The first multi-color photometric study of the short-period contact eclipsing binary DE Lyn

Amanda Hashimoto [a], Liyun Zhang [b,c,*], Xianming L. Han [a,b], Hongpeng Lu [b,c], Daimei Wang [b,c]

[a] Department of Physics and Astronomy, Butler University, Indianapolis, IN 46208, USA
[b] College of Science/Department of Physics & NAOC-GZU-Sponsored Center for Astronomy Research, Guizhou University, Guiyang 550025, PR China
[c] Key Laboratory for the Structure and Evolution of Celestial Objects, Chinese Academy of Sciences, Kunming 650011, PR China

HIGHLIGHTS

- We present the first multi-color VRI CCD light curves of an eclipsing binary DE Lyn.
- We obtained photometric parameters of DE Lyn with the Wilson & Devinney program.
- We found that the orbital period of DE Lyn exhibits a decreasing trend.

ARTICLE INFO

ABSTRACT

We observed the contact eclipsing binary of DE Lyn using SARA 0.9 m telescope at Kitt Peak National Observatory on February 9, 11, and 27, 2015. In this study, we obtained the first full phase coverage BVRI CCD light curves, analyzed the orbital period variation, and extracted the orbital parameters. We calculated the linear and quadratic ephemeris, and thereby found that DE Lyn has a decreasing orbital period rate of $-5.1(\pm 0.4) \times 10^{-7}$ days/year. We assume this decreasing trend is the result of the more massive component (secondary) transferring mass to the less massive component (primary), and we obtained a mass transfer rate of $dm/dt = 7.06 \times 10^{-7} M_\odot$/year. By using the updated Wilson & Devinney program, we found the orbital parameters of DE Lyn, which, in turn, enabled us to calculate the low degree of contact factor as $f = 9.02(\pm 0.01)\%$. In the future, its degree of contact will continue to increase and will evolve into an over-contact system.

1. Introduction

The research of binary stars has been vitally important in recent years, mainly because they can be the primary source of our knowledge regarding the fundamental properties of stars. The eclipsing binary DE Lyn has been researched previously by many astronomers, who published primary and secondary minima times of eclipsing binary (Paschke and Brat, 2006; Agerer and Hübscher, 2003; Hübscher, 2005; Diethelm, 2009, etc.). DE Lyn has been classified as an EW type of eclipsing binary, the minima HJD has been found to be 2451630.631, and the period as 0.40882 days (Otero et al., 2006). The minima times of DE Lyn have also been published and are available at the source O–C Gate (Paschke and Brat, 2006). Previously, the orbital parameters and the period variation have not been analyzed. In

our research, we use the CCD light curves to understand the period variation and orbital properties of the DE Lyn star.

2. Photometric observations

The observations were carried out on February 9, 11, and 27 in 2015 using the SARA telescope located at Kitt Peak National Observatory in Arizona. This telescope has a diameter of 91.4 cm and a focal length of 685.8 cm. It is located at a longitude of [West 111° 35 min 59.4 s] and latitude of [North 31° 57 min 36.0 s]. Its elevation is 2133 m. The CCD camera on the telescope has a resolution of 2048 × 2048 pixels, but was usually used in 2 × 2 binning mode, resulting in an effective resolution of 1024 × 1024 pixels. We used the Bessel B, V, R, and I filters, with exposure times of 60 s, 45 s, 30 s, and 30 s, respectively. The comparison and check stars were chosen near the object star, and the magnitudes and coordinates of these stars are listed in Table 1. The magnitudes were procured using the IRAF program in standard fashion, including trimming, bias subtraction, flat and dark field correction, cosmic ray removal, and performing aperture photometry. The BVRI light curves are plotted in Fig. 1, with the squares, circles, and triangles representing the corresponding dates. The HJD

Table 1
Coordinates and magnitudes of DE Lyn, check, and comparison stars.

