The 2009 Eclipse of EE Cephei

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Abstract An eclipse of the long period system EE Cephei occurred in 2009. CCD observations of this eclipse show a significantly different shape than the previous eclipse in 2003.

1. Background

The variability of EE Cephei was first identified by Romano (1956). His initial analysis indicated that this star was an R CrB type variable. However, this was later changed to an eclipsing binary type by Romano and Perissinotto (1966). The eclipsing nature was confirmed by Meinunger (1973).

Campaigns to observe the two eclipses in the 1990s were lead by Halbach (1992 and 1999). A study by Graczyk *et al.* (2003) evaluated eclipse data through epoch 8. This study proposed a disk model for the system. A CCD campaign in 2003 by Samolyk and Dvorak (2004) showed the eclipse to be highly asymmetrical, supporting the Graczyk *et al.* model.

The light elements from the *General Catalogue of Variable Stars* (GCVS; Kholopov *et al.* 1985) were used to predict these eclipses (no error values available). These are given in equation 1:

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

2. Observations

Observations were made with telescopes of 20- to 30-cm aperture. ST9E or ST9XE CCD imagers were used by all observers. Observations were made in Arizona, Texas, and Wisconsin. Observations from three different sites increased the number of clear nights available and helped us obtain a complete light curve. A Johnson *V* filter was used for all observations.

Field photometry of the following stars, provided by Brian Skiff (2003), was used for the comparison and check stars.

	GSC Nr.	Mag. *V*	*B–V*
Comparison Star	3973 1177	10.386	0.396
Check Star	3973 2150	11.248	0.109
Alternate check Star	3973 1103	11.232	0.410

These are the same comparison stars used for the 2003 eclipse (Samolyk and Dvorak 2004) so the light curves can be directly compared. Images by Simmons (2009) and Poklar were processed using AIP4WIN software. Images by Gerner (2009) and Samolyk were processed using MIRA software. Occasional simultaneous data between observers showed a correlation of 0.01 magnitude or better. All observations from this project are available in the AAVSO International Database.

3. Analysis

The model proposed by Graczyk *et al.* (2003) consists of an optically thick disk surrounded by a semi-transparent layer at the periphery. In addition to the contacts observed in a conventional eclipse, additional contacts occur at the beginning and end of the transit of the semi-transparent portion of the disk.

The duration of the 2009 eclipse (E = 10) caused by the optically thick disk (time between the first and fourth contact) was 37 days. The duration of the entire eclipse, including the semi-transparent layer, is estimated at 90 days. With a minimum magnitude of 11.25 *V*, this was among the shallowest eclipses on record. Other shallow eclipses include 1969 (E = 3) (Graczyk *et al.* 2003) and 2003 (E = 9) (Samolyk and Dvorak 2004). Graczyk *et al.* (2003) suggested that there was an inverse linear relationship between eclipse depth and duration. The 2009 eclipse is a decent fit to the Graczyk plot and supports this hypothesis.

With the exception of irregularities in the descending leg, the 2009 eclipse was much more symmetrical than the typical EE Cep eclipse. This indicates that axis of the disk has rotated significantly from its orientation during the 2003 eclipse. The irregular shape of the descending portion of the eclipse may have been caused by one or more anomalies in the disc structure revealed by the current disc orientation.

The time of mid-eclipse for the 2009 eclipse (E = 10) was determined to be HJD 2454842.1. The available times of minimum from eclipses are listed in Table 1. The Cycle and O–C are calculated using Equation (1).

All observations obtained for this study are available in the AAVSO International Database located at http://www.aavso.org.

4. The next eclipse

The next mid-eclipse of EE Cephei will occur during in July 2014. Observations for a four-month time period are planned to record all contacts of the eclipse.

5. Acknowledgements

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Table 1. Available times of minimum from eclipses of EE Cep.

