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DISCOVERY OF ECLIPSING BINARY NATURE OF SAO 31628 = BD+49°2997, COMMON COMPARISON STAR FOR CH CYGNI

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On 2000 June 22 and 2000 July 3, we observed the field containing both CH Cygni and SAO 31628 with the 1-meter Nickel telescope at UCO/Lick Observatory on Mt. Hamilton, near San Jose, California. The observations consisted of repeated 10-second exposures on 2000 June 22 (843 in all), and 30-second exposures on 2000 July 3 (487 in all), plus approximately 21 and 18 seconds of dead-time between each exposure for CCD readout and processing on 22 June and 3 July, respectively. Observations were performed using a Johnson B filter and the thinned, 1024×1024 SITe CCD currently in Lick's dewar #5 (24-μm pixels). The aim of these observations was to determine the flickering state of CH Cygni during a dip in optical flux. SAO 31628 was intended to be used as a constant comparison star.

As part of our standard observing procedure, each of the comparison stars, including SAO 31628, was examined for variability with respect to the others. The optical brightness of SAO 31628 was found to vary by more than 20%, with a light-curve shape indicating an eclipse by a companion (see Figure 1). The light curves in Figure 1 were constructed by forming the ratio of counts from SAO 31628 to an ensemble average of 4 other stars in the field (see Sokoloski et al. 2000 for details of this procedure), with counts extracted using simple aperture photometry. The light curves have been normalized to unity by dividing by the mean count rate outside of eclipse. The eclipse can be seen in its entirety on 2000 June 22, and the eclipse ingress can be seen on 2000 July 3. The eclipse duration is approximately 5 hours, and the time between the 2 eclipses (between eclipse minimum on 2000 June 22 and eclipse minimum from an extrapolated eclipse profile on 2000 July 3) is 11.242 ± 0.004 days.

The similar shape of the light curves around eclipse ingress suggests that we are seeing a repeat of the same event. Thus, an integral number of orbital periods of the binary probably occurred between the two observations. In order to investigate this possibility, we searched through over 50 hours of our previous Nickel observations of SAO 31628 (spread over 3 years), looking for unexplained variations. We found such variations, with the same shape as the June and July 2000 eclipses, in a 2.9-hour observation from 1998 July 22. Using this longer baseline, the orbital period of the binary was found to be $P_{\rm orb} = 3.747833 \pm 0.000007$ days. All other possible periods are ruled out by our data, except perhaps $P_{\rm orb} = 1.873917 \pm 0.000004$ days (i.e. half the above period). We had only 1/2 hour of data with which to test the hypothesis of a 1.873917 day period, and the data

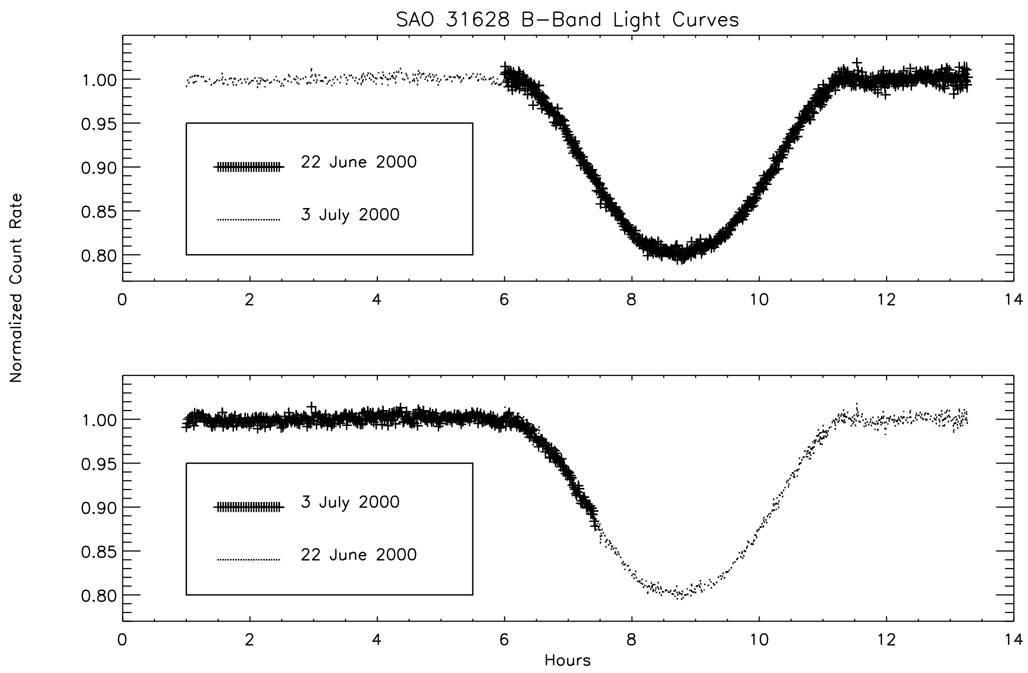

Figure 1. Differential B-band light curves for SAO 31628. The data from the 2 nights are shifted and overlaid to compare the light curve shapes. In the upper panel, the 22 June data are highlighted with larger plot symbols. In the lower panel, the data from 3 July 2000 are highlighted. The light-curve shapes appear to match quite closely in the region that overlaps

quality was poor due to high background. Because of our lack of good data at this period, we also cannot say anything about the presence, or shape, of a secondary eclipse around phase 0.5 of the 3.7 day orbital period. Finally, for completeness, we mention that there is also the possibility that the orbital period could in fact be $P_{\rm orb} = 7.49567 \pm 0.00002$ days, if one of the eclipses in 2000 is a primary and the other a secondary eclipse. Given the similarity of the eclipse shapes, however, we view this possibility as unlikely. In summary, we find that minimum in B light occurs on the ephemeris:

$$B_{\rm min} = \text{HJD } 2451717.8150 \pm 0.0005 + E \times (3.747833 \pm 0.000007) \text{ days},$$

where E is the number of cycles since $HJD =$ 2451717.8150 $\pm$ 0.0005.

A search of the Hipparcos/Tycho catalog indicates that SAO 31628 (Tycho identifier TYC 3551-00642-1) was flagged both for apparent variability and suspected duplicity. Our observations confirm both the variability and duplicity. The SIMBAD database lists SAO 31628 as a star with $B = 9.62$, $V = 9.36$, and spectral type A5.

With its brightness so similar to that of the irregularly variable symbiotic star CH Cygni, and it also being less than $4'$ away, SAO 31628 has been a natural choice for a comparison star by many observers (e.g. Rodgers et al. 1997, Leedjärv & Mikolajewski 1995, Panov & Stegert 1994, and Hoard 1993 just in the past few years). However, with variations in B of up to 0.2 mag every 3.7 days (comparable to the variations in CH Cygni), and possible variations every 1.9 days, some of the published observations of CH Cygni are likely to have been affected by the SAO 31628 eclipse. SAO 31628 should therefore be used with caution, and with awareness of the time of observations with respect to the phase of the binary motion. Additional observations of SAO 31628, to confirm the orbital period and search for a secondary eclipse, would be useful.

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