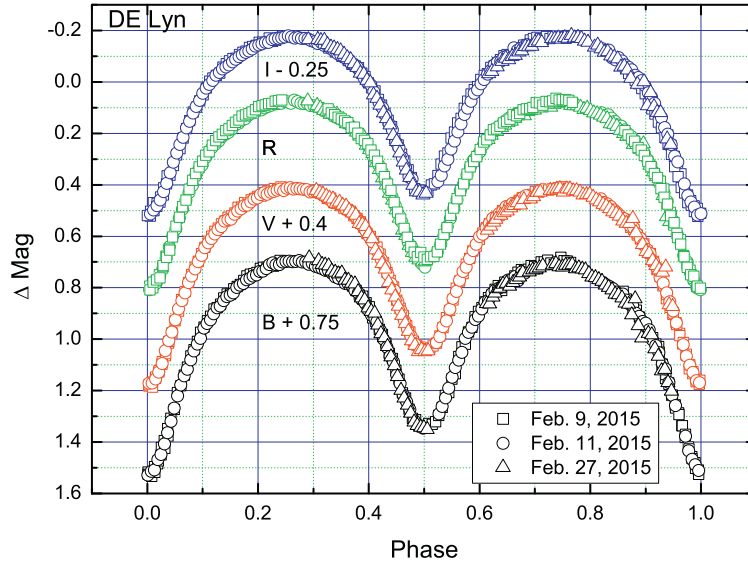| Targets	Name	Coordinates	Mag_J	Mag_H	Mag_K	Reference
Variable	DE Lyn	08:25:29;+57:43:28	11.712	11.358	11.253	Cutri et al. (2003)
Comparison	2mass J08244320+5745469	08:24:43;+57:45:46	11.525	11.051	10.952	Cutri et al. (2003)
Check	2mass J08253403+5743010	08:25:34;+57:43:01	13.182	12.774	12.742	Cutri et al. (2003)

Fig. 1. Our B, V, R, I light curves, with squares (□) representing the February 9, 2015 data, circles (○) representing the February 11, 2015 data, and triangles (△) representing the February 27, 2015 data.

Table 2
Photometric data of DE Lyn in B, V, R, and I bands.

B band		V band		R band		I band	
HJD	Δ mag	HJD	Δ mag	HJD	Δ mag	HJD	Δ mag
2457062.58206	0.2780	2457062.58278	0.3460	2457062.58333	0.3860	2457062.58379	0.4140
2457062.58449	0.3510	2457062.58521	0.3930	2457062.58576	0.4160	2457062.58622	0.4360
2457062.58693	0.4030	2457062.58764	0.4430	2457062.58819	0.4750	2457062.58865	0.4560
2457062.58935	0.4200	2457062.59007	0.4620	2457062.59062	0.5070	2457062.59108	0.4960
...	...	...	...	...	...	...	...
2457063.02523	0.7830	2457063.02594	0.7860	2457063.02649	0.7780	2457063.02940	0.7220
2457063.02767	0.7680	2457063.02839	0.7480	2457063.02893	0.7690	2457063.03182	0.6970
2457063.03009	0.7230	2457063.03081	0.7220	2457063.03135	0.7620	2457063.03426	0.6620
2457063.03252	0.6710	2457063.03324	0.6870	2457063.03378	0.7140	2457063.03669	0.6150
2457064.58265	0.0600	2457064.58339	0.0540	2457064.58393	0.1190	2457064.58441	0.1200
2457064.58510	0.0300	2457064.58582	0.0680	2457064.58637	0.1310	2457064.58682	0.1270
2457064.58752	0.0380	2457064.58825	0.0740	2457064.58881	0.1270	2457064.58927	0.1260
2457064.58996	0.0450	2457064.59068	0.0840	2457064.59123	0.1400	2457064.59169	0.1560
...	...	...	...	...	...	...	...
2457064.92880	0.0060	2457064.92708	0.0720	2457064.92763	0.1400	2457064.92810	0.1170
2457064.93124	0.0220	2457064.92952	0.0710	2457064.93008	0.1210	2457064.93054	0.1270
2457064.93369	−0.0120	2457064.93197	0.0600	2457064.93252	0.1190	2457064.93299	0.1190
2457064.93613	−0.0070	2457064.93442	0.0490	2457064.93442	0.1190	2457064.93544	0.1130
2457080.85161	0.1120	2457080.85233	0.1760	2457080.85287	0.2240	2457080.85334	0.2180
2457080.85403	0.1130	2457080.85476	0.1600	2457080.85530	0.2070	2457080.85577	0.2090
2457080.85646	0.0860	2457080.71916	−0.0020	2457080.71971	0.0740	2457080.72018	0.0860
2457080.72087	−0.0660	2457080.72611	0.0220	2457080.72666	0.0910	2457080.72712	0.0850
...	...	...	...	...	...	...	...
2457080.97607	0.2880	2457080.97435	0.2950	2457080.97490	0.3490	2457080.97781	0.3680
2457080.97851	0.3160	2457080.97680	0.3140	2457080.97734	0.3680	2457080.98026	0.3690
2457080.98095	0.3730	2457080.97924	0.3310	2457080.97978	0.3860	2457080.98514	0.4710
2457080.98340	0.3680	2457080.98168	0.3390	2457080.98223	0.4420	2457080.98759	0.4930