A 1992 ECLIPSE TIMING OF THE LONG PERIOD (5.61 YEARS) ECLIPSING BINARY EE CEPHEI

Edward A. Halbach
720 Ramshorn Drive, LPR
Estes Park, CO 80517-7035

Received: January 28, 1993

Abstract

The eclipsing binary EE Cep, visual magnitude 10.7 to 11.6/13.0, and a 5.61-year period, has had varied coverage since its discovery on photographs taken in 1947. Data added during the 1992 eclipse show that its period is quite stable.

G. Romano (Brun 1975), having left professional astronomy in Italy, resumed a photographic study of a group of variable stars in Cepheus at his private observatory in Trevese as an amateur variable star observer. In 1952, with 47 blue plates and 41 photovisual plates, he discovered a 1947 eclipse (Romano 1956; Baldinelli and Ghedini 1977) of a star later identified as EE Cephei. Weber (1956) later examined 34 plates taken between 1942 and 1956 and confirmed Romano's discovery of the 1947 eclipse at approximately JD 2432297.

EE Cep was studied along with 86 other stars considered to be R CrB stars. It was later classified (Herbig 1960) as a B5:neβstar. About 500 photographic plates were studied at Sonneberg Observatory (Meinunger 1973) during 1958, but no eclipse was recognized.

The elements taken from the *General Catalogue of Variable Stars* (GCVS) (Kholopov *et al.* 1985) are:

$$JD_{min} = 2434346.0 + 2049.53\ E. \quad (1)$$

The duration of the eclipse is D = 0.015 of the period, or approximately 30 days. E is the epoch starting with 0 at JD 2434346.0.

Literature in the Harvard and AAVSO libraries was searched for observations at each epoch to date. Observations were published as visual, photovisual, photographic, or photoelectric data, with or without light curves and times of minima. In some cases, the time at minimum was not given, so these data had to be replotted and the time of minimum determined by the tracing paper method. Secondary minima were never found. Times of minima were accepted as published, and estimates of uncertainty applied only when the light curve had to be reconstructed from the data. Table 1 lists the times of minima obtained from these references plus the 1992 occultation.

AAVSO visual observations made from 1964 through 1990 (Mattei 1992) indicated that eclipses did occur, but only the 1986 data were adequate to determine time of minimum.

In *AAVSO Alert Notice 155,* issued February 20, 1992, a request was made for observations of EE Cep with mid-eclipse estimated at about March 9, 1992. With the sun near vernal equinox, and EE Cep only 2 hours east, but at a high declination of +55°, EE Cep would be visible after sunset, low in the northwest, and again before sunrise, low in the northeast, giving 2 observing windows each day, weather permitting. The response from AAVSO observers was minimal. Observations made by Gerry Samolyk and Marvin Baldwin (Baldwin 1992), both avid AAVSO eclipse observers, resulted in usable curves, plotted in Figure 1. The time of minimum for

each light curve was determined by the tracing paper method with an accuracy of ±0.5 day.

Table 1. Contains times of eclipse minima for EE Cephei. Epoch numbers and O-C values refer to the new linear ephemeris in equation (2). O-C values are plotted in Figure 3.

Year	*Epoch (E)*	*Observed Minima (JD 2400000+)*	*O-C (days)*	*Type*	*Observer(s)*	*Reference*
1947	-1	32297	+0.1	pg	Weber	1, 3
1952	0	34346 ± 0.5	-0.3	pg	Romano	2, 3
1958	1	36399	+3.3	pg	Romano, Perissinotto	3
1964	2	38440	-4.9	pg	Romano, Perissinotto	3
1969	3	40493 ± 1	-1.5	pg	Baldinelli, Ghedini, Tubertini	3
1975	4	42543.3	-0.6	vis	Bauer, Braune, Klebert, Marx, Reimann	8
1975	4	42543.7	-0.2	pe	Locher	6
1975	4	42544	+0.1	pg	Baldinelli, Ghedini, Tubertini	3
1975	4	42544	+0.1	vis	Duruy, Thouet, Vedrenne, Verdenet	4
1975	4	42544.1	+0.2	pe	Rossiger, Pfau, Uhlig	6
1975	4	42544.2	+0.3	vis	Peter	6
1975	4	42544.2	+0.3	pg	Sharof, Perova	7
1975	4	42545.48	+1.6	pe, pg	Bahyl	5
1980	5	44594.1±0.4	+0.8	pe, pg	Baldinelli, Ferri, Ghedini	9
1986	6	46643 ± 1	+0.3	vis	AAVSO observers	10
1992	7	48691.0	-1.1	ccd	Borovicka	11
1992	7	48691.0	-1.1	vis	Halbach	11
1992	7	48692.5	+0.4	vis	Baldwin	11
1992	7	48692.99	+0.9	vis	Samolyk	11

