EM Cep – the Be Star

Nino Kochiashvili¹, Lidia Oskinova², Ia Kochiashvili¹, Rezo Natsvlishvili¹, Manana Vardosanidze¹, Sopia Beradze¹

¹ Ilia State University, E.Kharadze Abastumani Astrophysical Observatory, Georgia
² University of Potsdam, Institute for Physics and Astronomy, Germany

Strasbourg, September 3-5, 2018
Outline:

• properties of Be stars;
• about EM Cep, CB or Be star,
• the flare – energetics;
• old spectra ...
• new spectral data of 11 years duration (Kjurkchieva, Diana et al., AJ, 2016)
• New data
Be stars, problems

- Classical Be stars are non-supergiant, early-type stars whose spectra have, or have had at some time, one or more Balmer lines in emission (Struve 1931).
- Be stars were discovered by Secchi (1866).
- About 200 of them are among the naked-eye stars. This makes them one of the most conspicuous classes of variables (Percy, 2007).
- Be stars are:
  1. fast rotators
  2. no strong magnetic fields
  3. double-or even triplewave, (Cuypers et al 1989; Balona et al 1992) which was often interpreted as supporting evidence of a rotational nature.
  4. “decretion discs”
EM Cep (HD 208392, HIP 108073, SAO 19718) is a component of the visual binary ADS 15434, a member of the open cluster NGC 7160, with an age of 18 Myrs and a distance of 830 pc.

Emission in Hα from EM Cep: Plaskett & Pearce (1931); Merrill et al. (1932).

Rachkovskaia (1977) did not find radial-velocity variations of the Hα line in excess of 15 km/s or any phase dependent line-profile variations.

EM Cep was discovered to be a periodic variable by Lynds (1959).

Further observations showed the light variability to be quite irregular (Johnston 1970, Rachkovskaia 1975, 1976, Bakos & Tremko 1975).

The main peculiarity of EM Cep is that its light variability has not been found to be accompanied by any pronounced radial-velocity or color variations (Mars et al. 2010).
EM Cep

- EM Cep at Abastumani Observatory - observations from 1991 (Kochiashvili, 1999).

- For that time we knew, that:

- It is a bright (m(V)=7.03) short period variable with spectral class B1 IV+? Amplitude of its variability - 0.15 magnitudes and period – P=0.806187 days.

- Some of its investigators considered the star as a close binary system (Lynds: 1959a, Lynds 1959b; Johnston, 1970; Rachkovskaya: 1972, 1976; Bakos&Tremko 1975; Tremko& Bakos 1980; Karimie, 1979; Breinhorst & Karimie, 1980; Cristescu et al. 1981), some of them regarded it as a non-radial pulsator (Hilditch et al. 1982;).

- According to her observations, Rachkovskaya (1977) made a conclusion that EM Cep is either a β Cep type variable or an oblique rotator.
Known Flares of EM Cep

Fig. 1a—The light curve of EM Cep for J.D. (244) 1607-1613.

Fig. 1b—Same as above for J.D. 1621-1629.

Fig. 3—A flare of EM Cep in blue and yellow light observed on November 8, 1974.

Bakos & Tremko, 1975
EM Cep-the flare,
November, 1991
EM Cep – mass loss

- During the flare the luminosity growth in R band was $739 \, L_\odot$.

  Equivalent mass loss during 2 hours of flare in R passband: $M=10^{-14} \, M_\odot$.

- Analogically equivalent mass of the energy of anti-flare in U would be:

  $$M= 5 \times 10^{-14} \, M_\odot.$$
Formal solution of light curves

• We decided to get a formal solution of the light curves of EM Cep using the Wilson-Devinney code.

• Due to the unstable character of EM Cep light curves we used observations of 1999 only – during this period the star did not show significant changes of light curves. Those are data of August (4 nights) and October (5 nights).

