ACTIVITY OF THE UNIQUE X-RAY TRANSIENT CI CAM (XTE J0421+560)

V. Šimon[1], C. Bartolini[2], A. Piccioni[2], A. Guarnieri[2], and D. Hanžl[3]

[1]Astronomical Institute, Academy of Sciences of the Czech Republic, 251 65 Ondřejov, Czech Republic
[2]Dipartimento di Astronomia, Universita di Bologna, via Ranzani 1, 40127 Bologna, Italy
[3]Nicholas Copernicus Observatory and Planetarium, Kraví hora 2, 61600 Brno, Czech Republic

ABSTRACT

We emphasize the large difference between the optical color behaviour during the 1998 outburst and during the consequent quiescent interval of CI Cam. The variations of the optical/IR continuum on the time scale of weeks and months play a significant role after the outburst and cannot be explained by the changes of the extinction intrinsic to CI Cam. We find that the variations of the source of the optical light appear to be related to those of the X-ray source. We argue that the 1998 outburst can be explained by the thermal instability of the accretion disk, analogous to the outbursts of soft X-ray transients, if the disk in CI Cam heats up an extended envelope and/or a strong jet is formed.

Key words: accretion, accretion discs; binaries: close; circumstellar matter; stars: individual: CI Cam (XTE J0421+560); X-rays: binaries.

1. INTRODUCTION

CI Cam MWC 84 is an optical counterpart of the unique X-ray transient XTE J0421+560 (e.g. Frontera et al. (1998)), interpreted as a periastron passage of the compact object (Hynes et al., 2002) or a disk instability (Robinson et al., 2002). The outburst changed the appearance of the system (e.g. Clark et al. (2000); Hynes et al. (2002)). A possible orbital period $P_{\rm orb} = 19$ days was reported by Barsukova et al. (2005a). The distance is about 3–5 kpc (Miroshnichenko et al., 2002; Robinson et al., 2002).

2. DATA SOURCES AND ANALYSIS

The optical data were obtained by Maksutov 180/1000 mm, SBIG ST-6 (Ondřejov) and 400/1700 mm tel., SBIG ST-7 (Brno), and were supplemented by those of Barsukova et al. (2002, 2005b); Henden (2002); Henden & Sumner (2004). The 1.5–12 keV observations from $ASM/RXTE$ (Levine et al., 1996) (`http://xte.mit.edu`), $BeppoSAX$ (Parmar et al., 2000) and XMM (Boirin et al., 2002) served as the X-ray data. The resulting curves are shown in Fig. 1.

3. RESULTS

The form of the optical and near-IR activity of CI Cam changed from rapid variations prior to the 1998 outburst (Bergner et al., 1995) to smooth gradual variations occurring on the time scale of weeks and months (Fig. 1a). The most prominent variations are observed in the I band, with the amplitude decreasing toward the V (and U) passband. The brightness variations are accompanied by complicated shifts in the color diagrams (Fig. 1bcd) – they cannot be explained by the changes of the extinction intrinsic to CI Cam. There are large differences between the color variations during the 1998 outburst and after it. We argue that the variations of the optical/IR continuum must significantly contribute to the color changes, since the variations in the individual filters are not independent on each other. There appears to be a relation of the source of the optical light and the X-ray source in quiescence (Fig. 1ef). Even if the donor star and its wind are the dominant sources of the optical luminosity in quiescence, they still appear to affect both the intensity and absorption of X-rays which are likely to come from the accretion onto the compact object. We offer an interpretation in terms of a density enhancement in the transferring matter.

We can constrain the emission mechanism in outburst (Fig. 1g). Since $M_{\rm V}$ of SXTs in outburst tends to brighten with the increasing $P_{\rm orb}$ (and hence with a larger disk radius), CI Cam would have to possess a very large disk if this disk were the site of the luminosity during the outburst, in contradiction with the very short duration and rapid decay in the X-ray (e.g. $ASM/RXTE$, Robinson et al. (2002)) and optical region. We argue that most of the luminosity observed during the 1998 outburst comes from a site different from the disk – this is also supported by the reddening of $B-V$ and $V-R$ during the outburst (Fig. 1c) (a bluer color at maximum is expected in the case of the brightening of the disk of a roughly unchanged radius). We offer an interpretation in terms of the thermal instability of the disk + heating of the extended envelope by the brightened small disk and/or a formation of a strong jet. We note that CI Cam is not the only SXT that reddened during outburst (e.g. 4U 1543–47 (Buxton & Bailyn, 2004)). The periastron passage is an unlikely explanation, since no other outbursts have been observed by $ASM/RXTE$ since 1998 in spite of $P_{\rm orb} = 19$ days proposed by Barsukova et al. (2005a).

ACKNOWLEDGMENTS

This research has made use of the observations provided by the $ASM/RXTE$ team. This study was supported by the grant 205/05/2167 of the Grant Agency of the Czech Republic, the project ESA PRODEX INTEGRAL 90108 and ESA PECS project 98023. We thank Dr. Harmanec for providing us with the code HEC13.

