Quiescence and high states of five Z Cam stars and the related systems' parameters

Denislav Rusev, Daniela Boneva

Space Research and Technology Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

e-mail: denislav.rusev@gmail.com, danvasan@space.bas.bg

BULGARIAN ACADEMY OF SCIENCES
SPACE RESEARCH AND TECHNOLOGY INSTITUTE
Acad. G. Bonchev Str., Block 1, 1113 Sofia, Bulgaria; rel.: +359 2 988 35 03, e-mail: office@space.bas.bg, http://www.space.bas.bg

Highlights

- In this paper we present our study on five Z Cam stars: Z Cam (Camelopardalis); SY Cnc (Cancer); AY Psc (Pisces); AT Cnc (Cancer); IW And (Andromeda).
- We apply observational data from the American Association of Variable Star Observers (AAVSO) for two objects: Z Cam and AT Cnc. The constructed light curves are for different selected observational times. A quiescent period during high states is seen for both objects. The quiescence prolongs from months to years. We compare the observations of both objects and the similarity in their behavior is found.
- The systems' parameters of all five stars are presented. We compare the values of their masses, accretion rates and effective temperature, according to the orbital periods. (See the Table below). We found that the orbital periods are similar for all five objects.

Objects details: Z Cam stars

The Z Cam stars are Dwarf novae - one group of variable stars being observed today. Dwarf novae represent close binary systems where matter is transferred from a secondary star to a white dwarf, via an accretion disc.

Main characteristics of Z Cam stars:

- The short duration of minimum.
- The irregularity of the light curve
- The lesser amplitudes of variation compared to U Gems
- A "curious and very special feature" where the variable remains nearly constant at a magnitude in between the maximum and minimum. (Simonsen, AAVSO, 2016)

Particular features of several Z Cam type objects:

Z Cam – the prototype star of a subclass of dwarf novae that exhibit both outbursts and standstills
SY Cnc – the secondary star could be more massive of the pair (Smith, R.C.et al, 2005)
AY Psc - only this star shows deep eclipses(Kara, Jan et al, 2023)
AT Cnc - in a study of AT Cnc, it was found that the star possesses shallow, broad absorption lines, and it was suggested that the star is an eclipsing binary composed of a white dwarf and a faint red dwarf companion (Bond & Tifft, 1974)
IW And – a subtype of objects. Unlike the usual Z Cam star behavior the outburst follows the state of standstill (Szkody et al, 2013)

RESULTS

Long – and short- period light curves of Z Cam and AT Cnc

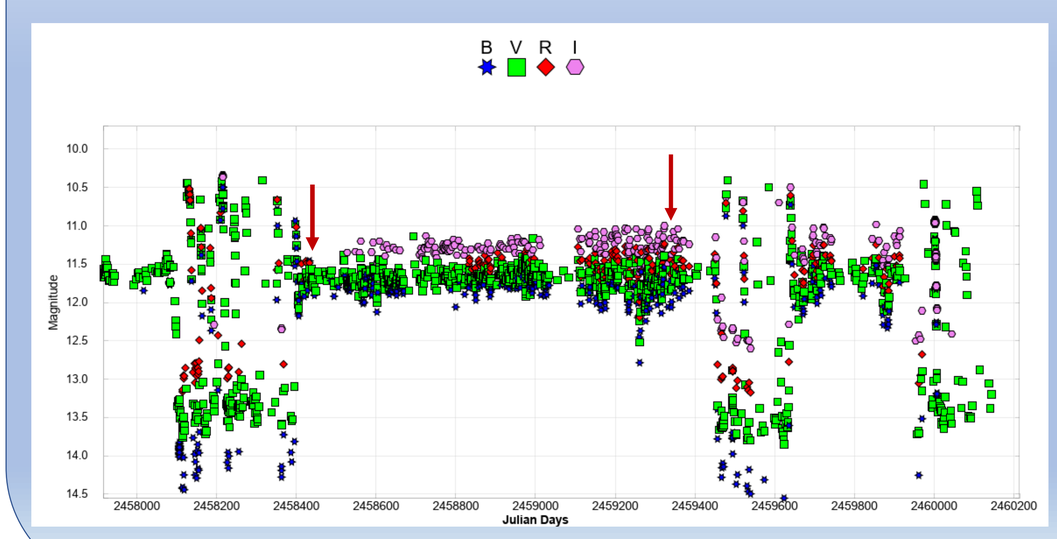
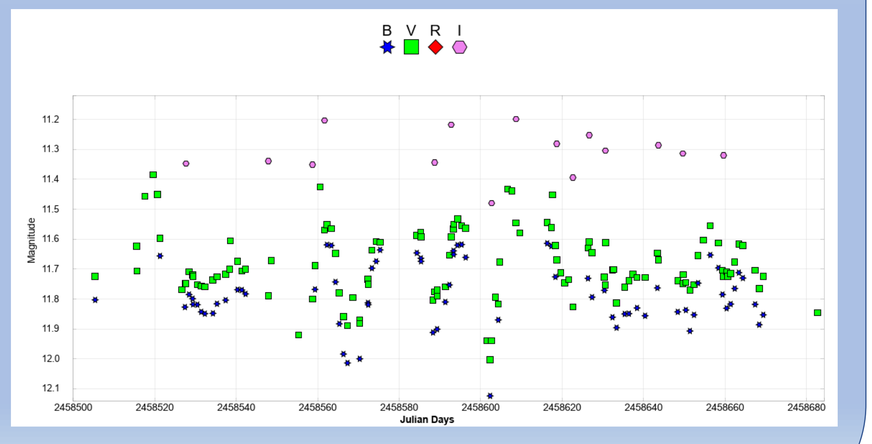


