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THE START OF THE 2003 ECLIPSE OF EE CEPHEI

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The variable nature of 11th magnitude star EE Cep (=BD+55°2693) was discovered by Romano (1956), and confirmed by Weber (1956), who observed two independent deep ($\Delta B \geq 1^{\mathrm{m}}\!\!.5$) minima in 1947 and 1952. The eclipsing nature of these minima was first suggested by Romano & Perissinotto (1966) who noticed a third minimum in 1958 July. Meinunger (1973) then observed two more minima in 1964 and 1969, and confirmed this suggestion. He published the first ephemeris for EE Cep eclipses with orbital period of 2049 days (5.6 years). So far there have been no traces of secondary eclipse in the light curve of EE Cep.

The most striking characteristics of EE Cep are the extremely large changes of shape and depth of the minima. Recently, Graczyk et al. (2003) compiled light curves of all available past eclipses. The observed depths range from about 2^{m} in 1958 and 1964 to about $0^{\mathrm{m}}\!\!.6 - 0^{\mathrm{m}}\!\!.8$ in 1969 and 1992. The depths of the eclipses correlate roughly inversely to their total durations. As an example, two different shape minima are presented in Fig. 1. The extremely shallow minimum ($\Delta B \approx 0^{\mathrm{m}}\!\!.6$) in 1969 was simultaneously the longest one ($D \approx 60^{\mathrm{d}}$). Additionally, this eclipse showed a flat bottom phase with duration $d \approx 20^{\mathrm{d}}$. Most typical eclipses are similar to that of 1975. They have depth at least $1^{\mathrm{m}}\!\!.5$ and show asymmetry of the ascending branch produced by a kind of slope-bottom phase in the minimum. A sketch view of such a typical minimum is presented in Fig. 2.

Multicolour $UBVRI$ observations of a 1997 eclipse (Mikołajewski & Graczyk 1999) showed that the amplitude of the minimum changes very weakly with the wavelength, from about $1^{\mathrm{m}}\!\!.75$ in U, to about $1^{\mathrm{m}}\!\!.45$ in I light. This is probably caused by selective extinction in semitransparent parts of a dark eclipsing body. The contribution of the secondary light in the red RI bands is negligible. The characteristic slope-bottom phase (C-D part in Fig. 2) during the eclipse is easy to understand if the obscuring body is very elongated and tilted with respect to the direction of motion (Graczyk et al. 2003). Changes of tilt angle produce variations in the duration and slope of this transit phase. In particular, when the tilt angle is very small, a flat-bottom phase would be observed during the minimum. Simultaneously, the effective thickness of the eclipsing body also changes during the different eclipses, causing variations of the minima depths. The most promising model remains that of a dark, precessing disk around a low luminosity central

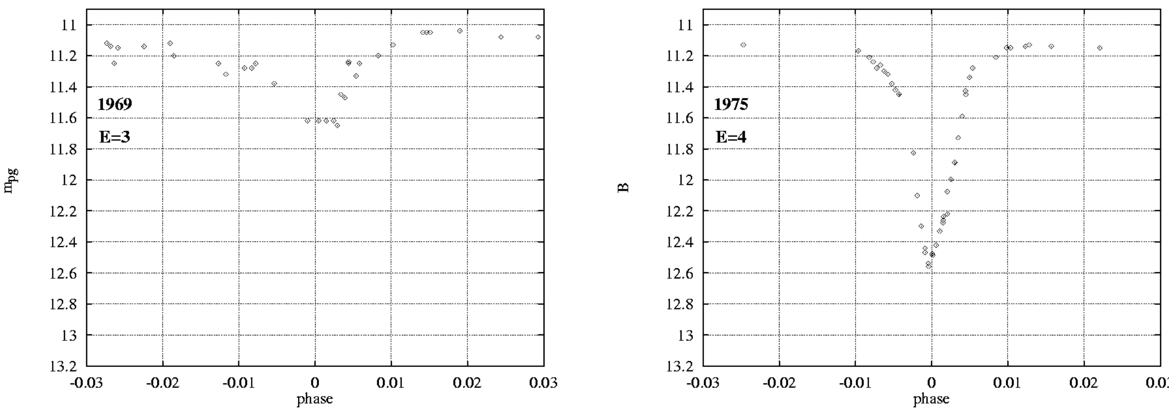

Figure 1. Examples of shallow, flat-bottom (*left*) and deep, slope-bottom (*right*) eclipses of EE Cep (Graczyk et al. 2003, and references therein).