1 = Weber (1956)
2 = Romano (1956)
3 = Baldinelli and Ghedini (1977)
4 = Brun (1975)
5 = Bahyl (1977)
6 = Meinunger (1976)
7 = Sharof and Perova (1976)
8 = Walke (1976)
9 = Baldinelli, Ferri, Ghedini (1981)
10 = Mattei (1992)
11 = This paper

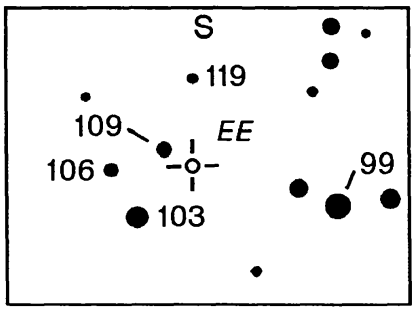
The author was uniquely fortunate - good weather for an extended observing period, plenty of observing time available in retirement, and clear horizons at 8000-ft. elevation - to monitor this eclipse. A month later, Dr. Jiri Borovicka of the Astronomical Institute in Ondrejov, Czech Republic, provided me with his data obtained through V and R filters on an ST-4 CCD camera used with an 18-cm reflector (1992).

Prior to making his observations, Borovicka determined magnitudes of comparison stars with a relative precision of ±0.08 magnitude. These values are shown in Table 2. Photodensitometric estimates on some 1969 plates (Baldinelli and Ghedini 1977) of the 10.9 comparison star showed a 0.5 magnitude variation, so this star was not used by him. Not having prior agreement on which comparison stars to

use, the observers light curves for the 1992 eclipse differ considerably, as seen in Figures 1 and 2.

The author's data are plotted in Figure 2; Borovicka's data are also plotted there, to the same scale. His light curves appear to be offset in brightness because of the CCD magnitude scale he employed.

Table 2. Magnitudes of comparison stars.

AAVSO Preliminary Chart	*AAVSO Sequence Visual*	*Borovicka V*	*Sequence R*
	10.3	10.53	10.32
	10.6	11.24	11.03
	10.9	11.34	11.22
	11.9	11.80	11.58

The times of minimum for the 1992 eclipse were determined using the tracing paper method. All of the available times of minimum are collected in Table 1. A linear least squares fit, giving all 19 times equal weight, yielded the ephemeris for the primary minimum which was used to compute the O-C residuals in Table 1:

$$JD_{min} = \underset{\pm 0.77}{2434346.17} + \underset{\pm 0.17}{2049.41}\ E. \qquad (2)$$

The next occultation should occur on JD 2450741.49, centered on the observing period of October 5 to November 4, 1997, at which time observing conditions should be very favorable.

References

Bahyl, V. 1977, *Astron. Tsirk,* **956**, 3.
Baldinelli, L., and Ghedini, S. 1977, *Mem. Soc. Astron. Italiana,* **48**, 91.
Baldinelli, L., Ferri, A., and Ghedini, S. 1981, *Inf. Bull. Var. Stars,* No. 1939.
Baldwin, M. E. 1992, AAVSO photoelectric observations, private communication.
Borovicka, J. 1992, private communication.
Brun, A. 1975, *Bull. Association Française des Observateurs d'Etoiles Variables,* **9**, 95.
Herbig, G. H. 1960, *Astrophys. J.,* **131**, 632.
Kholopov, P. N. *et al.* 1985, *General Catalogue of Variable Stars,* Fourth Edition, Moscow.
Mattei, J. A. 1992, observations from the AAVSO International Database, private communication.
Meinunger, L. 1973, *Mitt. Verand. Sterne,* **6**, 89.
Meinunger, L. 1976, *Mitt. Verand. Sterne,* **7**, 97.
Romano, G. 1956, *Doc. Obs. Circ.,* **8**.
Sharov, A. S., and Perova, N. B. 1976, *Astron. Tsirk,* **919**, 1.
Walke, K. 1976, *BAV Rundbrief,* **25**, 66.
Weber, R. 1956, *Doc. Obs. Circ.,* **9**, 38.

