Short-term spectral softening of black-hole binary Swift J1753.5–0127[†]

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The X-ray emission from black-hole binaries (BHBs) is driven by the release of gravitational energy from accreting matter falling into a black hole (BH). The X-ray intensities are known to fluctuate for approximately weeks or months (outburst). There are two states: the low-luminosity hard (low/hard) and the high-luminosity soft (high/soft) states. The X-ray spectra of the low/hard state can be well reproduced by a power law with a photon index of 1.4–2.1.[1)] The spectra of the high/soft state can be explained by optically thick thermal disk emission (accretion disk[2)3)]). Transitions between the low/hard and high/soft states during the outburst have been observed in many BHBs.

The Swift J1753.5–0127 outburst was occurred on May 30 2005.[4)] After the outburst, the source flux peaked on July 9 2005, and then gradually decreased for more than 9 years. Dips were observed in the 15–50 keV energy range that lasted for approximately 25 days (short-term variation). The dips are interpreted as a possible eclipse by the warped disk.[5)] Observations with *MAXI*[6)] revealed the increase of the intensity in the 2–4 keV energy range during the variation in 2009.[7)] The increase can not be explained by the eclipse. To investigate the cause of the short-term variation, we have studied the X-ray spectrum.

For another short-term variation of the source on April 23 2012, we succeeded in tracing its spectral time evolution, as shown in Fig. 1. We overlaid the light curves for the various energy ranges normalized by the mean count rates, which were calculated by averaging over approximately 40 days. The light curves below and above 10 keV were observed using *MAXI* and *Swift*[8)], respectively. The hump in the 0.7–4 keV band and the dip in the 15–50 keV band correspond to the growth and decay of the accretion disk, respectively (Fig. 1a). The X-ray spectrum observed by using the Swift-XRT[9)] changed during the short-term variation (Fig. 1b). The spectrum can be fitted by the emission model of the accretion disk. The disk temperatures ($T_{\rm in}$) and energy fluxes ($F_{\rm disk}$) changed from 0.48 to 0.2 keV and from 4.8×10^{-9} to 2.2×10^{-9} erg s^{-1} cm^{-2}, respectively. The best-fit parameters show the variation of the accretion disk and the state transitions from the low/hard to high/soft state (softening) during the short-term variation. The $F_{\rm disk}$ and $T_{\rm in}$ did not obey the relationship, $F_{\rm disk} \propto T_{\rm in}{}^4$, suggesting that the structure of the accretion disk changed during the softening.

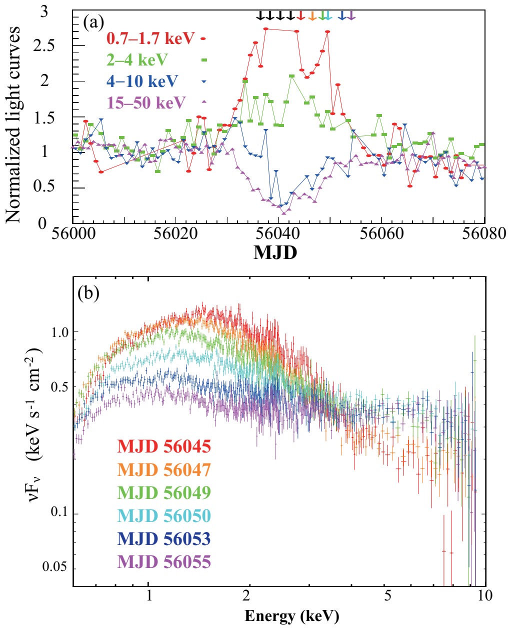

Fig. 1. (a) The light curves in energy ranges of 0.7–1.7 keV (red), 2–4 keV (green), 4–10 keV (blue), and 15–50 keV (magenta) normalized by the average value. Arrows indicate the XRT observations on MJD 56045 (red), 56047 (orange), 56049 (green), 56050 (cyan), 56053 (blue), 56055 (magenta), and the other dates (black). These colors correspond to the spectrum observed on MJD 56045, 56047, 56049, 56050, 56053, and 56055 in Fig. (b).

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