Recent X-ray Observations of Classical Novae with Suzaku

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ABSTRACT

We report the results of ToO observations for recent three classical novae with the Suzaku X-ray satellite. Classical novae occur in binary systems consisting of a white dwarf and a late-type companion. X-rays can be emitted at various stages in the post-burst evolution via different mechanisms, and it gives a powerful tool to unveil the currently-inaccessible phenomena shielded by the thick ejecta. Systematic studies with many samples are mandatory to elucidate a picture of classical novae, however, it was poorly studied because observations are quite difficult by faint, transient, and cataclysmic behaviors. We are therefore working on intensive follow-up observations of classical novae using Suzaku in collaboration with worldwide telescopes and satellites.

1. INTRODUCTION

Classical novae are a class of cataclysmic variables. Sudden outbursts occur by nuclear fusion of hydrogen on the white dwarf surface. X-rays can be emitted at various stages in the post-burst evolution via different mechanisms. Hard X-rays are often seen from an early phase, originating presumably from shocks in the expanding ejecta. In contrast, soft X-rays emerge in a later phase when the hot photospheric emission of the white dwarf is revealed by a thinning envelope. When the secondary star is a giant, the released energy and mass can propagate through significant circumstellar material that can form an X-ray emitting shock structure similar to those of supernova remnants but on much smaller scales both in time and space.

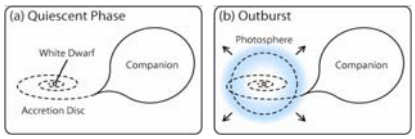

Fig.1. Schematic view of the Classical novae. (a) H-rich material accumulates on the white dwarf surface in the quiescent phase. (b) The outburst occurs and photosphere expands quickly.

2. OBSERVATIONS & ANALYSIS

For the classical nova V458 Vul, an observation yielded a well-exposed X-ray spectrum 88 days after the outburst, and we could identify emission lines from highly ionized neon, magnesium, and silicon on a hard X-ray continuum (figure 2 and 3; Tsujimoto et al., 2009, PASJ). For V2491 Cyg, we obtained the first detection of non-thermal X-rays from a classical nova explosion (figure 4 and 5; Takei et al. 2009, ApJL). Power-law emission, extending up to 70 keV with a very flat slope (photon index of 0.1), poses a challenge for understanding the emission mechanism as well as the acceleration mechanism of electrons in the explosion. For V2672 Oph, a timely pointed observation captured the rise phase of a remarkable soft X-ray flare. The flare spectral evolution during the rise was characterized by an increase only in the soft 0.5-2.0 keV energy band (figure 6, 7, and 8; Takei et al., in prep.).

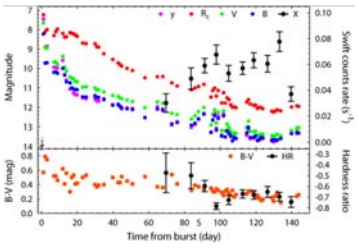

Fig.2. Evolution of V458 Vul in brightness and color. The epoch of the Suzaku observation is indicated with "S" on the abscissa (see figure 1 in Tsujimoto et al., 2009, PASJ).

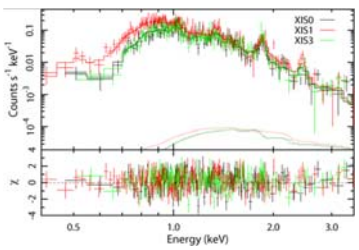

Fig.3. Background-subtracted V458 Vul spectra with Suzaku on day 88. Different colors are used for 3 CCDs. The top panel shows the data with crosses and the best-fit model with solid lines (see Tsujimoto et al., 2009, PASJ for details)

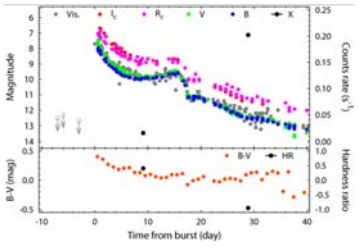

Fig.4. Evolution of V2491 Cyg in brightness and color. Suzaku count rates are shown in black. The optical data are taken by the AAVSO, VSOLJ, and other ground-based observations [4-10].

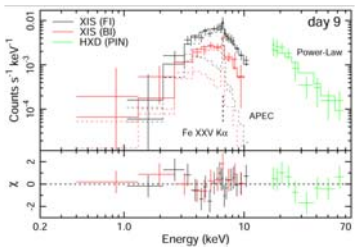

Fig.5. Background-subtracted V2491 Cyg spectra (cross) and the best-fit model on day 9. The best-fit models are shown by the solid (total) and dashed (each component) histograms (see Takei et al., 2009, ApJL for details).

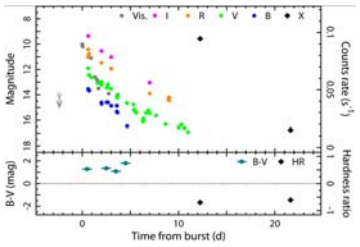

Fig.6. Evolution of V2672 Oph in brightness and color. Suzaku X-ray count rates are shown with black symbols. The optical photometry data are taken by the AAVSO.

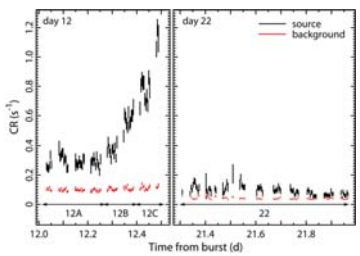

Fig.7. Source and background light curves with Suzaku on days 12 and 22.

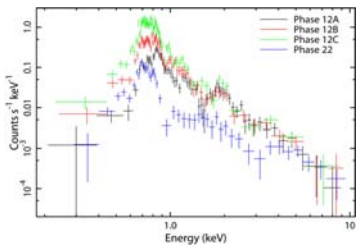

Fig.8. Background-subtracted V2672 Oph spectra on day 12 and 22.

3. DISCUSSION

Unique X-ray characteristics were found in three classical novae with high S/N light curves and spectra using the Suzaku satellite. Collaborations between ground observatories and multiple satellites, e.g., Swift and Suzaku, can take unprecedented quality dataset in transient sources such as novae.

REFERENCES

[1] Tsujimoto et al. 2009, PASJ, 61, S69, [2] Takei et al. 2009, ApJL, 697, L54, [3] Takei & Ness, 2010, AN, 331, 183, [4] Nakano, S., et al. 2008, IAUC, 8934, 1, [5] Tomov, T., et al. 2008, ATel, 1475, 1, [6] Tomov, T., et al. 2008, ATel, 1485, 1, [7] Lynch, D. K., et al. 2008, IAUC, 8935, 1, [8] Ashok, N. M., et al. 2008, CBET, 1354, 1, [9] Rudy, R. J., et al. 2008, IAUC, 8938, 2, [10] Helton, L. A., et al. 2008, CBET, 1379, 1