Astrophysics > High Energy Astrophysical Phenomena

Spectro-timing analysis of Cygnus X-1 during a fast state transition

Moritz Boeck, Victoria Grinberg, Katja Pottschmidt, Manfred Hanke, Michael A. Nowak, Sera B. Markoff, Phil Uttley, Jerome Rodriguez, Guy G. Pooley, Slawomir Suchy, Richard E. Rothschild, Joern Wilms

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We present the analysis of two long, quasi-uninterrupted RXTE observations of Cygnus X-1 that span several days within a 10 d interval. The spectral characteristics during this observation cover the region where previous observations have shown the source to be most dynamic. Despite that the source behavior on time scales of hours and days is remarkably similar to that on year time scales. This includes a variety of spectral/temporal correlations that previously had only been observed over Cyg X-1's long-term evolution. Furthermore, we observe a full transition from a hard to a soft spectral state that occurs within less than 2.5 hours - shorter than previously reported for any other similar Cyg X-1 transition. We describe the spectra with a phenomenological model dominated by a broken power law, and we fit the X-ray variability power spectra with a combination of a cutoff power law and Lorentzian components. The spectral and timing properties are correlated: the power spectrum Lorentzian components have an energy-dependent amplitude, and their peak frequencies increase with photon spectral index. Averaged over 3.2-10 Hz, the time lag between the variability in the 4.5-5.7 keV and 9.5-15 keV bands increases with decreasing hardness when the variability is dominated by the Lorentzian components during the hard state. The lag is small when there is a large power law noise contribution, shortly after the transition to the soft state. Interestingly, the soft state not only shows the shortest lags, but also the longest lags when the spectrum is at its softest and faintest. We discuss our results in terms of emission models for black hole binaries.

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