Figure 1. Light curves of Z Cam. The long period observations in BVRI bands show the transitions between the large amplitude variations in brightness and the period of quiescence in the high state (left, the standstill period is marked with red arrows; 052017 – 052023 calendar date). The small amplitude brightness variations during the quiescence of the star (right, 01-072019 cal. date). The observational times are in JD (Julian dates). The data are taken from AAVSO.



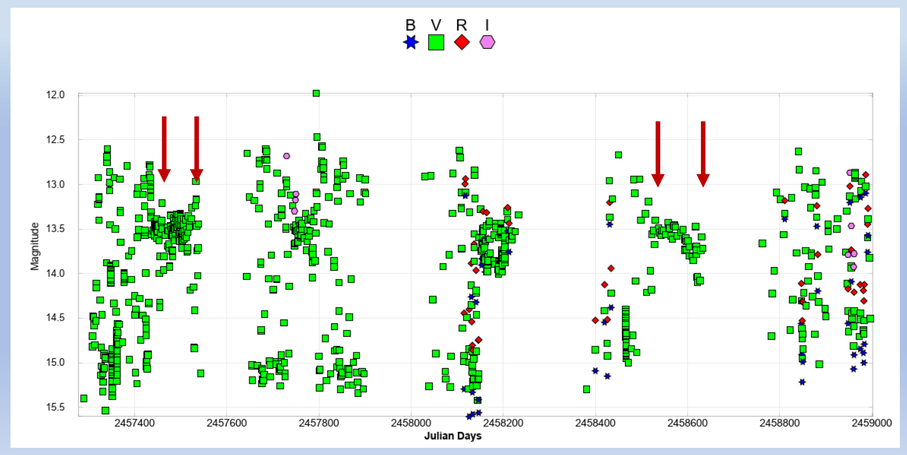
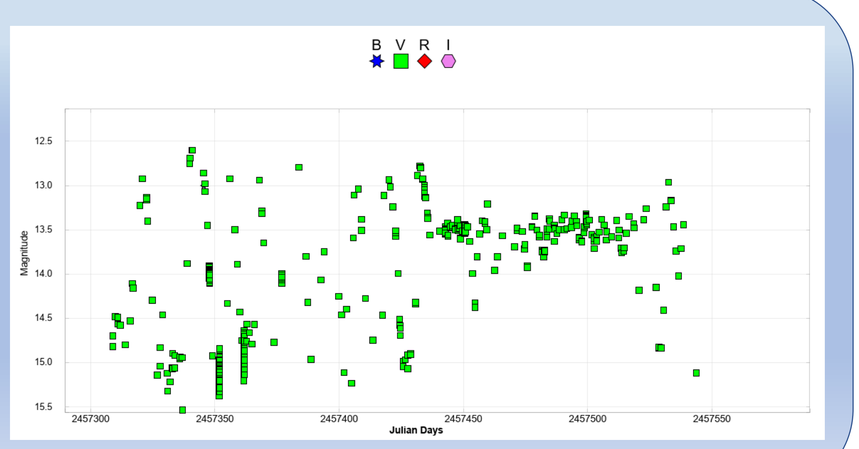