object (Mikołajewski & Graczyk 1999, Graczyk et al. 2003). The precession changes both the inclination of the disc to the line of sight, and the tilt of its cross-section to the transit direction. The unique shape of the eclipse observed in 1969 can be explained by a practically edge-on and non-tilted projection of the disc. Two hypotheses can be considered for such a disc: (i) it has a proto-planetary origin; (ii) it is a post-planetary object (a result of planetary disintegration). An important question is the nature of the central body embedded in the disk. It can be a low massive single star or a close binary system. The only similar object previously known with a dark circumstellar disc is ϵ Aur – the longest period ($\sim$ 27 years) eclipsing binary.

Surprisingly, low resolution spectroscopic observations during past eclipses (Brükner 1976, Baldinelli, Ferri & Ghedini 1981) did not detect any trace of secondary spectrum. Moreover, there were no changes in the spectrum (especially in Hα, Hβ emissions) despite the large depth of the minima (about $1\overset{\rm m}{.}5$). Our recent observations at Asiago Observatory ($R = \lambda/\Delta\lambda \approx 4000$) show that the profiles of the Hα and Hβ lines in the spectrum of EE Cep are very similar to those observed in Be stars. However, we cannot be sure that they indeed belong to the visible, eclipsed B5III component. The observed Hα and Hβ profiles are rather characteristic for Be stars located nearly pole-on (*e.g.* Hanuschik et al. 1996). Already far outside eclipse we found spectacular variations in the Hα emission (Graczyk et al.2003), which seem to be more naturally connected with the complex around the secondary. Additionally, in the same paper we pointed out variations in the radial velocities of the NaI absorption doublet. This finding can be considered an indication of its possible circumstellar origin. Moreover, last month we found these lines as pure P-Cyg type profiles (Fig. 3). This dramatic change can already be connected with the beginning of the eclipse.

The incoming event, according to the ephemeris of Mikołajewski & Graczyk (1999), has number $E = 9$. The mid-eclipse should occur on June 3, 2003. The external first contact of the semitransparent part of the disc (A in Fig. 2) can start at least three weeks earlier ($\sim$ May 13). The central part of the minimum (B-C-D-E in Fig. 2) should occur between $\sim$ May 23 and $\sim$ June 13 corresponding to the occultation of the primary by the inner, opaque part of the disc. The end of the minimum should take place $\sim$ June 24. We would like to remember that the eclipse duration D can last even $2-3$ weeks. In Graczyk

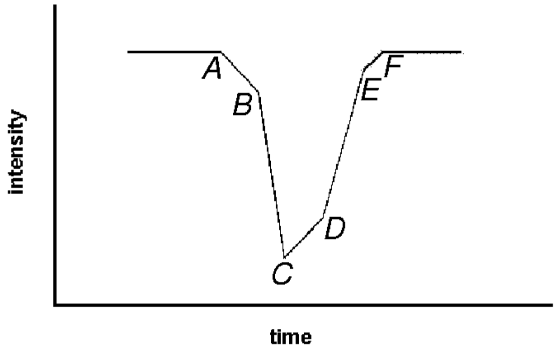

Figure 2. Schematic view of the EE Cep eclipse: A–B - descending atmospheric phase; B–C eclipse ingress; C–D transit phase; D–E eclipse egress; E–F ascending atmospheric phase.

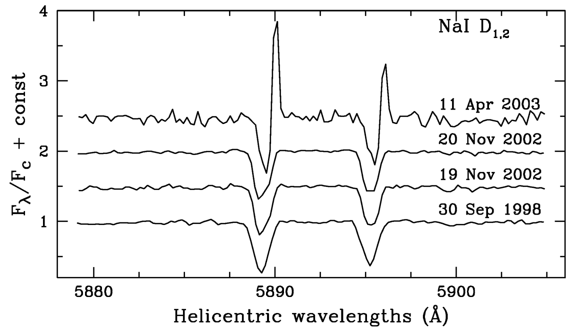

Figure 3. Profiles ($R = \lambda/\Delta\lambda \approx 15000$) of NaI $D_{1,2}$ doublet obtained with the coudé spectrograph of the 2m telescope at Rozhen Observatory.

et al. (2003) we speculate that the possible precession period may be about 50 years and the shape of the eclipse can be similar to the one observed in 1952. That one was very deep (at least $1\overset{\text{m}}{.}9$) and no longer than 40 days. A slope-bottom with inverse inclination, placed on the ascending branch of the present eclipse, would not be a surprise.