REFERENCES

Barsukova E.A., et al. 2002, AZh, 79, 309

Barsukova E.A., et al. 2005a, ATel, No.416

Barsukova E.A., et al. 2005b, conf. VAC-2004, Moscow, June 3–10, 2004 (attached to ATel 416)

Belloni T., et al. 1999, ApJ, 527, 345

Bergner Y.K., et al. 1995, A&AS, 112, 221

Boirin L., et al. 2002, A&A, 394, 205

Buxton M.M. & Bailyn C.D. 2004, ApJ, 615, 880

Clark J.S., et al. 2000, A&A, 356, 50

Frontera F., et al. 1998, A&A, 339, L69

Henden A. 2002, ftp://ftp.nofs.navy.mil/pub/outgoing/aah/sequence/cicam.dat

Henden A. & Sumner B. 2004, AJ, submitted

Hynes R.I., et al. 2002, A&A, 392, 991

Levine A.M., et al. 1996, ApJ, 469, L33

Miroshnichenko A.S., et al. 2002, A&A, 390, 627

Orlandini M., et al. 2000, A&A, 356, 163

Parmar A.N., et al. 2000, A&A, 360, L31

Robinson E.L., et al. 2002, ApJ, 565, 1169

Shahbaz T. & Kuulkers E. 1998, MNRAS, 295, L1

Vondrák J. 1969, BAIC, 20, 349

Vondrák J. 1977, BAIC, 28, 84

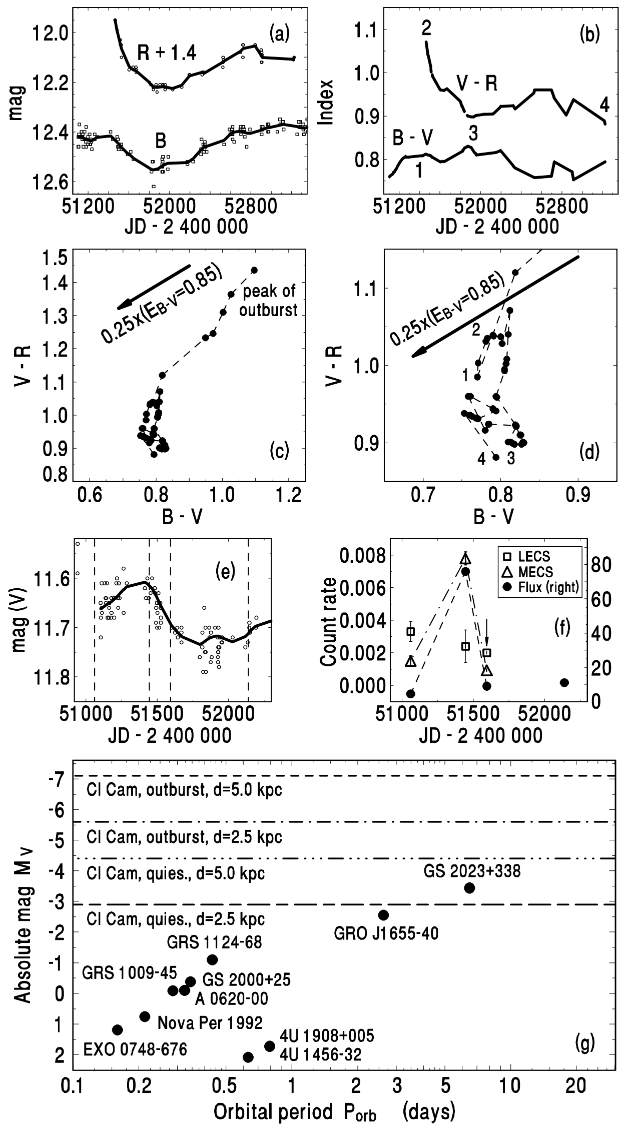

Figure 1. (a) Examples of the post-outburst light curves of CI Cam (daily means). The smooth lines represent the fits by the code HEC13 (author: Dr. P. Harmanec, method: Vondrák (1969, 1977)). (b) Examples of the time evolution of the color indices, determined from the fits in (a). The short vertical lines denote the positions of the observations for which the fits were made. (cd) Color-color diagrams. The lines connecting the points denote the time evolution. The vectors mark the reddening of CI Cam $E(B-V) = 0.85$ according to Robinson et al. (2002). The relation between the optical (e) and X-ray activity (f). The dashed vertical lines in (e) represent the moments of the X-ray observations. The points in (f) are connected by the line only for convenience. The data in JD 2451595 are the upper limits, as marked by the arrow. (g) Absolute magnitude $M_{\rm V}$ of soft X-ray transients (SXTs) (filled circles) at the outburst maximum versus $P_{\rm orb}$. The parameters of 10 SXTs, except for CI Cam, come from Shahbaz & Kuulkers (1998). $M_{\rm V}$ of CI Cam in quiescence and outburst are marked by the horizontal lines.