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UBV OBSERVATIONS OF THE MASS EXCHANGING SOLAR-TYPE BINARY, BE CEPHEI

RONALD G. SAMEC[1,3], N.W. GOTHARD[1], B.C. PARKER[1], T.W. SAVAGE[1], S.D. ANDERSON[1], DANNY R. FAULKNER[2,3]

[1] Department of Physics, Bob Jones University, Greenville, SC 29614 USA, rsamec@bju.edu

[2] University of South Carolina-Lancaster, Lancaster, SC 29721 USA, faulkner@gwm.sc.edu

[3] Visiting Astronomer, Lowell Observatory

Recently, we began an observation program aimed at obtaining precision multiband photometry of short period solar type binaries in the $0^d.3$ to $0^d.5$ period range. In this group, we expected to find some eclipsing binaries in a very near a state of contact, with one component experiencing Roche-lobe overflow. Systems with unambiguous EB light curves, and complicating asymmetries were targeted. BE Cephei (SVS 925 Cep, GSC 3996-75, RA(2000) = $22^h40^m51^s.59$, DEC(2000) = $58°40'7''.5$) is such a candidate.

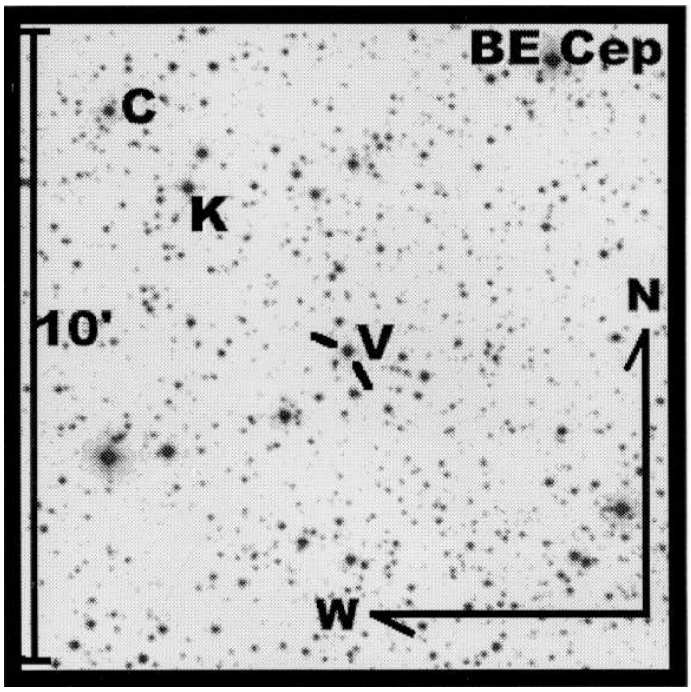

Figure 1. Finding chart (from The Palomar Sky Survey) of BE Cephei, V, the comparison star, C, and the check star, K.

