzaku observations. Suzaku observation of XB 1323-619 was reported in Bałucińska-Church et al. (2009).

2. Observation

XB1323-619 was observed with Suzaku from 2007 Jan. 9, 11:30, through Jan. 10, 22:00, for a net exposure of 56 ks. XIS was operated with the 1/4 window option to increase the time resolution to 2 sec, and the spaced-row change injection was employed. In this paper, we analysed only the XIS data, although significant flux was detected by HXD.

3. Analysis and Results

During the Suzaku observation, XB1323-619 was relatively dim ($L_X\sim1.5\times10^{36}$ ergs/s), but the regular dipping and bursting activities were clearly detected. Because the type-1 X-ray burst rate was significantly low in 2007 compared to the previous observations, the dim state is considerd to be due to the real decrease in the mass accretion rate. We divided the XIS data into 3, namely persistent (1.8–2.4 c/s), dip1 (1.2–1.8 c/s), and dip2 (0.0–1.2 c/s) depending on the count rate to see how the absorption lines change with the dip. We could see the absorption lines of He-like and H-like iron ions in all the 3 sets of data. We estimated the parameters of the absorption lines from the spectral analysis assuming narrow gaussian profiles.

We also analysed the XMM-Newton archive data (2003 Jan. 29 09:03–22:47). During the XMM-Newton observation, the source luminosity was 5.4×10^{36} ergs/s on average. Because of the gradual change of the X-ray flux, we divided the data into persistent, dip1 and dip2 by eye and determined the parameters of the iron absorption lines. The results are shown in Figure 1.

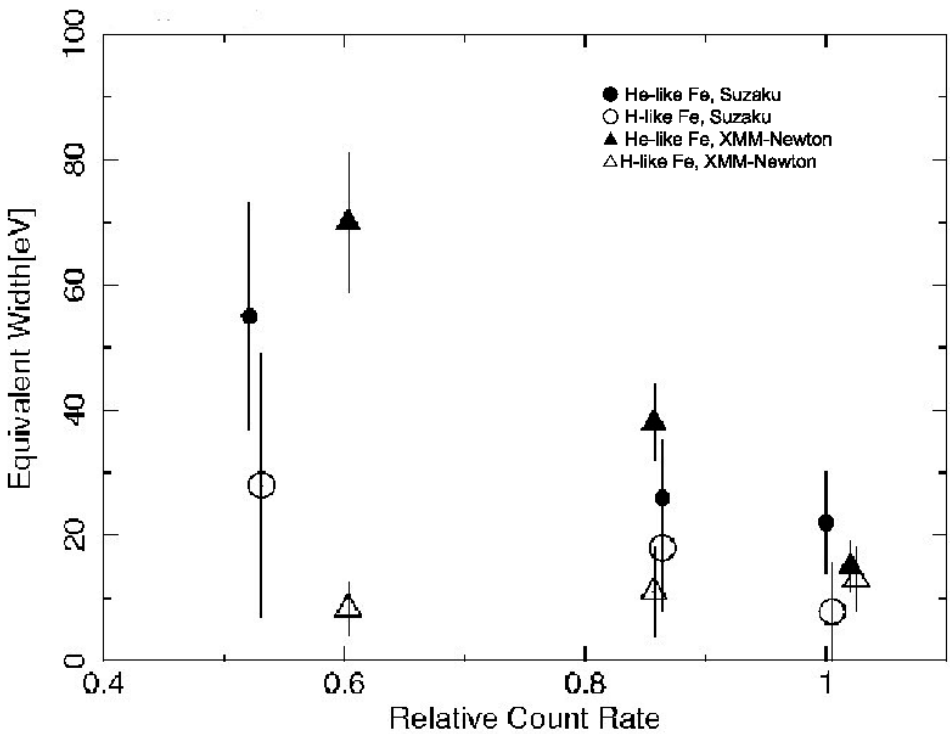

Fig. 1. The EWs of He/H-like iron absorption lines obtained with Suzaku and XMM-Newton are plotted as a function of count rates which are normalized by those of the persistent emission. The EWs of Suzaku and XMM-Newton show similar behaviour in spite of a factor of 4 difference in luminosity.

4. Discussion

As shown in Figure 1, the EWs of the He/H-like iron absorption lines and their changes with dips are very similar between the Suzaku and XMM-Newton observations in spite of the luminosity difference of a factor of 4. The EWs of He-like iron increase in the dip, while those of H-like iron stay almost constant. This means that ξ-parameter of the plasma decreases in the dip. We calculated the column densities of iron ions from the curve-of-growth analysis, and then the ξ-parameters. We found that $\log \xi$ changes from $\sim$3.4 (persistent) to $\sim$2.6 (dip2). We can estimate the distance of the line-forming region from the neutron star using the ξ-parameter. The ξ-parameter may be ralated to the distance as follows:

$$\xi \equiv \frac{L}{nr^2} \sim \frac{L}{N(H)r}, \tag{1}$$

where L represents the X-ray luminosity, n a number density of the plasma, r distance of the line-forming region from the neutron star, and $N(H)$ hydrogen-equivalent column density. Using the ξ and other estimated parameters, we found that r was roughly $\sim 10^{10}$cm for both the Suzaku and XMM-Newton data regardless of persistent or dip. This means that the absorption lines are formed near the outer edge of the accretion disk. However, the line-forming region may be different from the bulge of the disk, because the bulge is considered to be in the low-ionization state (Bałucińska-Church et al. 2009).

In spite of a factor of 4 difference in luminosity, the EWs of the absorption lines, hence the ξ–parameter, are not very different between the Suzaku and the XMM-Newton observations. This may be naturally explained in the framework of the α-disk. If we assume that the length of the disk material along the line-of-sight is proportional to its scale height, we can rewrite the r and $\dot{M}$ dependence of the ξ-parameter as follows:

$$\xi \simeq \frac{L}{N(H)r} \propto \frac{L}{\rho H r} \propto \dot{M}^{\frac{3}{10}} r^{-\frac{1}{4}}, \tag{2}$$

where ρ is the plasma density and H the height of the disk. If we assume the location of the plasma is same at the outer boundary of the disk, the luminosity change of a factor of 4 produces only 1.4 times change in the ξ parameter. This explains why the absorption lines look similar between the Suzaku and XMM-Newton observations.

References

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