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New Eclipsing Close Binary Star In The Constellation of Sextants

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During a Center for Backyard Astrophysics (CBA) photometric campaign on cataclysmic variable VZ Sex, one of the field stars was serendipitously discovered to be a variable by the author. A finding chart for the new variable is shown in Figure 1, the new variable noted as “var.” The coordinates of the object are (J2000) 09^{o}45’03.75” +04^{o}01’29.4” found by utilizing ALADIN (Bonnarel et al. 2000).

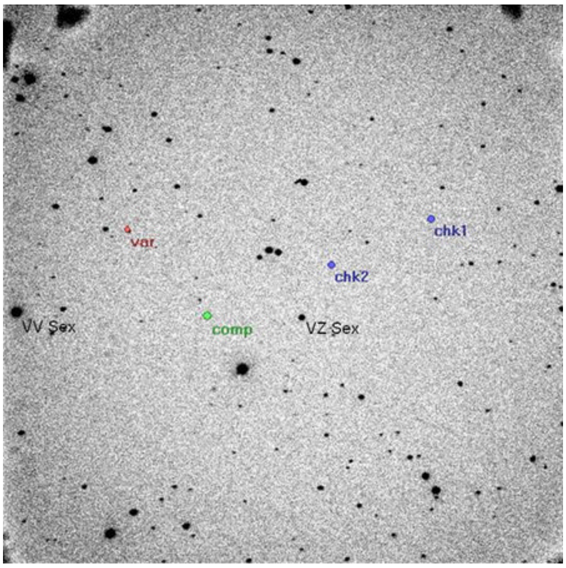

Figure 1: Finding chart for new variable. North is up, East is to the left, with a FOV ~20x20 arcminutes. The new variable “var” and the comparison stars used (comp, chk1, chk2) for photometry are labeled in addition to the other variables in the field (VV and VZ Sex).

The field near VZ Sex was observed on 12 nights during 2008 January with an 0.30-m Schmidt-Cassegrain telescope. A total of 5,919 images were collected, unfiltered, with a thermoelectrically cooled SBIG ST-9 CCD camera and had exposure times of 30-60 seconds. All of the CCD images were processed using Cmuniwin (http://c-munipack.sourceforge.net/). This PC-based software with a graphical user interface was converted from individual algorithms originally developed by Filip Hroch (1998). In short, the images are 1) converted to FITS format if necessary, 2) flat-fielded and dark subtracted if desired, 3) processed to find stellar targets and photometrically measured utilizing the methods of DAOPHOT (Stetson 1987), 4) target lists are pattern matched to identify stars in each image via the algorithm of Groth (1986), and 5) variable, comparison and check stars selected to generate differential photometry and light curves. Additionally, the inhomogeneous ensemble photometry method (Honeycutt 1992) used in the analysis of the data with Cmuniwin can yield the light curve for every star in the field of interest and help find variable stars. The variability of this star was revealed by the large 0.26 sigma uncertainty in its instrumental ensemble magnitude (mag) compared to other field stars averaging 0.05 mag at the same brightness. The uncertainty in the differential magnitude photometry was estimated by comparing the non-variable comparison and check stars that averaged 0.017 mag, see (C-K) on figures 2 and 4. Observations on two of these nights are shown as differential light curves in Figure 2 and show a close eclipsing binary star with primary and secondary eclipses.

A period search of the data using the phase-dispersion minimization (PDM) method of Stellingwerf (1978) is shown in Figure 3. A total of 5000 individual frequencies were tested in the interval from 0.2 to 0.6 days. The strongest peak is flanked by spurious peaks. These represent aliases of the true period (P) due to observation time sampling inherent in the data. Corresponding spurious periods (Π) can be identified as described by Lafler & Kinman (1965),

$$1/\Pi = 1/P \pm n$$

for simple values of n. Some of these aliases are indicated as Π_n in Figure 3. Power spectra methods as described by Horne and Baliunas (1986) and Schwarzenberg-Czerny (1996) were also utilized to verify the orbital period obtained via PDM.

The methods were also tested on several light curve data sets that were constructed such that the time of true observations was preserved, but the observed magnitudes were randomly shuffled and assigned to these observation times. This has the effect of evaluating the “windowing” function for the period searches, discriminating against periods inherent in the time sampling of the data and further checking the validity of the power found in the strongest signal. These search results revealed a period of 0.27337 days.

