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Abstract

Thermal instability of accretion disk should appear when a persistent low mass X-ray binary (LMXB) goes into quiescence. We analyze the complicated X-ray activity of one such case, KS 1731-260. On the decline from a strange, 12 years long outburst, it went through a series of so-called echo outbursts with the properties similar to the ordinary soft X-ray transients. We interpret the onset of echo outbursts as a decrease of the mass transfer rate which lead to a transition from a thermally stable to unstable disk. The X-ray spectrum at the peak of the echo outburst is consistent with that in the high state outbursts. The echo outbursts are outside-in. A series of heating and cooling fronts formed and the disk just reached a steady-state at the outburst peak. We show that the individual echo outbursts are dependent on each other in KS 1731-260. KS 1731-260 provides a link between persistent and transient systems.

Results

- On this remarkable system we show that the transition from persistent X-ray sources to quiescence (or even hibernation) goes through a series of outbursts with the properties similar to SXTs.
- We interpret the echo-outbursts in KS 1731-260 as a decrease of the mass inflow rate from the donor which lead to a transition from a thermally stable to unstable disk.
- Peak intensity of the echo-outbursts lies on the extrapolation of a gradually decaying level of emission prior to the onset of instability.
- Evolution of the X-ray hardness ratios HR1 and HR2 with $\Gamma_{echo}$ shows that the X-ray spectrum at the peak of the echo-outburst is consistent with that in the high state (main outburst). The disk thus appears to achieve steady-state during the maxima of echo-outbursts. They appear to be a continuation of the spectral evolution exhibited in the high state.
- Evolution of HR1 and HR2 bears a resemblance to that in 4U 1820-30 (Simon 2001) and suggests that KS 1731-260 is still, too.
- The rise of the echo-outbursts steeper than the decay implies that the heating front starts in the outer disk region invisible in type of X-rays. An alternative explanation by an optically thin advection-dominated accretion flow (ADAF) is unlikely because the disk did not get into low state between most echo-outbursts ($\Gamma_{echo}$ was clearly above the quiescent values, a series of heating and cooling fronts thus formed). The luminosity between echo-outbursts is much higher than observed later by XMM by Wijnands et al. (2002).
- Relativley smooth profiles of the O-C curve and WZMH suggest that the individual echo-outbursts are dependent on each other in KS 1731-260. Their recurrence time $\tau_{echo}$ enganges complicated, non-constant variations, accompanied by the complicated variations of the outburst parameters. This cannot be explained purely by a steadily decreasing mass inflow from the donor (e.g. also accretion changes are needed).
- We interpret the ~12.5 years lasting 'main outburst' as being caused by a real increase of the mass outflow from the donor, and not by the thermal instability of the disk alone. The reason is that the transitional in the long-lasting main outburst remains only slightly higher than the typical luminosity of the peaks of the echo-outbursts. This can be explained if the disk was kept in steady-state by the increased mass inflow from the donor.
- The state of long-term activity of 'classical' SXTs is not the same as in KS 1731-260. Well observed SXTs (e.g. Aql X-1, 4U 608-53) display outbursts activity in which the disk alternatess between cold and hot state. On the contrary, the disk in KS 1731-260 was depleted during a short time and this system may be in a hibernation state now.
- Long-term activity of KS 1731-260 provides a link between persistent and transient LMXBs.