New Eclipse Timings and Preliminary Analysis of USNO-A2.0 1425-05691757

Matthew A. Wood
Department of Physics and Space Sciences and The SARA Observatory, Florida Institute of Technology, Melbourne, FL 32901

Walter Van Hamme
Department of Physics, Florida International University, Miami, FL 33199

Vanessa Wilkat
Department of Physics and Space Sciences and The SARA Observatory, Florida Institute of Technology, Melbourne, FL 32901

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Abstract We present new observations of the W UMa star USNO-A2.0 1425-05692757 obtained during an observing campaign of the ZZ Ceti variable BR Cam. We confirm the W UMa classification and present new data and an updated ephemeris.

1. Introduction

While obtaining CCD time-series data of the ZZ Ceti variable BR Cam (= G191-16) as part of a multi-site campaign (principal investigator: Gerard Vauclair) in December 2004, we serendipitously discovered that one of our comparison stars (star 1425-05691757 in the *USNO-A V2.0 Catalog* of Monet *et al.* 1998) was variable. A little digging uncovered that this object had been observed the previous year by Kim *et al.* (2004) and was listed as star "V1" on their finding chart. Based on the small amplitude difference of the variations in the *V* and *I* bands, Kim *et al.* argued that the star was a W UMa-type eclipsing binary.

2. Observations

We observed the system using the SARA 0.9-m telescope located at Kitt Peak National Observatory on the nights 2004 December 11 through 17 (UT). Integration times were 20seconds per exposure in order to resolve the rapid variations of the pulsating white dwarf BR Cam. The observations were unfiltered to maximize the signal-to-noise ratio in the campaign target star BR Cam. The CCD used was an Apogee AP7p, with a back-illuminated SITe SIA-502AB 512×512 detector, subframed to 296×208 pixels to reduce readout time. Pixels on this camera measured 24 microns squared, for a scale of 0.75 arcsec/pixel. Read noise for the camera was 12.2 electrons r.m.s., and the gain was 6.1 electrons per ADU. We used MaxIm

DL/CCD to control the CCD camera and to write images to disk. The raw data frames were bias, dark, and flat field corrected using standard IRAF routines. Once the data frames were calibrated, we performed time-series aperture photometry using the external IRAF package CCD HSP written and kindly provided by Antonio Kanaan (U. Federal Santa Catarina, Brazil). CCD HSP automates the field alignment and photometry extraction for time-series CCD data. *[Ed. note: The data may be downloaded from ftp://ftp.aavso.org/public/datasets/jwoodm352.txt]*

3. Results

We show a sample light curve in Figure 1. The new observational data (HJD, Δm) are available in the electronic version of this paper. We fitted the light curve with the Wilson-Devinney program (Wilson and Devinney 1971; Wilson 1979, 1994; Van Hamme and Wilson 2003), making some assumptions about the color and temperature of the primary component and the mass ratio of the system. Kim *et al.* (2004) list magnitudes $B = 16.3$ and $R = 15.5$, extracted from the *USNO-A V2.0 Catalog* (Monet *et al.* 1998). Assuming the system to be relatively unevolved, the color $B–R = 0.8$ indicates a star of spectral type approximately F4 and temperature approximately 6,700 K. Because the eclipses are partial and very shallow, a photometric mass ratio is difficult to determine. Light curve fits of nearly equal quality for different values of the mass ratio can be found, each corresponding to a detached but close-to-contact configuration, with both stars filling 97% (by radius) of their limiting lobes. For all these solutions, the temperature difference between the stars averages 500 K, and inclination angles are in the range 45° to 50°. Given the speculative nature of these very preliminary results, we do not list specific solution parameters. We confirm that the light curve of USNO-A2 1425-05691757 is consistent with that of a close-to-contact or a marginally overcontact W UMa binary seen at low inclination.