• Orbital elements of Cristescu et al. (1965) were used as input data. We took fillout=0.17 for the system. This is a case of W UMa type eclipsing binary. The Model and parameters are presented below for R band.
Model of EM Cep – as a CB

- Mass ratio input = 0.450000, mass ratio < 1 = 0.450000
- Omega 1 = 2.732271, Omega 2 = 2.732271
- Omega inner = 2.778437, Omega outer = 2.506876
- C 1 = 3.864964, C 2 = 3.864964
- C inner = 3.928641, C outer = 3.554074
- Fillout 1 = 0.170000, Fillout 2 = 0.170000
- Lagrangian L1 = 0.581283, Lagrangian L2 = 1.564814
- AG = r1(back) = 0.491607, AS = r2(back) = 0.352983
- BG = r1(side) = 0.460921, BS = r2(side) = 0.314321
- CG = r1(pole) = 0.431211, CS = r2(pole) = 0.300105
- DG = r1(point) = 0.581283, DS = r2(point) = 0.418717
- Surface area 1 = 2.682987, Surface area 2 = 1.339518
- Mean radius 1 = 0.461246, Mean radius 2 = 0.322470
- inclination = 46.500, wavelength = 6600.00
- temperature 1 = 22500.00, temperature 2 = 28500.00
- luminosity 1 = 0.5849, luminosity 2 = 0.4151
- gravity coefficient 1 = 0.300, gravity coefficient 2 = 0.000
- limb darkening 1 = 0.000, limb darkening 2 = 0.000
- reflection 1 = 1.000, reflection 2 = 0.600
- Third light = 0.0000
By its light variation character the EM Cep shows certain similarity with Eri variable (Kochiashvili et al., 2007). Consequently we calculated our photoelectric data for half-period (see Bakis et al., 2007). The results are presented for R band (Kochiashvili&Kochiashvili, 2008).
Hα Lines of EM Cep - Byurakan

11.08.2002

10.12.1999
New spectral observations of EM Cep in Bulgaria

New spectral observations were carried out by the 2m RCC telescope (Kjurkchieva, Diana et all, AJ, 2016)

It was used a CCD Photometrics AT200 camera with an SITe SI003AB 1024x1024 pixel chip mounted on the Coudé spectrograph (grating B&L632/14.7°) on the 2m telescope of the National Astronomical Observatory at Rozhen, Bulgaria.

The resolution of the spectra is 16 400, and most spectra have a S/N ratio in the range 150–250.

Initially, EM Cep was observed in the spectral range centered on Hα, but after July 2005, the spectral range was changed to include the He I 6678 line.
Be and B States

Fig. 1.— A Sample of EM Cep spectra in the Be state. The spectra have been offset for clarity.

Fig. 2.— A Sample of EM Cep spectra in the B state.
So according to:

- EM Cep switches between B and Be star states, as revealed by the level of H emission, but spends most of its time in the B star state.

- EM Cep has been considered to be an eclipsing, near contact binary of nearly equal-massed B stars in order to reproduce regular photometric variations; however, this model is problematic due to the lack of any observed Doppler shift in the spectrum.

\[ M^* = 12.5 \, M_\odot \, , \]

disk masses: on the order of \( 3 \times 10^{-11} M^* \)

mass loss rate of \( \approx 3 \times 10^{-9} M_\odot \, \text{yr}^{-1} \).

- \( R \, \text{polar} = 6.3 \, R_\odot \); \( R \, \text{equatorial} = 9.45 \, R_\odot \), \( \text{Teff} = 26 \, 000 \, K \)
Spectral Observations of EM Cep

In 2017 several spectral observations have been obtained with the spectrograph FLECHAS on the 0.9 m telescope of the University Observatory Jena. The H region in the spectra clearly shows the Be state (black, orange and blue graphs) and the B state (green). Does switching from the B to Be state occur within a few days?

Fig. 5: Hα region in the spectra of EM Cep.
New observations of 2017-Abastumani, 48 cm Cassegrain
Thank you!