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# FM CMa: hot and massive eclipsing binary with a pulsating component

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**Abstract.** Long-term spectroscopic monitoring of the eclipsing system FM CMa obtained between 2017 – 2023 at the Skalnaté Pleso (SPO, Slovakia) and Cerro-Tololo Interamerican observatories (CTIO, Chile) is presented. Preliminary analysis of the TESS high-precision satellite photometry (sectors 7 and 33, only FFI – Full Frame Image) shows that the eclipses in the system are total, and there is a slow apsidal motion. The light-curve solution requires a substantial amount of third light. In addition, the TESS light curve exhibits low-amplitude variability (in the out-of-eclipse parts), probably caused by radial pulsations with a frequency of about 5.5 cycles/day (4.3 hours). Line profiles show strong asymmetries corresponding to the photometric ephemeris but the possible third component is not visible. The nature of the system is discussed.

**Key words:** binary stars – eclipses – pulsations

## 1. Introduction

FM CMa ($V_{\max} = 8.73$, $\alpha_{2000} = 07^{\rm h}\ 05^{\rm m}\ 42.1^{\rm s}$, $\delta_{2000} = -12^\circ\ 48'\ 43''$, HD 53756, TIC 148502346, TYC 5389-2875-1) is a hot eclipsing binary composed of a B2 primary and a colder secondary orbiting in $P = 2.78945$ days. Although the system is rather bright, it is neglected. Detailed information about the system is available in the literature (e.g. Hill 1967; van Hoof 1973; Eggen 1978; Kaltcheva & Hilditch 2000).

## 2. Observations

Our spectroscopic observations of FM CMa were obtained at the SPO with a MUSICOS-clone spectrograph fiber-fed from a 1.3m Nasmyth-Cassegrain telescope. In total, 19 high-resolution ($R = 35\,000$) spectra were obtained from

**Table 1.** The best photometric elements of the system, $P$ – orbital period, $T_0$ – time of the periastron passage, $i$ – inclination angle, $r_{\rm pri}$ – fractional radius of the primary component, $r_{\rm sec}/r_{\rm pri}$ – ratio of the component radii, $e$ – orbital eccentricity, $l_3$ – third light expressed in the out-of-eclipse brightness of the eclipsing pair, $T_{\rm pri}$, $T_{\rm sec}$ – effective temperatures of the compontents

| Parameter | Value | $\sigma$ |
|---|---|---|
| $P$ [d] | 2.78928 | 0.00012 |
| $T_0$ BJD [TDB] | 2459202.9041 | 0.0034 |
| $i$ [deg] | 86.7 | 0.6 |
| $r_{\rm pri}$ | 0.2640 | 0.0025 |
| $r_{\rm sec}/r_{\rm pri}$ | 0.596 | 0.009 |
| $e$ | 0.067 | 0.005 |
| $\omega$ [deg] | 274.4 | 0.4 |
| $l_3$ | 0.95 | 0.15 |
| $T_{\rm pri}$ [K] | 17368 | – |
| $T_{\rm sec}$ [K] | 14700 | 450 |

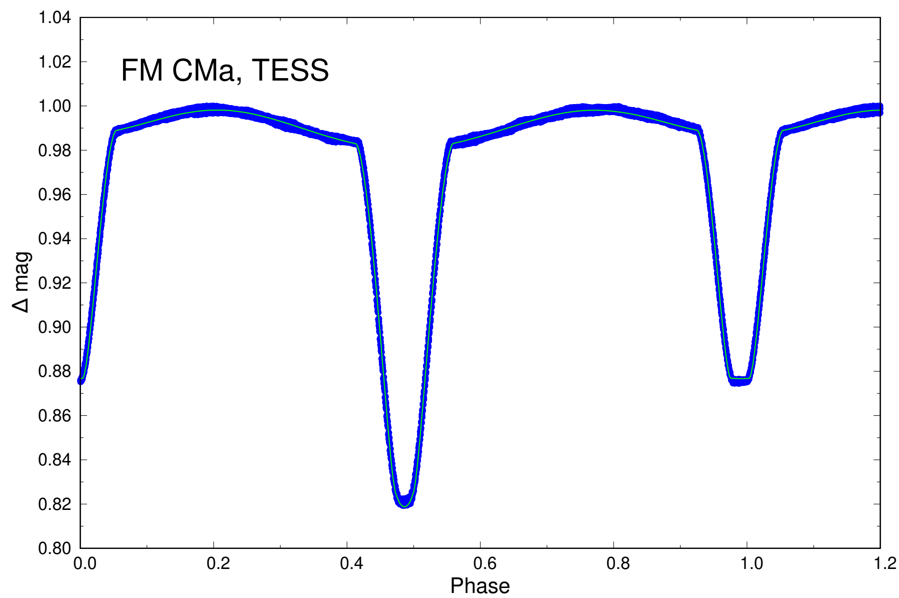


**Figure 1.** The best fit to the TESS photometry (sector 33) obtained with RMF. The fit corresponds to the parameters listed in Table 1.