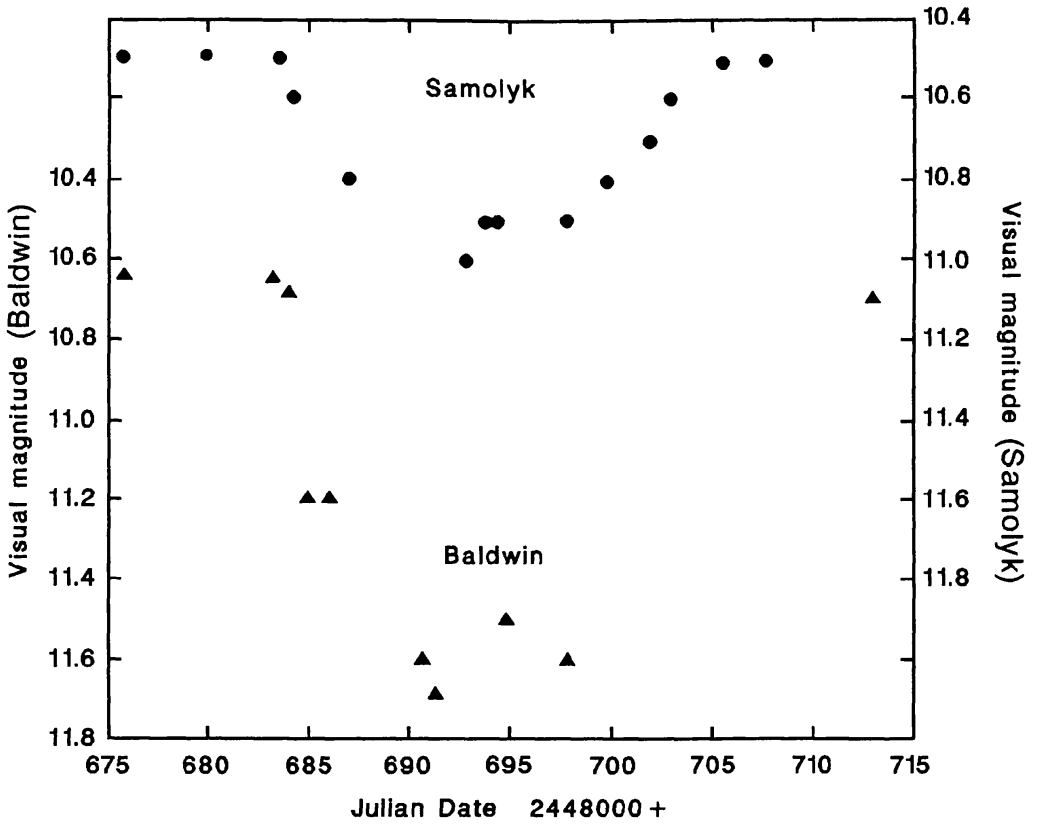


Figure 1. Visual light curves for the 1992 eclipse of EE Cep from Samolyk's (circles) and Baldwin's (triangles) data.

