

# Photometric study of the close eclipsing binary MM Dra

Rumen Bachev<sup>1</sup>, Evgeni Semkov<sup>1</sup>, Nikolay Kacharov<sup>1,2</sup>, Alok C. Gupta<sup>3</sup>,  
Evgeni Ovcharov<sup>2</sup>, Anton Strigachev<sup>1</sup>

<sup>1</sup> Institute of Astronomy, Bulgarian Academy of Sciences, Sofia 1784, Bulgaria

<sup>2</sup> Department of Astronomy, University of Sofia, 5 James Bourchier, Sofia 1164, Bulgaria

<sup>3</sup> Aryabhata Research Institute of Observational Sciences (ARIES), Manora Peak,  
Nainital - 263129, India  
anton@astro.bas.bg

(conference poster)

**Abstract.** We present new photometric data for an EW-type binary star – MM Dra. Light curve data in B and R colors for a total of 37 hours of observation have been analyzed. We obtained a new period of the binary – 0.26548 (0.00001) days, slightly larger than previous estimates, but broadly consistent with the previously reported minima epochs. The presence of O’Connell effect in the light curve is noted.

**Key words:** stars: binaries: eclipsing – stars: individual: MM Dra

## Фотометрично изследване на затъмнителната двойна MM Dra

Румен Бачев, Евгени Семков, Николай Качаров, Алок Гупта,  
Евгени Овчаров, Антон Стригачев

Представени са нови фотометрични данни за затъмнителната двойна от EW тип MM Dra. Изследвана е кривата на блясъка в B и R цветове за ок. 37 часа наблюдения. Получен е нов период на звездата – 0.26548 (0.00001) дни. Той е малко по-голям от предишни оценки, но е в относително съгласие с наблюдаваните досега минимума. Отбелязва се и присъствието на ефекта на О’Конъл в кривата на блясъка.

## Introduction and observational data

MM Dra is an EW type eclipsing binary that has been discovered as such by [Lee et al. 2000]. It is close to a known blazar 1ES 1959+650 and initially, before its variability had been discovered, it was used as a reference star to monitor variability of the blazar (i.e. star “5”, [Villata et al. 1998] ). In the course of a recent optical monitoring of 1ES 1959+650 (to be published elsewhere) we performed a parallel photometric study of MM Dra. The field was monitored for 9 nights between July and September 2009, with a total monitoring time of about 37 hours. Repeating 60 – 180 sec exposures were taken mostly in B and R filters and occasionally V and I frames were taken as well. The object was observed with the 60-cm telescope at AO Belogradchik, Bulgaria, equipped with a FLI PL9000 CCD and during one night – with the 50/70 Schmidt telescope at NAO Rozhen, Bulgaria, equipped with a FLI PL16803. Both cameras are equipped with standard BVRI filters sets. Table 1 presents the log of the observations.

All frames (in total of about 500) were properly dark current and flat field corrected. Aperture photometry was performed in respect to the star “4” in the field [Villata et al. 1998] in order to extract the magnitudes of MM Dra.

**Table 1.** Log of observations

Date	Telescope	Total monitoring (h)	Filters	Exposures
26.7.2009	60 AOB	4.2	patrol BR + VI	120 s
27.7.2009	60 AOB	4.1	patrol BR + VI	120 s
28.7.2009	60 AOB	4.1	patrol BR + VI	120 s
29.7.2009	60 AOB	4.0	patrol BR + VI	120 s
30.7.2009	60 AOB	3.9	patrol BR + VI	120 s
17.8.2009	60 AOB	4.3	patrol BR + VI	120 s
20.8.2009	60 AOB	3.7	patrol BR + VI	120 s
21.8.2009	60 AOB	4.5	patrol BR + VI	120 s
22.9.2009	50/70 NAO	4.0	patrol BR	180/60 s

## Results

Based on the extracted light curves we obtained the period of the variable –  $P=0.26548$  (0.00001) days, Fig. 1. This period is somewhat longer than the one reported by [Lee et al. 2000], i.e. 0.2644, which however was obtained based on poorer data. The other two known primary minima published for this variable, HJD 2451457.04 [Lee et al. 2000] and HJD 2454326.583 [Brat et al. 2007] seem to be in an acceptable agreement with the newly obtained period and a primary minimum determined in this study –HJD 2455061.433 (0.001).

