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Editors: J. C. Tello, A. Riva, D. Hiriart & A. J. Castro-Tirado

SIMULTANEOUS MONITORING OF BINARY X-RAY SOURCES IN THE OPTICAL AND X-RAY BANDS

Vojtěch Šimon[1,2]

RESUMEN

Discutimos la importancia del monitoreo simultáneo de fuentes binarias de rayos-X en las bandas del óptico y rayos-X. Monitorear es importante para investigar los procesos que operan en la escala de años, en especial respecto a eventos impredecibles como las transiciones de estado alto/bajo y las explosiones. La estrategia aquí discutida puede aclarar los procesos de acreción ya que la radiación óptica y de rayos-X a menudo es emitida de distintas regiones de la binaria. Mostramos algunos ejemplos de los sistemas binarios con objetos compactos acretantes de distintos tipos donde las observaciones de varios instrumentos a bordo de satélites (RXTE, Swift) son combinadas con series de datos largas y simultáneas de varios telescopios basados en tierra.

ABSTRACT

We discuss the importance of the simultaneous monitoring of binary X-ray sources in the optical and X-ray bands. Monitoring is important for investigating the processes that operate on the timescales of years, especially as regards the unpredictable events like the high/low state transitions and outbursts. The strategy discussed here can shed more light on the accretion processes since the optical and X-ray radiations are often emitted from different regions of the binary. We show some examples of the binary systems with the accreting compact objects of various kinds where the observations provided by the X-ray monitors onboard satellites (RXTE, Swift) are combined with a long, simultaneous dense series of data from various ground-based telescopes.

Key Words: accretion, accretion disks — binaries: general — instrumentation: miscellaneous — methods: observational — radiation mechanisms: general — X-rays: binaries

1. INTRODUCTION, ANALYSIS, AND RESULTS

Binary X-ray sources are emitters of radiation over a very broad spectral region and are often very active on various timescales (e.g. Lewin et al. 1995). Their monitoring and searching for the relation of their long-term activities in various spectral regions are important for investigating the processes that operate on the timescales of days, months and years, especially as regards the unpredictable events like the high/low state transition and outbursts. This can be achieved by a combination of data from the ground-based monitors observing in the optical band and the monitors onboard the satellites observing in the X-ray band.

CCD V band observations of the ASAS-3 project[3] (Pojmanski 1997) were obtained with a 200/2.8 camera (exposure time of 180 s). They mapped various fields of the sky in a densely covered time segment between the years 2001 and 2009. Also the data in various databases like AAVSO and AFOEV contain a large number of the optical (mainly visual and CCD) data and play an important role in investigation of the long-term activity of various types of objects which display the large-amplitude variations of brightness.

The All Sky Monitor ASM/*RXTE* (Levine et al. 1996) [4] monitored the sky in the X-ray band between 1996 and 2012. Especially the one-day means of the sum band intensities $I_{\rm sum}$ in the 1.5–12 keV band were very useful for investigation of fainter sources. The monitor BAT/*Swift* has been operating since 2004 (Barthelmy et al. 2005; Krimm et al. 2013). Beside searching for GRBs, it also provides observations of X-ray sources in the 15–50 keV band.

Sco X-1: An example of the relation of the activity in this low-mass X-ray binary (e.g. Lewin et al. 1995) is shown in Fig. 1. The optical emission coming from the accretion disk embedding the neutron star (NS) displays strong fluctuations on the super-orbital timescales. They can be considered to be the recurring shallow low states. Although Sco X-1 is a bright X-ray source no matter what the state of the optical emission is, the profile of the 1.5–12 keV

[1]Astronomical Institute, Academy of Sciences of the Czech Republic, 251 65 Ondřejov, Czech Republic (simon@asu.cas.cz).

[2]Czech Technical University in Prague, FEL, Prague, Czech Republic.