Fits to single-night light curves, keeping all parameters fixed and only adjusting the zero-epoch ephemeris parameter, resulted in seven new eclipse timings which we list in Table 1 together with estimated standard errors. The minima were also computed independently with the Kwee and Van Woerden (1956) method, a procedure which essentially yielded the same values for the minima (differences were less than the quoted standard errors). A weighted linear least squares fit of the new minima and those of Kim *et al.* (2004), using weights inversely proportional to the variances of the minima, gives an updated ephemeris of

$$\begin{aligned} HJD_{min} = 2452965.22757 &+ 0.4640995\,E. \\ \pm 0.00056 &\pm 0.0000052 \end{aligned} \qquad (1)$$

The corresponding O–C diagram is shown in Figure 2. There is no indication of period variability, although the scatter of the two groups of O–C residuals seems large compared to the size of typical eclipse timing errors. In particular, multi-passband photometry is needed to determine colors. A firm handle on the mass ratio will require obtaining radial velocities and a large telescope, given the magnitude of this object.

4. Acknowledgements

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Table 1. Epochs of minimum light for USNO-A2.0 1425-05691757.

HJD	*Standard Error*	*Epoch**
2453350.66399	0.00068	830.5
2453350.89555	0.00068	831.0
2453351.82648	0.00046	833.0
2453352.75026	0.00044	835.0
2453352.98459	0.00066	835.5
2453353.91067	0.00058	837.5
2453356.69420	0.00090	843.5

** Epoch is with respect to ephemeris Equation (1).*

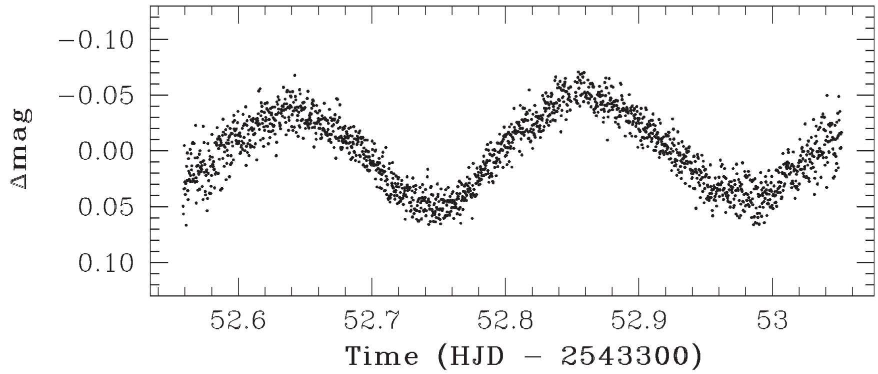

Figure 1. USNO-A2.0 1425-05691757 light curve obtained on 13 December 2004 (UT).

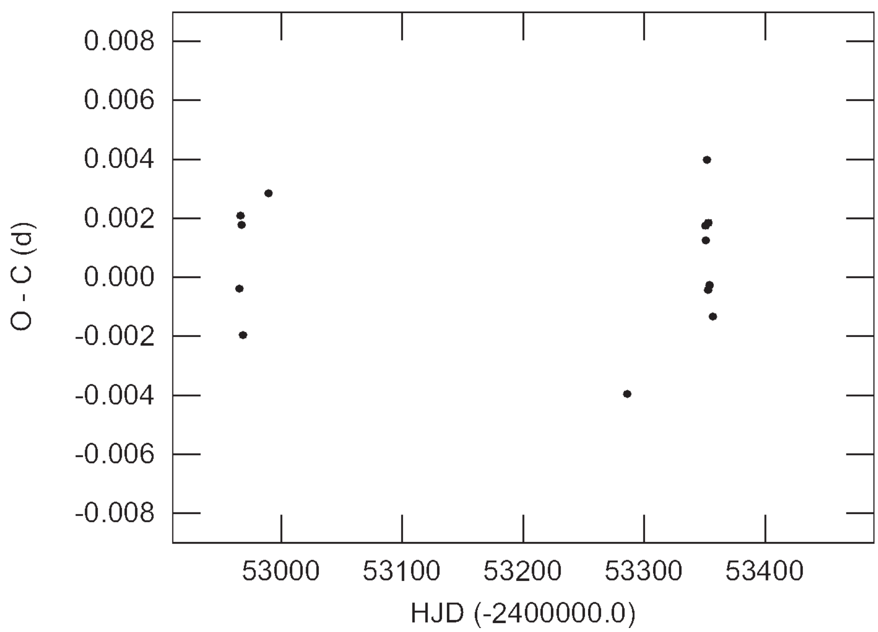

Figure 2. Eclipse timing residuals with respect to ephemeris (1).