January 2017 to March 2023. Because of its low declination, FM CMa was also observed with the CHIRON spectrograph (with an image slicer and $R = 70\,000$) fiber-fed from a 1.5m telescope at the CTIO. In total 7 spectra were obtained from October till December 2022. The spectra confirm the early B spectral type manifested by the dominant hydrogen Balmer and neutral helium lines. Only the strongest metallic lines are visible (e.g., Mg II 4481 Å, C II 4267 Å, the silicon triplet, Si III 4552 Å, 4567 Å, 4574 Å). The paucity of metallic lines complicates the determination of the radial velocity and spectra disentangling. The hydrogen-line profiles are asymmetric indicating a blend of two (or more) components. The light-curve solution indicates, the bolometric flux ratio of the primary and secondary component to be about 0.18.

In addition to the total eclipses, ellipsoidal variation and reflection effect, the TESS light curve exibits additional low-amplitude variability, well visible in the out-of-eclipse parts of the light curve. This variability is very probably caused by radial pulsations. The dominant pulsational frequency is about 5.5 cycles/day (4.3 hours). The TESS light curve has been analysed using code RMF (Roche ModiFied code) (Garai et al., 2022). The light-curve model required a significant contribution of third light amounting to about 0.95 of the out-of-eclipse brightness of the eclipsing pair. Preliminary elements are listed in Table 1 and the corresponding fit to the TESS data is shown in Fig. 1. A comparison of the data from the two TESS sectors (almost two years apart) clearly shows that there is a slow apsidal motion with the apsidal motion cycle about $U = 92$ years long.

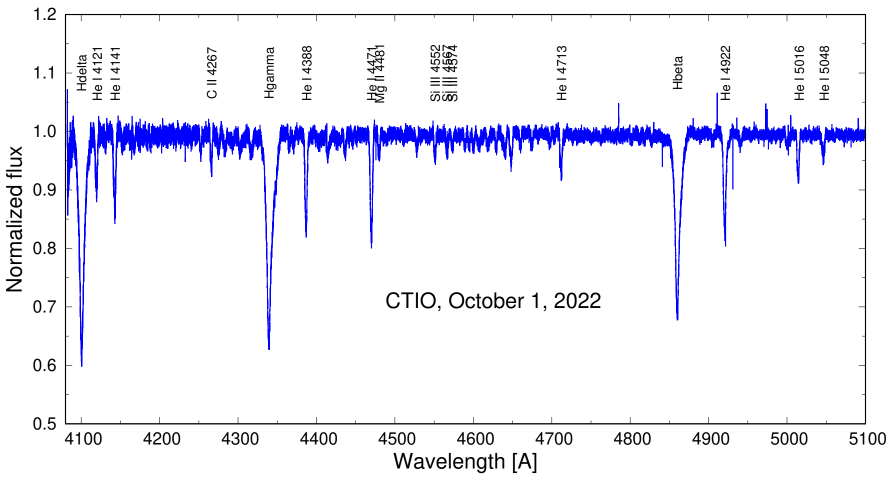


**Figure 2.** Blue spectrum of FM CMa with an identification of the most prominent spectral lines. A slight asymmetry best visible in the red wing of the hydrogen lines is very probably caused by the fainter and colder secondary component.

## 3. Conclusion

A preliminary analysis of the spectra indicates that the secondary component is possibly a rapidly rotating star which further complicates its detection and modelling, similar to the case of e.g., HD183986 (Vaňko et al., 2022). No traces of the possible tertiary component indicated by the photometric solution were found. Further spectroscopy will be focused on the total eclipses in the system which could help in disentangling the component's spectra.

Figure 2 shows that some lines in the blue part of the spectrum are slightly asymmetric. The variable asymmetric shapes of the absorption lines in this eclipsing system can be caused by the complex and non-uniform wind flows from the two components in the orbital plane. A similar system with an orbital period of 1.8 days with two massive B-type components AH Cep was detected in X-rays by Chandra observatory (Ignace et al., 2017). Its X-ray luminosity can originate from the wind collision between the two stars, supporting the complexity of the circum-stellar matter distribution in such systems.

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