Photometric observations of EE Cep (with CCDs or photomultipliers) from widely spaced longitudes will help to obtain a detailed light curve of this minimum and to determine precisely all six contacts A-F (Fig. 2). These observations will be useful for numerical modelling of the disc. We recommend as comparison and check stars the brightest objects from the Meinunger's (1975) sequence (Fig. 4). Their Johnson magnitudes, obtained using a diaphragm cooled photometer attached to the 60cm reflector at Toruń observatory, are:

Star	U	B	V	R	I	n
a = BD + 55°2690	10.86	10.68	10.38	10.09	9.87	40
b = GSC 3973 2150	11.31	11.47	11.23	10.99	10.81	5
c = BD + 55°2691	11.59	11.47	11.22	10.96	10.75	2

Our data are in good agreement with earlier UBV measurements for star "a" (Meinunger 1976), V brightness for "b" and "c" stars (Skiff 2003) and BRI estimations for all these objects from USNO-B1 catalogue (Monet et al. 2003). Star "c" was suspected variable (Baldinelli & Ghedini 1976), and its contemporary magnitudes differ about $0\overset{\text{m}}{.}1$ from the data of Barbieri et al. (1973). Nevertheless, our own observations and the observations of Skiff (2003) do not confirm its variability.

Very important will be high resolution spectroscopic observations during the eclipse. We expect the appearance of strong shell spectrum from the gaseous component of the disc, as in ϵ Aur (Ferluga & Mangiacapra 1991), and possible strengthening of the diffuse interstellar bands (DIBs) caused by the dust component of the disc. Several strong DIBs (*e.g.* $\lambda\lambda$ 6619 Å, 5780 Å, 5797 Å, 5850 Å) are visible already in the spectrum outside the eclipse. Possible changes in the Balmer line profiles should determine where their emissions arise, i.e. whether the primary is a Be star. Of course, systematic radial velocity measurements are necessary for the spectroscopic orbit solution and the estimation of the masses of the EE Cep system components.

Also very important should be infrared photometric (at least JHK) observations during and outside the eclipse. These could be helpful in finding the flux originating in the disc and its central object, as well as in estimating their temperatures.

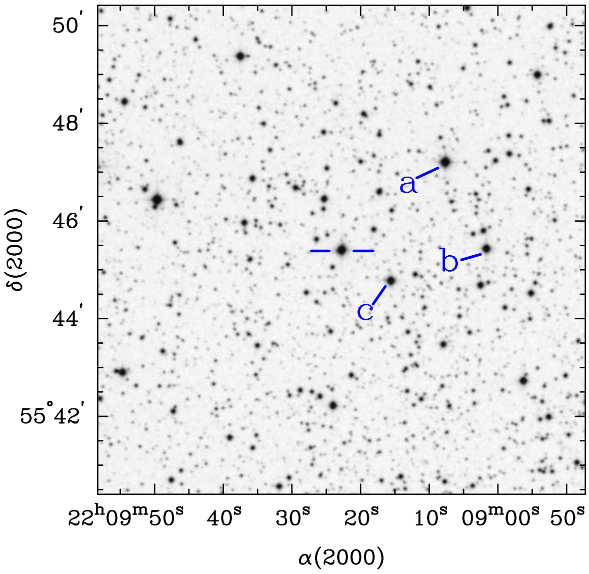

Figure 4. $10' \times 10'$ DSS-2-red finding chart for EE Cep.

We started our $UBVR_CI_C$ and optical spectroscopic observations of EE Cep at Toruń, Rozhen and Asiago observatories. Of course, it is not realistic to expect that we will be able to secure enough data for a good photometric and spectral coverage of the eclipse. Because of this we welcome future collaboration with interested observers.

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