GRS 1758–258: RXTE monitoring of a rare persistent hard state Black Hole

Maria Obst 1, K. Pottschmidt 2, A. Lohfink 1, J. Wilms 1
M. Böck 1, D. M. Smith 3, J. A. Tomsick 4, K. Kreykenbohm 1

1Remeis Observatory/ECAP, Bamberg, Germany; 2CREST/NASA-GSFC, Greenbelt, MD, USA; 3UMBC, Baltimore, MD, USA
4UMCP, College Park, MD, USA; 5SCDF/UCSC Santa Cruz, CA, USA; 6SSL/ISI, Berkeley, CA, USA

E-mail: maria.obst@sternwarte.uni-erlangen.de

Abstract

GRS 1758–258 is the least studied of the three persistent black hole X-ray binaries in our Galaxy. It is also one of only two known black hole candidates, including all black hole transients, which shows a decrease of its 3–10 keV flux when entering the temporarily dormant soft state, rather than an increase. We present the spectral evolution of GRS 1758–258 from RXTE-PCA observations spanning a time of about 11 years from 1998 to 2009. During this time, seven dim soft states are detected. We also consider INTEGRAL monitoring observations of the source and compare the long-term behavior to that of the bright persistent black hole X-ray binary Cyg X-1. We discuss the observed state transitions in the light of physical scenarios for black hole transitions.

1. Background modeling: Galactic Ridge Emission

The disk becomes visible in the dim soft states, the low source flux increasing the error bars.

- Soft states are most likely due to a decrease in mass accretion rate.
- RXTE-PCA spectra in the 3–20 keV band were fitted with an absorbed powerlaw, a weak neutral iron line, and a black body disk component where required, always including the Galactic ridge emission (see below). The column density due to interstellar absorption in the direction of GRS 1758–258 is at $N_H = 1.5 \times 10^{21}$ cm$^{-2}$ according to earlier results (Pottschmidt et al., 2008). The disk becomes visible in the dim soft states, the low source flux increasing the error bars.

2. Hardness Intensity Diagram

For energies $>20$ keV the HID of GRS 1758–258 shows a clear hysteresis for hard and soft state fluxes (absorbed fluxes, see Fig. 7). This behavior is similar to that shown by black hole transients over their entire outburst ("h-shaped" HED; Fender et al., 2004). Different from transients, there is no rise in the hard state from quiescence. During the most extreme soft state the 3–20 keV flux is clearly below the lowest hard state flux, with no full return to the hard branch observed down to near-quiescence. A comparison at these energies with our long-term RXTE monitoring observations of the persistent black hole X-ray binary Cyg X-1 is in preparation.

3. RXTE Monitoring

Results from spectral fits to 2003–2009 INTEGRAL monitoring data of GRS 1758–258 (Lohfink et al., 2011) allow us to extend the HID studies to higher energies (Fig. 8). For a luminosity-based comparison with the Cyg X-1 RXTE monitoring data, we assumed a distance of 2.5 and 8.5 kpc for Cyg X-1 and GRS 1758–258, respectively. As expected neither source shows hysteresis for energies $>20$ keV, i.e., in an energy range where only one, namely the hard, spectral component dominates. We confirm with the most extensive datasets to date that the hard states of both sources are remarkably similar in luminosity and hardness. While the decay towards softness, lower luminosity states is qualitatively similar in both sources as well, the luminosity of GRS 1758–258 has dropped more severely at a given hardness level than that of Cyg X-1. Overall, the tracks of GRS 1758–258 in both HIDs are consistent with a persistent hard state source with occasional softening due to a temporary decrease in the mass accretion rate as suggested by Smith et al. (2002).

References


Acknowledgments

We thank A. Bodaghee, V. Grinberg, and M. Hanke for helpful discussions.

The X-ray Universe – Berlin, Germany, 2011 June 27 – 30