Stellar flare of a close binary system during the NICER-Hisaki Observing Campaign 2018-2019

*Tomoki Kimura[1], Wataru Iwakiri[2], Atsushi Yamazaki[3], Go Murakami[3], Fuminori Tsuchiya[4], Kazuo Yoshioka[5], Hajime Kita[3], Masaki Kuwabara[3], Shin Toriumi[3]

1. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, Sendai, Japan, 2. Faculty of Science and Engineering, Chuo University, Tokyo, Japan, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan, 4. Planetary Plasma and Atmospheric Research Center, Tohoku University, Sendai, Japan, 5. Department of Complexity Science and Engineering, University of Tokyo, Kashiwa, Japan

Dynamics of stellar flare is still not well understood compared to the sun because of lack of continuous monitoring of distant stars at multiple wavelengths. Here we present a flare event at a close binary system, UX Arietis, monitored with the planetary extreme ultraviolet (EUV) space telescope Hisaki and the NICER X-ray Telescope from late 2018 to early 2019. Time variabilities in the EUV and X-ray spectra of the binary were successfully monitored from the beginning to the end of flare. Emission power at the Hisaki EUV wavelengths peaked at 6e+24 W, which is comparable with that measured in the NICER X-ray wavelength at 0.4-8 keV. The EUV spectrum was indicative of carbon, nitrogen, oxygen, and silicon ion emission lines. Electron temperature and density, emission measure, and ion balance were reduced from the emission lines by the spectral diagnostics. The spectral diagnostic indicates that EUV emission region with density and temperature comparable to the solar chromosphere expanded to spatial scale of a stellar radius (1-4e+6 km) during the flare. We interpret the EUV emission region is a flare ribbon expanding in the chromosphere. The X-ray spectrum was also diagnosed in a similar manner with the EUV spectrum with a collisional plasma emission model implemented in the XSPEC tool. Derived parameters are indicative of a compact flare loop on a spatial scale of stellar radius heated up simultaneously with the flare ribbon expansion. The derived flare spatial scale clearly contradicts the previous implication that the flare loop bridges between the two stars of binary system separated by 1.6 AU (2.4e+8 km) (Simon et al., 1980). At the flare rising time, the total mass of flare loop 3e+18 kg was significantly supplied from the chromosphere by the evaporation upflow with a speed of ~500km/s. The total energy of 1e+30 W was dissipated in the flare, which leads the magnetic flux of the flare loop to be more than 55G. These results are the first ever constraints on the mass and energy transfer processes between the flare loop and chromosphere at the stars.

Keywords: star, flare, Hisaki satellite