Figure 2. Light curves of AT Cnc. The long period observations in BVRI bands show the transitions between the large amplitude variations in brightness and the period of quiescence in the high state (left, the standstill period is marked with red arrows, 062015 – 052020 calendar dates). For this object they are shorter. The small amplitude brightness variations during the quiescence of the star (right, 102015 – 062016 cal. dates). The observational times are in JD (Julian dates). The data are taken from AAVSO.



Systems' parameters

Parameters / Object	m_{max}	m_{min}	P_{orb} [days]	M_{wd} [M⊙]	M_2 [M⊙]	q	$\dot{M}$ [M⊙yr^{-1}]	T_{eff} [K]
Z Cam	10.0[8]	14.5[8]	0.289[8]	(0.99 ±0.15) [5]	**(1.39 ±0.02) [tp]**	(0.71±0.10) [5] (1.4±0.2)[2]	**4.9x10^{-6}** [5]	57 000 (of wd) [12]
SY Cnc	11.0[8]	14.0[8]	0.382[8]	(0.27 – 0.57±0.12) [9]	(0.19-0.36±0.11) [9]	(0.61-0.68±0.21) [9]	--	--
AY Psc	14.5 [3]	16.4 [11]	0.217[4]	0.90[4] --1.31[3]	0.59[3]	0.50[4]	2.4x10^{-10} - 1.6x10^{-8} [4]	4100[4] (of the 2ndary)
AT Cnc	12.5[1]	15.5[1]	(0.201 ±0.0006)[7]	(0.9±0.5) [6][7]	(0.47±0.05) [6]	(0.52±0.12) [6]	--	--
IW And	13.6 [1]	18.6 [1]	0.154[10]	0.75[10]	0.27[10]	0.36[10]	3x10^{-9} [10]	25 000 (of wd) [10]

Table 1: The basic parameters of the five Z Cam objects: m_{min} and m_{min} are the maximum and minimum apparent magnitudes. M_{wd} and M_2 are the masses of the primary and secondary components, respectively; P_{orb} is the orbital period; $\dot{M}$ is the accretion rate; **q** is the mass ratio; **Teff** is the effective temperature of the primary or the secondary component. (See the References for [N] citations, [tp] - this paper)

Concluding remarks

- In this paper we showed the main characteristics of Z Cam stars. As we can see these stars are very interesting objects because of their behaviour of outbursts following standstills and again outbursts. They help us understand even better the different kind of cataclysmic variable stars.
- We are now aware that the behaviour of Dwarf Novae is quite difficult.

Reference

[1]AAVSO
[2] Coppejans, D.; K¨ording, El. G, Miller-Jones, James C.A.; Rupen, M. P.; Sivakoff, Gr. R. et al; 2016; MNRAS, 463, 2, 2229
[3] Han, Zh.; Qian, Sh.; Voloshina, Ir.; Zhu, Li-Ying; 2017;arXiv:1705.03163
[4] Kara, Jan; Zharikov, S.; Wolf, M. et al; 2023; ApJ, 950, 1, 47, 19
[5] Knigge, Ch; Long, K. S., Blair, W. P.; Wade, R. A., 1997, ApJ, 476, 1, 291
(6) Kozhevnikov, V.P.; 2004; Astronomy and Astrophysics, 419, 1035
[7] Nogami, D., Masuda, S; Kato, T; Hirata, R., 1999, PASJ, 51, 115-125
[8] Ohshima, T., 2022, Stars and Galaxies, University of Hyogo
[9] Smith, R. C.; Mehes, O.; Vande P. D.; Hawkins, N. A. et al; 2005; MNRAS, v.360, 1, p. 364
[10) Szkody, P; Albright, M.; Linnell, Al. P.; Everett, M. E. et al; 2013; PASP, v.125, 934, p. 1421
[11] Gülsecen et al 2009);
[12] Hartley et al, 2005

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