Long-term temporal and spectral analysis of neutron star low-mass X-ray binary 4U 1636-536

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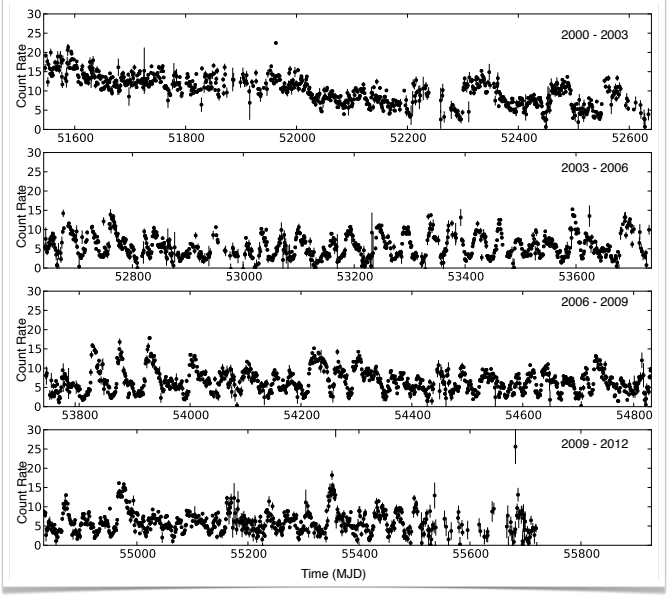
Introduction

We present here an undergoing photometric and spectroscopic studies on a decade long X-ray variation in the neutron star X-ray binary system, 4U 1636-536. The source has been exhibiting a transient- like behaviour since 2002. the multi-wavelengths photometric studies suggest that the ~30-40 d variation could be due to the accretion instability within the binary. Because of its relatively short variation timescale and abundant archive data from various X-ray observatories, 4U 1636-536 indeed is an ideal laboratory to study the physics of accretion near compact object like neutron star and black hole.

A decade of long term variation

Figure 1: RXTE/ASM (2-12 keV) light curves from 2000 to 2011 June 9

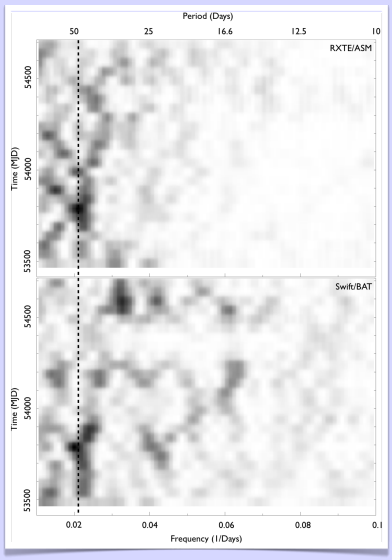


(**Figure 1**) During 2000-2001, the All sky Monitor onboard the Rossi X-ray Timing Explorer (RXTE/ASM) begun to record an obvious, gradual decline of X-ray flux level (2-12 keV) from the neutron star low-mass X-ray binary (LMXB) 4U 1636-536. Within a year, the LMXB began to exhibit a substantial quasi-periodic, long-term variation[1].

(**Figure 2**) Based on multi-year monitoring data covering broad wavelengths from various X-ray satellites, such as RXTE, INTEGRAL, Swift, and etc., it is clear that the long-term variation of 4U 1636-536 is a persistent phenomenon in the last decade.