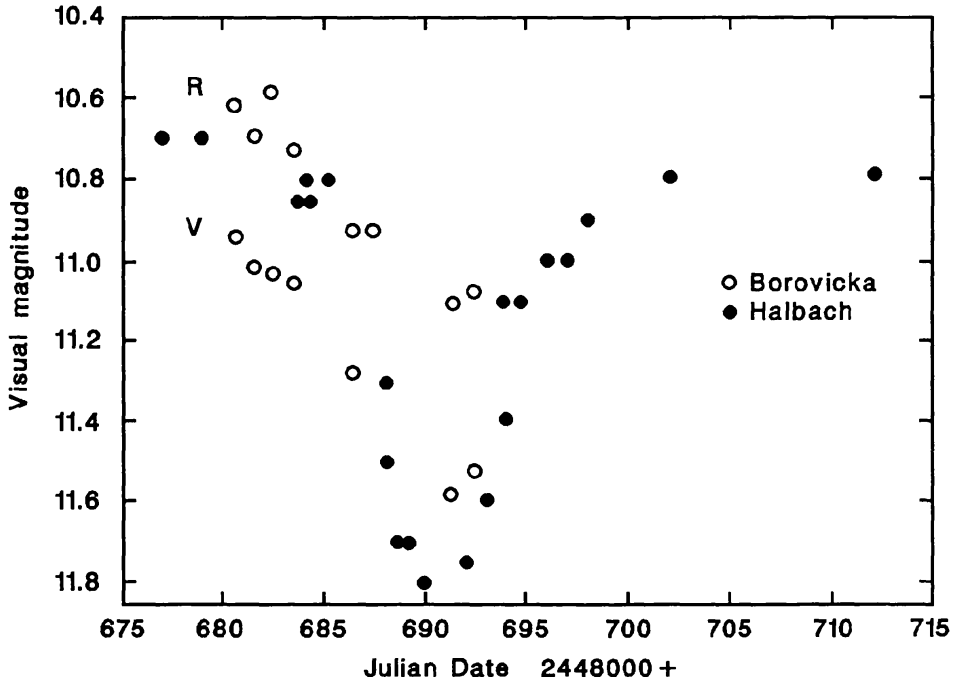


Figure 2. Visual light curve from Halbach's data (filled circles) and CCD light curve with V and R filters from Borovicka's data (open circles) of the 1992 eclipse of EE Cep.

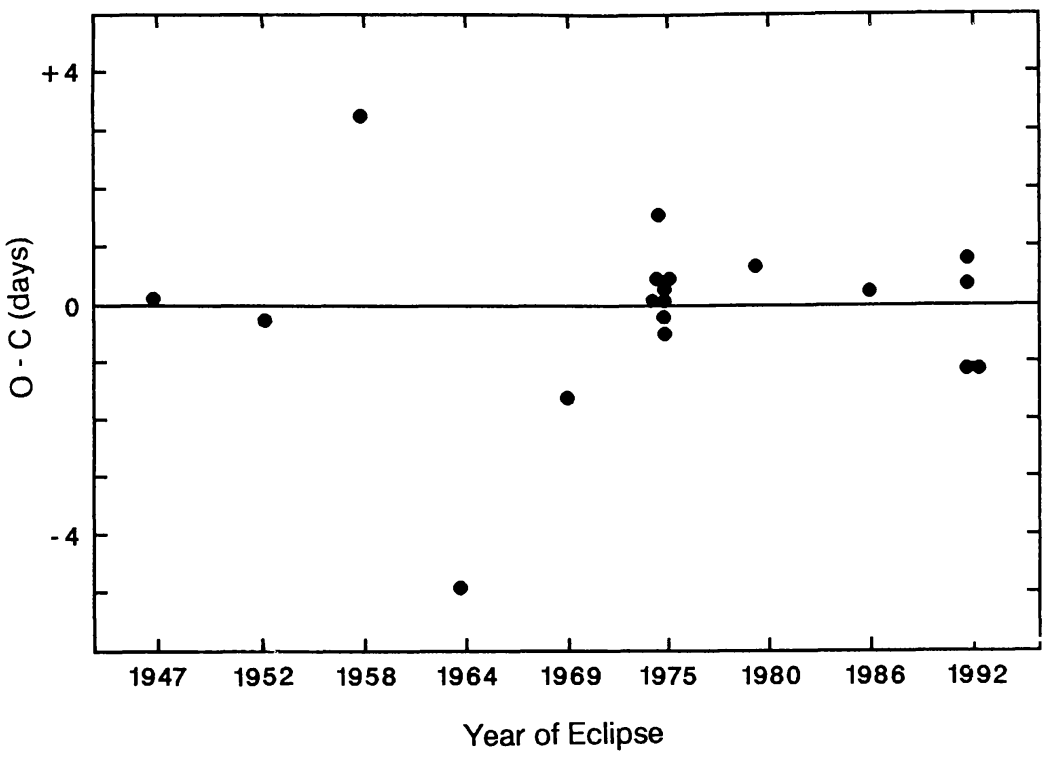


Figure 3. O-C diagram for 1947-1992 eclipses of EE Cephei (period = 5.61 years).