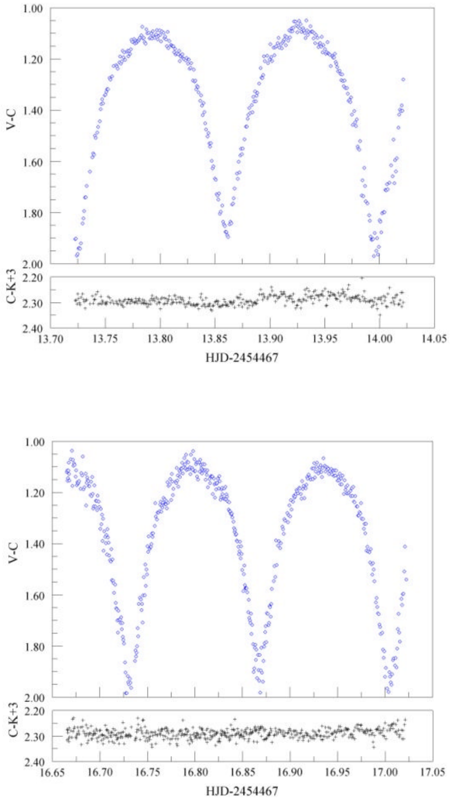

Figure 2: Light curves of the new variable star on two nights during 2008 January. Variable minus Comparison (V-C) star differential magnitudes are in the upper panels, Comparison minus Check (C-K) non-variable stars plus an arbitrary 3 magnitude offset in the lower panels.

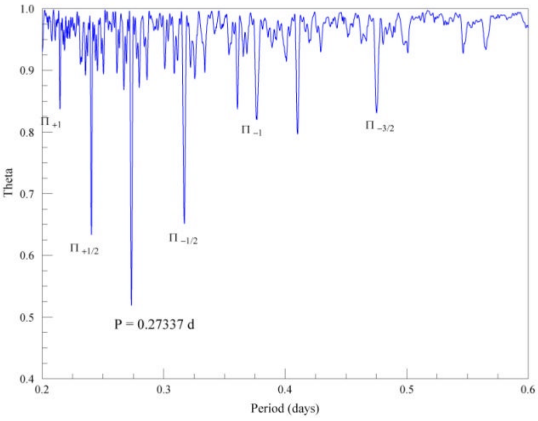

Figure 3: Phase dispersion minimization showing the orbital period and aliases.

Times of minima were measured from the light curve for both primary and secondary eclipses utilizing the method of Kwee and van Woerden (1956) and listed in Table 1. These values were then used in an analysis of the observed versus predicted eclipse times from a simple linear ephemeris $T=T_0+P\times N$ with a period (P) of 0.27337 days, where T_0 is the time of primary mid-eclipse and N is the integer orbital cycle count.

The orbital light curve of the system is shown in Figure 4 using the adopted linear ephemeris found from the O-C analysis for primary eclipse minimum light,

$$\text{Minimum}=2454467.875367(3) + 0.273378(9) \times \text{N}.$$

Table 1: Eclipse times for primary and secondary minima.

Eclipse Times	Cycle
2454467.875523	0.0
2454468.970523	4.0
2454474.982974	26.0
2454475.803898	29.0
2454477.990228	37.0
2454478.810321	40.0
2454479.904548	44.0
2454480.997827	48.0
2454481.817233	51.0
2454483.731170	58.0
2454484.004438	59.0
2454486.738720	69.0
2454468.830931	3.5
2454474.846434	25.5
2454477.853875	36.5
2454478.947156	40.5
2454479.767204	43.5
2454480.859942	47.5
2454483.867169	58.5
2454485.780074	65.5
2454486.878207	69.5

As can be seen in comparing Figures 2 and 4, significant scatter is introduced when overlaying multiple orbits in the phased light curve. In Figure 2, the single nights reveal slightly shallower minima at secondary eclipse than at primary eclipse. Additionally, the irregular shape of the light curve at maximum light and their slightly unequal maxima is a classic indicator of magnetic activity (star spots) on one or both of the stars.

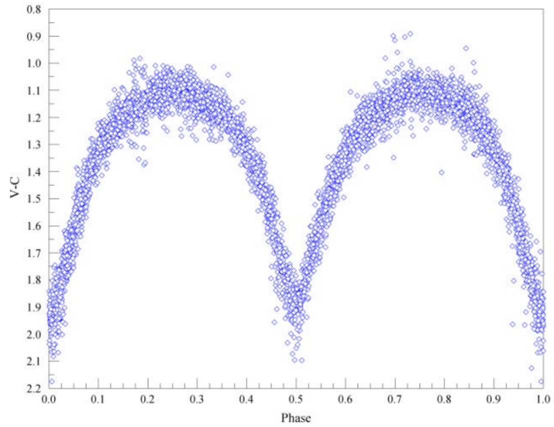

Figure 4: Phased orbital light curve of the new variable.

Because of the continuous change in brightness over the orbital cycle and the short orbital period, the stars are very close together in this system. Therefore it is expected that they are in a circular orbit and synchronously rotating, which is supported by the light curve morphology. This proximity will tend to make the stars tidally distorted and create such an observed light curve.

It is likely that tidally enforced synchronous rotation of the stars in this system helps enhance their magnetic activity level as they are spun up by their orbit, compared to single stars. Rotation, especially rapid rotation, is a prerequisite for the creation of strong magnetic phenomena seen in stars through an internal dynamo. For a recent review see Donati (2004).

Collection of multicolor light curve and subsequent binary modeling will help establish parameters such as the stellar spectral types, temperatures and sizes of the two stars in this newly discovered close binary system.

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