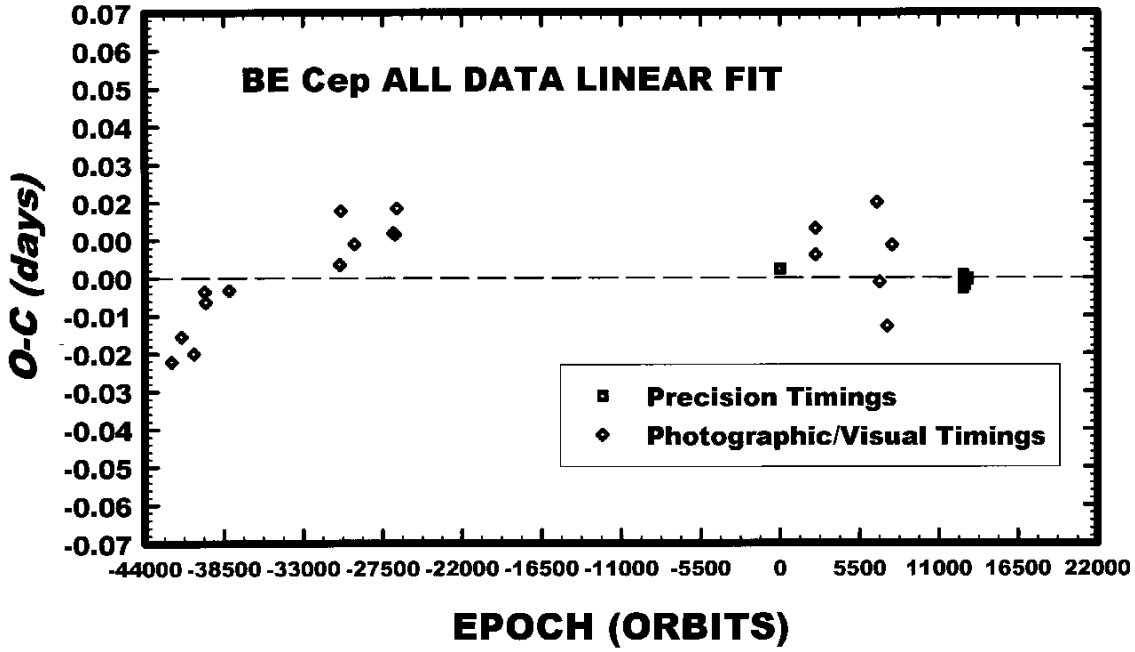

Figure 2. $O - C$ residuals for all available timings of minimum light as calculated from Equation (1).

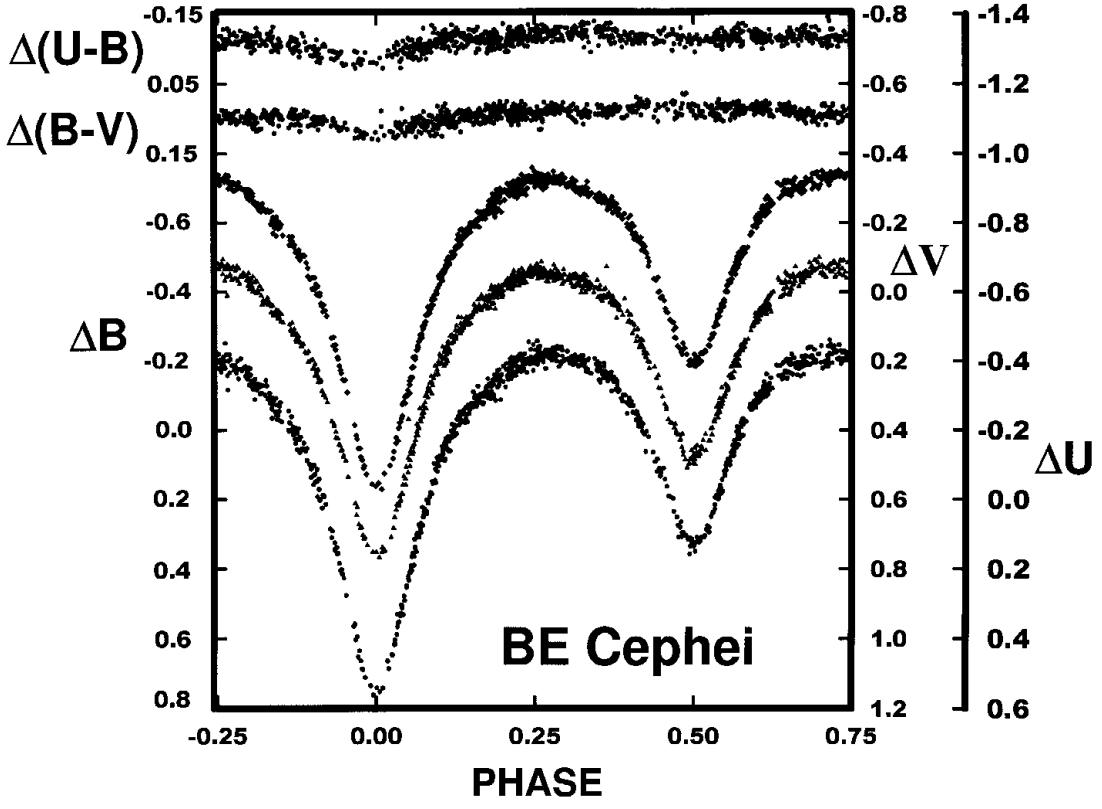

Figure 3. U, B, V light curves and $U - B$, $B - V$ color curves for BE Cephei as standard magnitude differences, variable minus comparison star.