[3]http:// archive.princeton.edu/∼asas

[4]http://xte.mit.edu/

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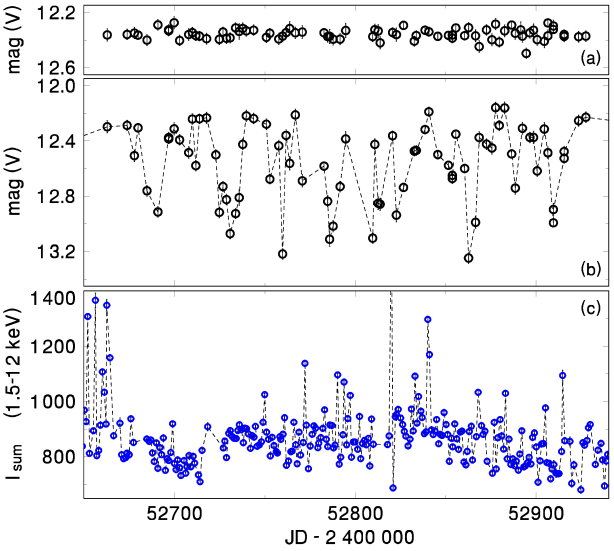

Fig. 1. Activity of Sco X-1. **a)** ASAS data of the check star (RA=16:19:45; DEC=-15:34:30 (2000)). **b)** Segment of ASAS data of Sco X-1. **c)** Its ASM/*RXTE* observations. The points are connected by a line only to guide the eye. Uncertainties of the observations are marked in each panel.

emission coming from the close vicinity of the NS is almost independent on that in the optical band and displays its own long-term evolution. Also Bradt et al. (1975) found only a weak relation of the activities in these two spectral regions.

AM Her: In the high state of this polar (e.g. Warner 1995), cyclotron component is dominant in the V band while bremsstrahlung emission dominates in the medium and hard X-ray bands (Kuulkers et al. 2006). The relation between these two components is established in the beginning of the given high-state episode but it does not reproduce for each such episode (Šimon 2011). Because of the low signal, the BAT data in Fig. 2 were averaged or fitted by the HEC13 code (written by Harmanec 1992). The BAT signal can be considered to be reliable and above the noise level only in the optical high state. The scatter is enhanced by the strong orbital modulation (Matt et al. 2000). Fig. 2 shows that the time evolution of the hard tail of the bremsstrahlung component is in good agreement with that of the cyclotron emission in the high states in this monitored time segment.

We show the importance and the possibilities of the simultaneous monitoring of binary X-ray sources in the optical and X-ray bands. This combination yields new results of investigation of the accretion processes because the optical radiation is emitted

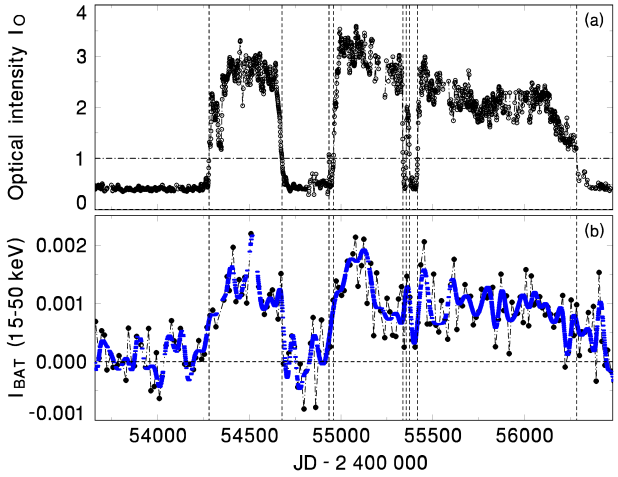

Fig. 2. Activity of AM Her. **a)** Optical monitoring AAVSO data (Henden 2013) (one-day means). Vertical lines mark the times of crossing the level of 14.3 mag. **b)** Smoothed BAT/*Swift* observations. The line represents the HEC13 fit. The points mark the 15-day means.

from different regions of the binary than the X-ray one. We show some examples of the binary systems with the accreting compact objects of various kinds where the observations provided by the X-ray monitors onboard satellites (*RXTE*, *Swift*) are combined with a long, simultaneous dense series of data from various ground-based telescopes.

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