Fig. 1 shows the phase diagram of MM Dra for B and R colors (the light curve data are available upon request). The primary minima amplitudes are 0.53 (B) and 0.46 (R) magnitudes. The difference between the primary and the secondary minima is 0.15 (B) and 0.13 (R) mag. A clear indication for the existence of the O’Connell effect (magnitude difference between the two maxima) is apparent from the diagram – it is about 0.05 (B) and 0.04 (R) mag. The phase difference between the minima is consistent with 0.5.

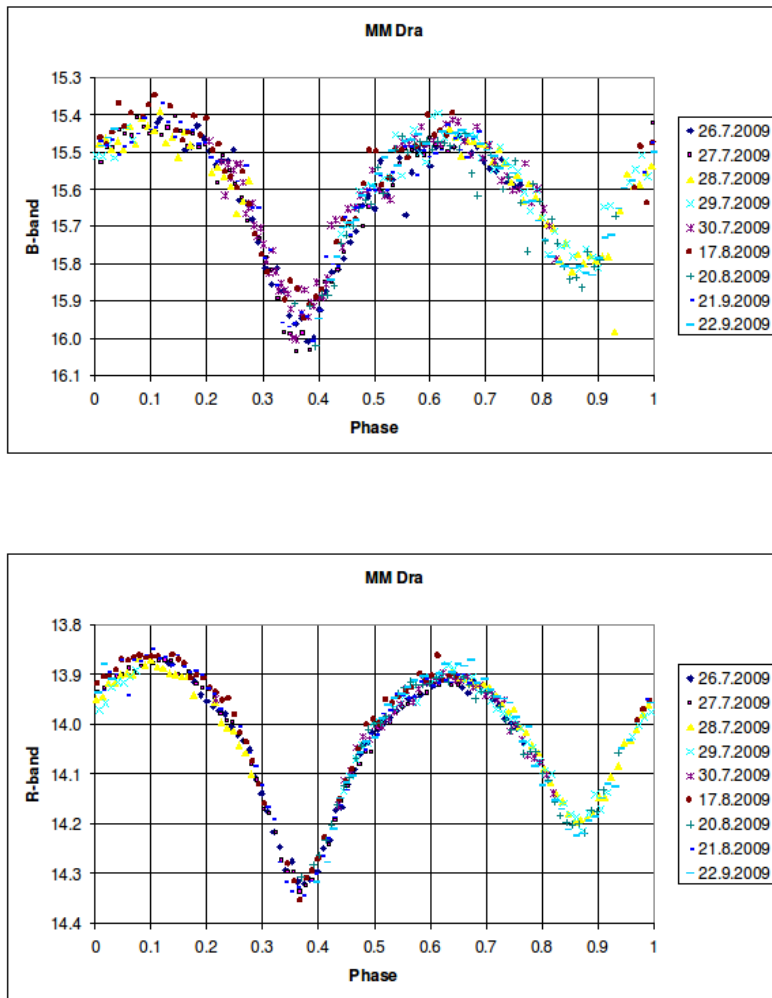
## Conclusions

There are about 1000 known EW binaries in the Galaxy. Studying these objects can help to better understand the interaction between the components and ultimately – the binary evolution. In this work we present high-quality photometric data in two colors for an EW type binary – MM Dra that allowed us to adjust some parameters of the binary – the period, amplitudes, etc.

*Acknowledgments:* This research was partially supported by the grants BIn-13/09 and DO 02-85 of the NSF, Bulgarian Ministry of Science and Education. RB and AS acknowledge the kind hospitality of ARIES, Nainital, India, where much of this work has been done.

## References

- Brat L., Zejda M., Svoboda P., 2007, *OEJV* 74, 1  
 Lee H.J., Lee M.G., Kim S.-L., 2000, *IBVS* 4848, 1  
 Villata M., Raiteri C. M., Lanteri L. et al. 1998, *A&AS* 130, 305



**Fig. 1.** Phase diagrams for MM Dra for B-band (upper panel) and R-band (lower panel). An arbitrary phase shift is added for clarity. Magnitudes are measured in respect to star “4”, [Villata et al. 1998] The period found is 0.26548 (0.00001) days. The individual observing runs are shown as different symbols



**Fig. 2.** In the closing dinner of the Conference



**Fig. 3.** In the closing dinner of the Conference