ACTIVITY OF V1223 SGR OBSERVED WITH INTEGRAL

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ABSTRACT

We report on the observations of the intermediate polar V1223 Sgr by IBIS and OMC onboard $INTEGRAL$ in a state of brightness which we call a shallow low state. We have a unique opportunity to investigate the relation between the activity in the optical and far X-ray region on long time scales; we present far X-ray spectra (E up to 60 keV) and the relation between far X-ray and optical flux. We demonstrate their stability during this state over an interval of 400 days. Even in this state, both the profile of the optical modulation with the orbital period and the phase of the minimum light in the OMC data are in good agreement with those determined by Jablonski & Steiner (1987) for the high state. The beat period is still dominant, which suggests that the stream-disk overflow still operates in this state of activity.

Key words: accretion, accretion discs; binaries: close; circumstellar matter; stars: individual: V1223 Sgr; X-rays: binaries.

1. INTRODUCTION

V1223 Sgr is an intermediate polar (IP) with the magnetic field of the white dwarf (WD) weak enough to allow a formation of the disk (e.g. Beuermann et al. (2004)). The orbital period is $P_{\rm orb} = 0.1402440$ days (Warner & Cropper, 1984) and the rotational period of the WD is $P_{\rm rot} = 746$ sec (Osborne et al., 1985). $P_{\rm rot}$ is observed in X-rays while the beat period $P_{\rm beat} \approx 794$ sec (Steiner et al., 1981) is seen in the optical. This system displays a strong long-term activity, dominated by episodes of low states (Garnavich & Szkody, 1988). Also a brief outburst from a high state, with the duration of ~ 6 hours and an amplitude of $\sim$1.5 mag, was reported by van Amerongen & van Paradijs (1989). X-ray observations of IPs often concentrate on isolated series with the aim at study of the rotational modulation and/or the spectrum. The relation between the X-ray and optical activity, especially on long time scales, remains to be established.

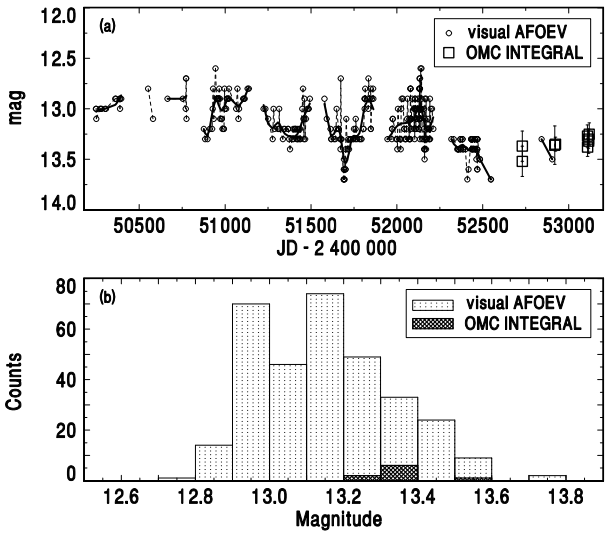

Figure 1. (a) Recent activity of V1223 Sgr in the optical passband. The smoothed curve represents the fit by the code HEC13 (written by Dr. P. Harmanec, the method of Vondrák (1969, 1977)). (b) The statistical distribution of the brightness for the fit by HEC13 and the OMC data.

2. DATA SOURCES AND ANALYSIS

The $INTEGRAL$ data used here were obtained in the framework of the Galactic Plane Scans and the deep observations of the Galactic center. These observations can be grouped into three intervals of time. The IBIS ISGRI data were reduced by OSA software ver. 4.2 and the fluxes were extracted by 2-D Gaussian fit using `mosaic_spec` (part of the new OSA release). The optical data were obtained from the OMC images (100 sec exposure times only).