JD(min) Heliocentric 2400000+	*Cycle*	*O–C*	*Method*	*Observers*
32297	–1	0.5	photographic	Weber
34346	0	0.0	photographic	Romano
36399	1	3.5	photographic	Romano, Perissinotto
38440	2	–5.1	photographic	Romano, Perissinotto
40493	3	–1.6	photographic	Baldinelli, Ghedini, Tubertini
42543.3	4	–0.8	visual	Bauer, Braue, Klebert
42543.7	4	–0.4	PEP	Locher
42544	4	–0.1	photographic	Baldinelli, Ghedini, Tubertini
42544	4	–0.1	visual	Duruy, Thouet, Vedrenne, Verdenet
42544.1	4	0.0	PEP	Rossiger, Pfau, Uhlig
42544.2	4	0.1	visual	Peter
42544.2	4	0.1	photographic	Sharof, Perova
42545.48	4	1.4	PEP, photo	Bahyl
44594.1	5	0.4	PEP, photo	Baldinelli, Ferri, Ghedini
46643	6	–0.2	visual	AAVSO Data
48691.0	7	–1.7	visual	Halbach
48691.0	7	–1.7	CCD	Borovicka
48692.5	7	–0.2	visual	Baldwin
48693.0	7	0.3	visual	Samolyk
50743.8	8	1.6	visual	Samolyk
50743.9	8	1.7	CCD	Cook
50744.0	8	1.8	visual	Berg
52795.0	9	3.2	CCD	Samolyk, Dvorak
54842.5	10	1.2	CCD	Samolyk, Poklar

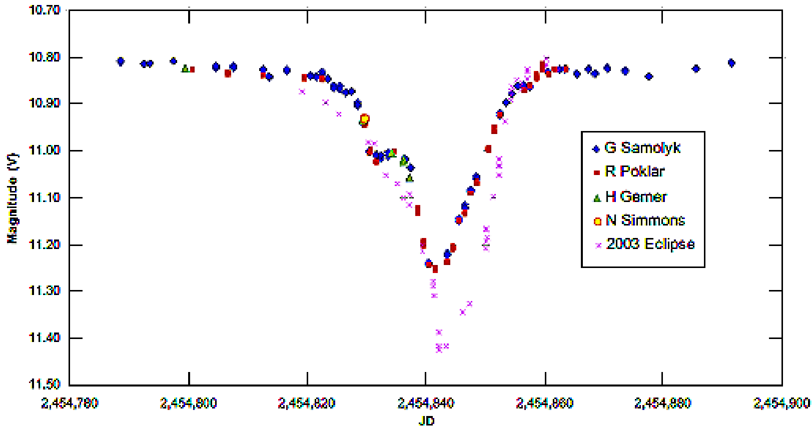

Figure 1. Observations of the 2009 eclipse of EE Cep. The 2003 eclipse (x-symbol) is shown for comparison. Observers are: Samolyk (diamond); Poklar (solid square); Gerner (triangle); Simmons (open square).

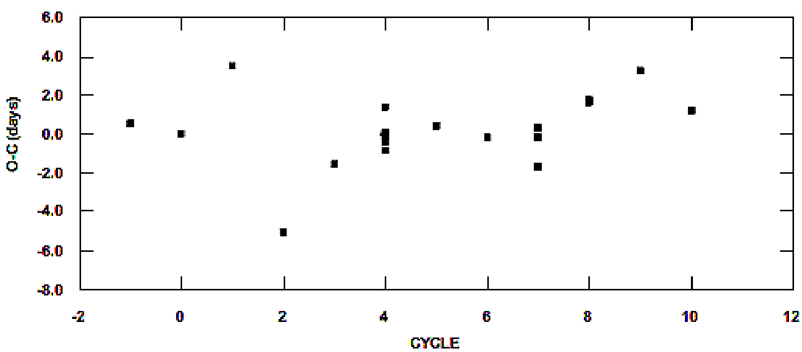

Figure 2. Times of minimum of EE Cep listed in Table 2. The O–C values were calculated using Equation (1).