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Orbital variations and outbursts of the unusual variable star V1129 Centauri☆

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HIGHLIGHTS

- V1129 Cen is classified as a β Lyr type binary which occasionally exhibits outbursts.
- The light curve is dominated by ellipsoidal variations with a period of $21^h\ 26^m$ and superposed eclipses.
- Model calculations permit to constrain some basic system parameters.
- V1129 Cen may be a dwarf nova with an exceptionally early type and slightly evolved mass donor star.

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ABSTRACT

The variable star V1129 Cen is classified in the GCVS as being of β Lyr type. Unusual for such stars, it exhibits outbursts roughly once a year, lasting for ∼ 40 days. For this reason, a relationship to the dwarf novae has been suspected. Here, for the first time a detailed analysis of the light curve of the system is presented. Based on observations with high time resolution obtained at the Observatório do Pico dos Dias and on the long term ASAS light curve the orbital variations of the system are studied. They are dominated by ellipsoidal variations and partial eclipses of a probably slightly evolved F2 star in a binary with an orbital period of $21^h\ 26^m$. Comparison with the characteristics of dwarf novae show that the observational properties of V1129 Cen can be explained if it is just another dwarf novae, albeit with an unusually bright and early type mass donor which outshines the accretion disk and the mass gainer to a degree that many normal photometric and spectroscopic hallmarks of cataclysmic variables remain undetected.

1. Introduction

Cataclysmic variables (CVs) are binary stars where a Roche-lobe filling late-type component (the secondary) transfers matter via an accretion disk to a white dwarf primary. A particular subclass of CVs are the dwarf novae which occasionally exhibit outbursts with amplitudes of a few magnitudes, lasting from days to weeks. These are caused by a temporary increase of the brightness of the accretion disks in these systems.

It may be surprising that even after decades of intense studies of CVs there are still an appreciable number of known or suspected systems, bright enough to be easily observed with comparatively small telescopes, which have not been studied sufficiently for basic parameters to be known with certainty. In some cases even their very class membership still requires confirmation.

Therefore, I started a small observing project aimed at a better understanding of these stars. First results have been published in Bruch (2016), Bruch (2017a) and Bruch and Diaz (2017). Here, I present time resolved photometry and a limited amount of spectroscopy of the unusual system V1129 Cen. To these data I add long term observations retrieved from the ASAS-3 data archive Pojmanski (2002).

V1129 Cen is not a normal CV. In fact, the relationship of the star to the cataclysmic variables is quite unclear. In spite of its high brightness of ∼ $9\overset{m}{.}7$ not many details are known about the star. It is classified as a β Lyr type eclipsing binary in the 17th name list of variable stars Kazarovetz et al. (2008). β Lyr systems are binaries made up of stars in tight or even semi-detached orbits. Their evolutionary state may range from two main sequence stars to a pair with a highly evolved secondary component and a less evolved primary with mass transfer between them (Hoffman et al., 2008). Due to the proximity of the stellar components the light curves are dominated by ellipsoidal variations often in combination with mutual eclipses.

☆ Based partially on observations taken at the Observatório do Pico dos Dias / LNA

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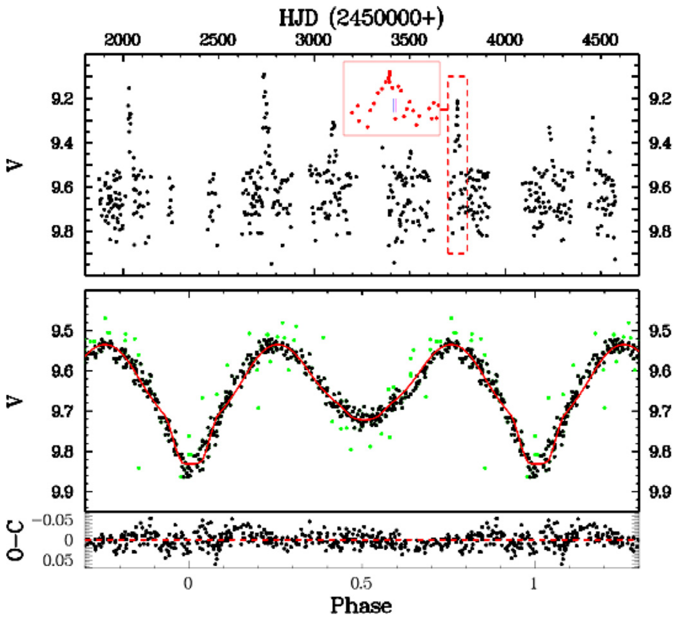

Fig. 1. *Top:* ASAS-3 long term light curve of V1129 Cen. The insert contains an expanded view of the outburst selected by the broken-lined box. The vertical lines mark the epochs of detection (blue) and non-detection (magenta) of He II λ4686 Å emission by Walter et al. (2006). *Centre:* The same data (without outbursts) folded on the orbital period. The outlying green data points were disregarded in the model fits discussed in Section 3.3. The red graph represents the best model fit. *Bottom:* Difference between the observed light curve and the best model fit. The zero level is indicated by the red broken line in order to better visualize systematic deviations. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