3. RESULTS

We report on the observations of the intermediate polar V1223 Sgr by IBIS and OMC onboard $INTEGRAL$ in a state of brightness which we call a shallow low state

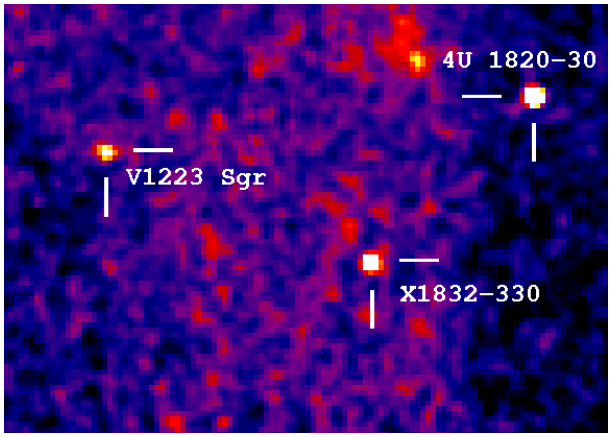

Figure 2. Mosaic of the field of V1223 Sgr obtained by IBIS in the 25–40 keV passband, with the starting exposure time in JD 2452730.2 and the integration time of 66700 sec. Size of the field is $9.5^\circ \times 6.8^\circ$. *North is up, East to the left.*

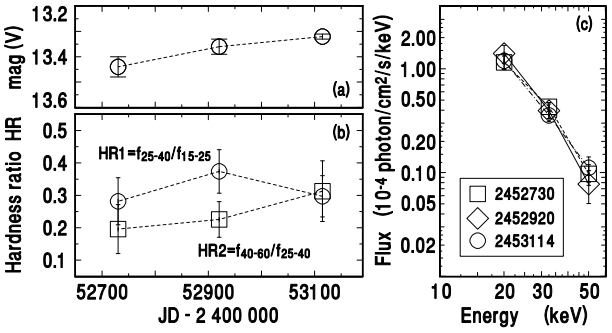

Figure 3. Time variations of the V *band magnitude (a) and hardness ratios of far X-ray intensities (b) of V1223 Sgr. The points in each panel are connected by the line only for convenience. (c) The corresponding far X-ray spectra from IBIS. The Julian Date of each spectrum is listed.*

($V \approx 13.5$; Fig. 1ab), while the magnitude in the high state is about $V \approx 12.8 - 13.0$ (e.g. Garnavich & Szkody (1988)). A trend of a slow decay of the optical brightness of V1223 Sgr with several short episodes of a shallow low state was apparent for several years before this event (Fig. 1a).

V1223 Sgr is clearly detected in the softer passband of IBIS (Fig. 2). We establish the relation between the activity in the optical and far X-ray spectral region on long time scales in a shallow low state (Fig. 3ab). We show the stability of this relation, and of the profile of the X-ray spectra (E up to 60 keV (Fig. 3c)) during this state over an interval of 400 days. The spectral profile remains largely unchanged during this time interval, which suggests that the extreme tail of the bremsstrahlung X-ray spectrum displays a remarkable stability.

Our observations imply the luminosity in the 15–25 keV passband to be $\sim 1.2 \times 10^{33}$ erg/s and still a relatively bright disk (i.e. by several magnitudes brighter than the deep low states observed by Garnavich & Szkody (1988)). The irradiation of the disk by X-rays thus appears to play a role since the disk should be already in the region of thermal instability during our observations – outbursts and a large decrease of the optical flux are thus expected, which is not observed.

Even in the shallow low state, both the profile of the optical modulation with the orbital period and the phase of the minimum light in the OMC data are in good agreement with those determined by Jablonski & Steiner (1987) for the high state. Using the method of Scargle (1982) contained in the code AVE, we find that the beat modulation still dominates over the rotational modulation, which suggests that stream-disk overflow still operates in the shallow low state. This overflow thus persists even when the mass transfer rate decreases ~ 3 times with respect to the high state.

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REFERENCES

Beuermann K., et al. 2004, A&A, 419, 291

Garnavich P. & Szkody P. 1988, PASP, 100, 1522

Jablonski F. & Steiner J.E. 1987, ApJ, 323, 672

Osborne J., et al. 1985, Sp.Sc.Rev., 40, 143

Scargle J.D. 1982, ApJ, 263, 835

Steiner J.E., et al. 1981, ApJ, 249, L21

van Amerongen S. & van Paradijs J. 1989, A&A, 219, 195

Vondrák J. 1969, BAIC, 20, 349

Vondrák J. 1977, BAIC, 28, 84

Warner B. & Cropper M. 1984, MNRAS, 206, 261

Winkler C., et al. 2003, A&A, 411, L1