Table 1: Epochs of Minimum Light, BE Cep

JD Hel. 2400000+	Cycles	$(O-C)_1$	$(O-C)_2$	Source
45647.3090	0.0	0.0021	−0.0036	KL
51021.8381(2)	12664.0	0.0008	0.0020	PO
51022.8970(5)	12666.5	−0.0013	−0.0001	PO
51069.7933(2)	12777.0	−0.0006	0.0008	PO
51070.8534(4)	12779.5	−0.0014	−0.0001	PO
51074.6725(4)	12788.5	−0.0019	−0.0006	PO
51074.8854(2)	12789.0	−0.0012	−0.0002	PO
51156.3698	12981.0	−0.0005	−0.0010	BE
51162.3117	12995.0	−0.0001	0.0014	BE

Sources: KL = Kaluzny (1986),
BE = BBSAG #118, #119, E. Blatte,
PO = Present Observations.

BE Cep was discovered by Florija (1950), whose light curve is of EB-type with an difference of eclipse depths of 0.11 mag. He calculated the following light elements:

$$\text{J.D. Hel Min I} = 2428751.314 + 0.424400 \times E.$$

Hoffman (1984) took B, V photoelectric observations and archived them. Kaluzny (1986) used the observations to determine two timings of minimum light and to calculate a B curve solution from phase-binned averages. He performed a "grid of solutions" with nonphysical albedoes (3 to 6), and gravity darkening (fixed at 0), to accommodate the light curve distortions. Subsequent times of minimum light have been published by Romano (1958), Ashbrook (1952, 1953), Borovicka (1986), Kolarova (1986), and in the BBSAG issues #98, #99, #101 and #102, all by Kurt Locher, and the BBSAG #118 and #119 by Ernst Blatter with CCD.

Our present UBV observations were taken with the Lowell 0.79-m reflecting telescope on the nights of July 25–27, 29–30 (RGS and DRF) and September 11–13, and 17 (DRF), 1998 with a thermoelectrically blue-enhanced, S-13 cathode, PMT. About 850 observations were taken at each filter. The comparison (GSC 03996-637, RA(2000) = $22^{\rm h}40^{\rm m}51\overset{\rm s}{.}59$, DEC(2000) = $58°40'7\overset{''}{.}5$), and check star (GSC 03996-1524, RA(2000) = $22^{\rm h}41^{\rm m}01\overset{\rm s}{.}25$, DEC(2000) = $58°38'59\overset{''}{.}1$) are shown as C, and K in Figure 1 along with the variable, V. The V − C magnitudes averaged 0.12 mags and 0.10 mags in $\Delta(B-V)$ and $U-B$, respectively. Preliminary photometric transformations yield $B-V = 0.74$, which corresponds to a G7 spectral type for the primary component. The magnitude range is 11.80–12.51 in V.

Six mean epochs of minimum light were determined from the observations made during three primary and three secondary eclipses by our undergraduate researchers using the bisection of chords technique. These precision epochs of minimum light are given in Table 1 along with their standard errors in parentheses. Linear and quadratic ephemerides were calculated using the available 31 epochs of minimum light:

$$\text{J.D. Hel Min I} = 2445647.3068(22) + 0.42439438(15) \times E, \quad (1)$$

$$\text{J.D. Hel Min I} = 2445647.3126(12) + 0.424394036(71) \times E - 1.6(3) \times 10^{-11} \times E^2. \quad (2)$$

Equations 1 and 2 were used to calculate the $(O-C)_1$ and $(O-C)_2$ residuals, respectively, in Table 1. The linear residuals are shown in Figure 2.

The UBV light curves and the $B-V$ and $U-B$ color curves of the variable are shown as Figure 3 as differential standard magnitudes (V − C) versus phase. The probable error of a single observation was 8, 9, and 10 mmag in U, B and V, respectively. A near contact solution with a stream impact spot and cool spot has been computed using the Wilson Code (Wilson 1994, 1990, Wilson & Devinney 1971). The final parameters include: $T_1 - T_2$ = 460 K, m_2/m_1 = 0.680(6), and fill-out-factor = 98.5 %. The impact spot parameters are co-latitude = 90(4), longitude = 350(1), Spot Radius = 8(2), T-Factor = 1.21(5).

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