Although 4U 1636-536 seems to vary on a time scale of 30~40 days. This time scale is, by no mean, a precise periodicity and has been continuously evolving over last decade without showing any trace of a even longer time scale, such as the superorbital

Figure 2: Dynamic periodograms of RXTE/ASM and Swift/BAT data



The light curve phenomenology

Figure 3A: Close view of INTEGRAL/ISGRI, Swift/BAT, and RXTE/ASM light curves

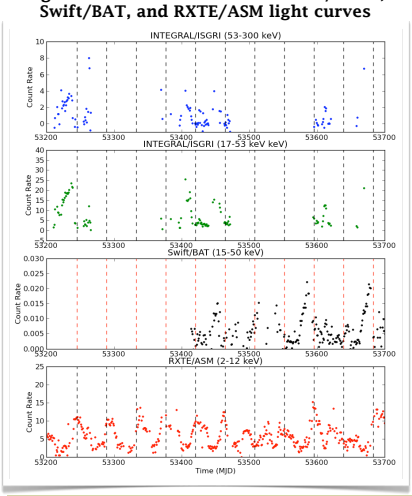
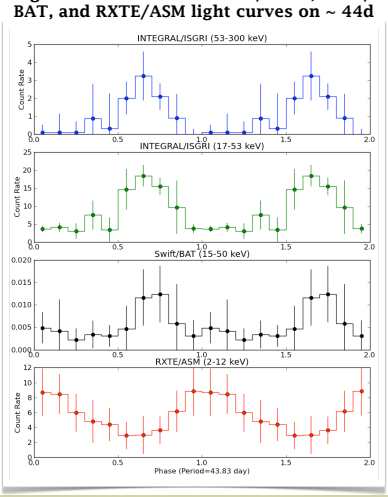


Figure 3B: Folded INTEGRAL/ISGRI, Swift/BAT, and RXTE/ASM light curves on ~ 44d

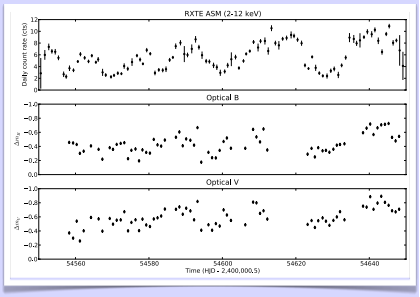


period seen in SMC X-1[2].

(**Figure 3,4**) More remarkably, this variation is energy-dependence between optical, soft (<20 keV) and hard (>20 keV) X-rays.

The optical/soft X-ray correlation may be explained by the X-ray reprocessing at the surface of disc or companion star, and its Soft/hard X-rays relation resembles the state transition seen in many black hole X-ray binaries, i.e., GX 339-4[3].

Figure 4: RXTE/ASM and optical light curves

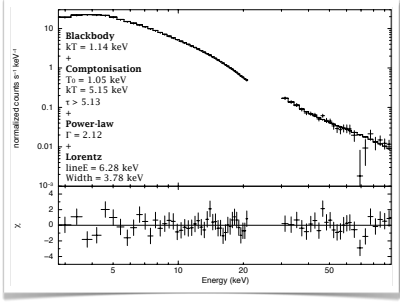


The spectral evolution in 4U 1636-536

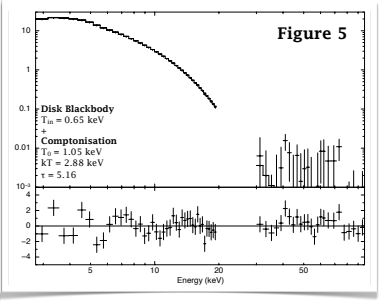
(**Figure 5**) demonstrates RXTE/PCA+HEXTE spectra of 4U 1636-536 at two particular variation phases (based on RXTE/ASM flux)[4].

We are currently working on a broadband spectral analysis using data from RXTE, INTEGRAL, Swift, and Suzuku to compare the spectral evolution in 4U 1636-536 to the spectral transition in black hole X-ray binaries. We are also very interested in studying the mechanism(s) of higher energies (20 ~ 300 keV) from X-ray binaries.

1 Shih et al., 2005, MNRAS, 361, 602
2 Clarkson et al., 2003, MNRAS, 339, 447
3 Caballero-Garcia et al., 2009, ApJ, 692, 1339
4 Shih et al., 2011, MNRAS, 412, 120



MJD 53612: at a RXTE/ASM minimum



MJD 54270: at a RXTE/ASM maximum