In the particular case of V1129 Cen, however, apart from variations typical for such stars, recurring at a period of 0.893025 days, S. Otero[1] found faint outbursts with a duration of ∼ 40 days recurring on the time scale of one year. The ASAS (Pojmanski, 2002) long term light curve contains several such events which reach an amplitude of up to $0\overset{m}{.}6$ (upper frame of Fig. 1). The spectral type of F2 V of Houk (1978) is later than that of the large majority of β Lyr stars but much earlier than that of the donor star in any CV. Unusual for a star of this type, (Walter et al., 2006) observed emission of He II λ4686 Å on 2006, Jan 16.2 UT which, however, was absent on 2006, Jan 19.3 UT. Both of these observations occurred during an outburst as is shown by the insert in the figure, where the corresponding epochs are marked by vertical lines. The authors leave the question open whether the emission was transient or if the source was eclipsed during the second observation. It is not clear what causes this unusual (for a β Lyr star) behaviour. Ritter and Kolb (2003) have included the star as a possible U Gem type dwarf nova in the on-line version of their catalogue.

If the system indeed contains a dwarf nova or behaves like one, persistent mass transfer through an accretion disk should take place and thus flickering should be expected to be present. Whether this would be observable or not depends on the degree of modulation of the flickering light source and its relative contribution to the total light of this peculiar system. In order to verify the presence of flickering and to investigate the question whether or not the properties of V1129 Cen are compatible with a dwarf nova classification, I observed the star on several occasions in 2014, 2015 and 2016. Because of their superior quality I will concentrate here on the 2016 light curves. These data are complemented by observations retrieved from the ASAS data archive. Additionally, I obtained a few spectra in 2015 in order to verify the eventual presence of emission lines as observed by Walter et al. (2006).

This study is organized as follows: In Section 2 the observations and data reduction techniques are briefly presented. Section 3 then deals with the results of the observations and of model calculations. A discussion follows in Section 4. Finally, the conclusions are briefly summarized in Section 5.

Table 1
Journal of observations.

Date	Start (UT)	End (UT)	*B*
2016 Mar 09	1:19	5:10	*
2016 Apr 05	0:20	7:11	10.2
2016 Apr 05/06	23:56	5:53	10.1
2016 Apr 06/07	23:56	6:30	10.1
2016 Apr 08	1:18	6:06	10.2
2016 Apr 14	0:31	1:51	10.3
2016 Apr 14/15	23:55	5:56	10.1
2015 Feb 14	5:58	7:49	**

* unreliable.
** spectroscopic observations.

2. Observations and data reductions

All photometric observations were obtained at the 0.6-m Zeiss and the 0.6-m Boller & Chivens telescopes of the Observatório do Pico dos Dias (OPD), operated by the Laboratório Nacional de Astrofísica, Brazil. Time series imaging of the field around the target star was performed using cameras of type Andor iKon-L936-B and iKon-L936-EX2 equipped with back illuminated, visually optimized CCDs. A summary of the observations is given in Table 1. Some light curves contain gaps caused by intermittent clouds or technical reasons. In order to resolve any rapid flickering variations the integration times were kept short. Together with the small readout times of the detectors this resulted in a time resolution of the order of 5^s. In contrast to observations of other targets within the observing project mentioned in Section 1, in spite of the short integration times the high brightness of V1129 Cen not only permitted but demanded (in order to avoid saturation) the use of a filter. A *B* filter was chosen. Even so, I did not perform a rigorous photometric calibration but express the brightness as the magnitude difference between the target and the nearby comparison star UCAC4 223–607051 ($B = 13.564$; Zacharias et al., 2013), the constancy of which was verified through the observations of several check stars[2]. The average nightly *B* magnitude of the target is included in Table 1.

In addition to the photometric observations, eight spectra of 600 s exposure time were obtained on 2015, February 14, at the 1.6 m Perkin Elmer telescope of OPD. An Andor iKon-L936-BR-DD camera was employed. Exposures of a He-Ar lamp for wavelength calibration were taken after every second stellar exposure. From the FWHM of the lines in the comparison spectra a spectral resolution of ≈ 4 Å is estimated.

Basic data reduction (biasing, flat-fielding) was performed using IRAF. For the construction of light curves aperture photometry routines implemented in the MIRA software system (Bruch, 1993) were employed. The same system was used for all further data reductions and calculations. Throughout this paper time is expressed in UT. However, whenever observations taken in different nights were combined (e.g., to fold them on the orbital period)

[1] The internet links to the corresponding communications cited in the online version of the Ritter & Kolb catalogue (http://varsao.com.ar/NSV_19488.htm) or in Walter et al. (2006) (http://ar.geocities.com/varsao/NSV_19448.htm) appear not be active any more.

[2] It seems that the comparison star shows small variations on the time scale of months and years which, however, have no bearing on the results of this study.