# 学位論文要旨

Near-infrared observational studies of black hole low mass X-ray binary GRS 1915+105 in the X-ray low luminous state
(X 線で暗い状態のブラックホール低質量 X 線連星 GRS 1915+105 の近赤外線の観測的研究 )

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A black hole low-mass X-ray binary is a binary system of a black hole and a low mass star (less than solar mass, hereafter companion star). The black hole is surrounded by an accretion disk and occasionally ejects plasma with relativistic velocity (jet). The energy of the object is supplied by the gravitational energy released by the gas from the companion star as it falls into the black hole. The radio and soft X-ray emissions are synchrotron radiation from the jet and blackbody radiation from the inner parts of the disk, respectively. Candidate for the origin of the near-infrared (NIR) emission is the jet, the outer parts of the disk and the companion star. Which of these is the main origin depends on the state of the object. The main origin can be determined by detailed NIR observations and multi-wavelength observations with the radio and X-ray bands. If the origin of the NIR emission can be accurately determined, more detailed information on the geometry and emission mechanisms of the jet and the disk can be provided from multi-wavelength spectral analysis.

The black hole low-mass X-ray binary GRS 1915+105 is a well-known source; the first observation of superluminal motion of radio blobs in our galaxy, 14 regular patterns of X-ray variation, and relationship between a disk wind and the jet. One of the other most unique characteristics, not seen in any other black hole low-mass X-ray binary, is that GRS 1915+105 has continuously been in the high flux state in the X-ray band for about 26 years since its discovery in 1992. The radio is also bright, often in the range of a few mJy to several hundred mJy, leading to many opportunities for the multi-wavelength observation between the radio and X-ray bands. NIR observations were also performed, but were much smaller in amount than the radio and X-ray observations.

In mid-2018 and mid-2019, GRS 1915+105 suddenly dimmed and transitioned to the faintest state in soft X-ray observations ($<$10 keV). From the X-ray spectral analysis, the main factor of the second X-ray dimming was found to be the X-ray obscuration. However, there are few reports of the NIR observations before and after the second dimming, and the characteristics of the NIR flux variations and the origin of the NIR emission are not clearly understood.

We performed long-term, dense NIR observations in two bands with Kanata telescope at the Higashi-Hiroshima Observatory from April 2019 to November 2020. The radio and X-ray data were taken from Yamaguchi interferometer and from MAXI and RXTE, respectively.

Focusing on the variation timescales longer than one day, the followings were found. Comparing with the NIR flux until 2008, the NIR flux after the second X-ray dimming was found to be higher than the maximum flux level of the past. A more detailed investigation of the NIR variation before and after the second X-ray dimming showed that there was a NIR brightening during the X-ray dimming. The radio flux was higher after the second X-ray dimming as well as the NIR flux.

Focusing on the variation timescales shorter than one day, the followings were found. After the second X-ray dimming, the NIR flux showed variations on timescales of more than ten minutes (flares). However, the flare was not seen on all days, and on some days flare was absent during more than 5 hours of observations. The base line flux of the flare after the second X-ray dimming was clearly higher than that of the past flares. On the other hand, there was no obvious difference of the rise and decay timescales and amplitude of the flare.

Before and after the second X-ray dimming, the followings were found for the origin of the NIR emission of the variation timescales longer than one day. Before the second X-ray dimming, and the radio to NIR spectrum could not be explained by the jet. This suggests that the origin of the NIR emission before the second X-ray dimming is not the jet but the disk or the companion star. On the other hand, after the second X-ray dimming, the radio and NIR fluxes were both high, and the high fluxes were kept for at least 90 days in both bands. This suggests that the jet is the main origin of the NIR emission after the second X-ray dimming. However, since the NIR flux was higher than the maximum flux level of the past, non-jet origin may also contribute to the NIR band. The non-jet candidate is not the disk due to the low X-ray flux, but the X-ray obscuration.

After the second X-ray dimming, the followings were found for the variation on timescales of shorter than one day. There are two scenarios that explain the difference of the base line flux of the past and after the X-ray dimming. The first is that the intrinsic rise and decay timescales are different and the flare after the X-ray dimming has longer intrinsic timescales. The second is that the origin of the flare after the second X-ray dimming is different from the past flare, and that the origin of the flare after the second X-ray dimming is the jet and the non-jet origin with longer timescales.