Suzaku Observations of the Gamma-Ray Binary 1FGL J1018.6–5856

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ABSTRACT

We performed Suzaku observations of the gamma-ray binary 1FGL J1018.6–5856. Recent observations by the Fermi Gamma-ray Space Telescope and follow-up observations in other wavelengths revealed that the gamma-ray source is a new member of the rare gamma-ray binary class with an orbital period of 16 days. Here we report on results from Suzaku observations of 1FGL J1018.6–5856. With the high statistics of the Suzaku data, we are able to perform phase-resolved spectroscopy. We compare the Suzaku results with earlier observations performed by Swift XRT.

Key words: X-rays: binary — X-ray: individual (1FGL J1018.6–5856)

1. Introduction
Recent gamma-ray observations have revealed that several X-ray binaries (XRBs) are radiating GeV and/or TeV gamma rays. Those objects constitute a new subcategory of XRBs, called gamma-ray binaries.

The gamma-ray source 1FGL J1018.6–5856 is identified as a gamma-ray binary by Ackermann et al. (2012) based on the gamma-ray data taken by Fermi LAT and follow-up observations in other wavelengths. One of the common characteristics of gamma-ray binaries is GeV and TeV gamma-ray flux modulation synchronized with binary orbital periods. Ackermann et al. (2012) found such modulation with a period of 16.58 days.

A counterpart to the gamma-ray source was found in optical, X-rays, and radio. Optical spectroscopy indicates that the counterpart is a star with a spectral type of O6V((f)). This is almost the same as the stellar object in another gamma-ray binary LS 5039, which has O6.5((f)). The Swift XRT detected a X-ray point source whose location is consistent with that of the optical counterpart. All the observational results indicate that 1FGL J1018.6–5856 is a gamma-ray binary system. Here we report results obtained with Suzaku observations of 1FGL J1018.6–5856.

2. Observations
We observed 1FGL J1018.6–5856 with Suzaku four times in 2012. The observation log is shown in Table 1. Obs1 covers the phase interval when X-ray peak was found by the Swift XRT. The other three observations, Obs2, 3, and 4, were performed to follow the spectral evolution in the other part of the orbit.

We used XIS data in the following. For the lightcurves shown below, we extracted backgrounds from off-source region and simply subtracted them. For the spectral studies, we generated non-X-ray background spectra using xisnxbgen. We extracted X-ray background spectra from off-source regions and subtracted them after correcting for the vignetting effect of the XRT.

3. Analysis & Results
3.1. Temporal Analysis
Figure 1 is the folded lightcurve of 1FGL J1018.6–5856 obtained with the XIS (XIS0 + XIS3). The time bin width is 20 ks. We also plot Swift XRT data taken from Ackermann et al. (2012). Compared to the Swift XRT lightcurve, it seems that the flux becomes maximum at earlier phase $\phi < 0.96$.

3.2. Spectral Analysis
We analyzed the spectra obtained in each observation. For Obs2, we divided the data into three time intervals and made spectra for each of them in order to follow the spectral evolution during the flux decay.

All the spectra are well fit with absorbed power laws. Since the absorption column density $N_H$ and the photon index $\Gamma$ generally correlate, we simultaneously fit all the spectra with $N_H$ as a common parameter and see how $\Gamma$ changes as a function of orbital phase. From the fitting, we obtained $N_H = (8.0 \pm 0.9) \times 10^{21}$ cm$^{-2}$ and $\Gamma = 1.47 – 1.78$.

Figure 2 shows the examples of the spectra where the
black and red points are the spectra for the hardest (the first time interval in Obs2) and softest (Obs1) cases, respectively. In Figure 3, we plot unabsorbed flux over the energy range of 1–10 keV and $\Gamma$ as functions of orbital phase. It is evident that the spectrum becomes hard particularly around $\phi = 0.0$.

Fig. 2. XIS spectra obtained in $0.96 < \phi < 0.98$ (black) and $0.60 < \phi < 0.63$ (red).

4. Discussion
The gamma-ray binary 1FGL J1018.6–5856 is very similar to LS 5039 in terms of the spectral type of the stellar object and also the gamma-ray properties (Ackermann et al. 2012). The X-ray spectra of the two systems also resemble each other with photon indices $\Gamma \sim 1.5$, suggesting the same emission mechanism.

Except for the peak at $\phi \sim 0.0$, the X-ray orbital modulation of 1FGL J1018.6–5856 seems stable in the period from 2011 to 2012 as shown in Figure 1. A similar stability is found in LS 5039 by Kishishita et al. (2009), who found the orbital modulation is stable over the past decade. As pointed out by Kishishita et al. (2009), the stability can be the common characteristics of the gamma-ray binaries hosting O-stars.

The X-ray peak at $\phi \sim 0.0$ is found to be highly variable. The peak may be produced by the same mechanism as the peak found in LS 5039 at inferior conjunction, which also indicates some degree of variability. Measurements of the orbital parameters of 1FGL J1018.6–5856 are necessary to discuss this point in more details.

Fig. 3. Orbital variation of unabsorbed flux in the energy range of 1–10 keV (top) and photon index (bottom).

References
Ackermann, M. et al. 2012 Science, 335, 189