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Multi-wavelength study of long-term activities of galactic Be/X-ray binaries

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A Be star is an early-type massive star with a circumstellar disk, and a Be/X-ray binary (BeXB) is a binary system composed of a Be star and a compact star. Be stars and BeXBs are important not only for their interesting phenomena related to their disks but also in terms of binary evolution, gravitational wave astronomy, and cosmology. However, many aspects of the physics remain unknown, such as the mechanisms of disk formation and the two types of outbursts in BeXBs. One way to investigate the activity of massive stars including Be stars is to study periodic flux oscillations in the amplitude of less than a few percent and on the time scale of hours to days caused by their rotation and pulsation. Study of such flux variations has been difficult due to limitation of ground-based observations, but Transiting Exoplanet Survey Satellite (TESS), which brings high-accuracy and high-cadence continuous optical photometric data of all-sky sources, has enabled comprehensive investigation of Be star activities in BeXBs.

The purpose of this study is to constrain the relationship between Be star activities and the circumstellar disk in BeXBs. Therefore, we investigated long-term variations of flux periodicity and multi-wavelength luminosity using TESS data and multi-wavelength long-term light curves for 17 galactic BeXBs. As a result, we confirmed long-term optical and near-infrared (OIR) variations originating from circumstellar disks for all targets with available OIR light curves, and five sources exhibited giant outbursts. In addition, we found anti-correlations between the infrared excess and the amplitude of flux oscillations for the five giant outbursters, which appears to contradict the conventional idea that non-radial pulsation contributes to the growth of the circumstellar disk. After examining multiple scenarios to explain these results, we conclude that there should be a genuine inverse correlation between the pulsation amplitude and the disk growth, and pulsations may not contribute to the mass ejection. We proposed a scenario in which internal temperature changes of the Be star cause a transition between a pulsation active state and a mass-ejection active state. For a more rigorous discussion, more frequent and multi-wavelength observations of flux periodicity are required.