Mass-transfer in close binary and their companions

Wenping Liao[1,2], **Shengbang Qian**[1,2,3], **Liying Zhu**[1,2,3] **and Linjia Li**[1,2]

[1] Yunnan Observatories, Chinese Academy of Sciences, P.O. Box 110, 650216 Kunming, P.R. China

[2] Key Laboratory for the Structure and Evolution of Celestial Objects, Chinese Academy of Sciences, P.O. Box 110, 650216 Kunming, P. R. China

[3] University of the Chinese Academy of Sciences, Yuquan Road 19#, Shijingshan Block, 100049 Beijing, P. R. China

E-mail: [1] `liaowp@ynao.ac.cn`

Abstract. Secular and/or cyclical orbital period variations of close binaries can be derived by analyzing the (O-C) diagram. The secular variations are usually explained as mass transfer between components, while the most plausible explanation of the cyclic period changes is the light-travel time effect (LTTE) through the presence of a third body. Mass transfer and additional companions in close binary systems are important for understanding the formation and evolution of the systems. Here, UV light curves of several close binaries based on the Lunar-based Ultraviolet Telescope (LUT) observations are presented and analyzed with the Wilson-Devinney (W-D) method. Then, based on those light-curve solutions and new analysis of the orbital period variations, the multiplicity, geometrical structure and evolution state of targets are discussed.

1. Introduction

Three Algol-type binaries (AI Dra, TW Dra and V548 Cyg) were observed by using the LUT. The light variability of AI Dra was suspected by Schilt & Hill [1] and its Algol type eclipsing nature was confirmed by Geyer et al. [2]. Many observations and detailed photometric and spectroscopic analysis have been carried out since its discovery. By using the LUT, AI Dra was monitored in October 2014. The variability of TW Dra was discovered in 1910 [3]. It is an Algol-type system with a delta scuti-like oscillating primary component [4], also the A-component of the visual binary ADS 9706. Detailed spectroscopic and photometric investigations of TW Dra have been published. A historical summary of investigation was given in Tkachenko et al. [5] and Zejda et al. [6]. By using the LUT, near-UV light curve of TW Dra is reported. The light variability of V548 Cygni was discovered by Hoffmeister [7]. Until 1983, several studies have been published. After that, the binary has generally been neglected in photometric analysis.

LUT is one of the payloads on the Chang'e-III lunar lander, it works in the near ultraviolet band ($245 \sim 345$ nm) [8]. It is a 15-cm telescope with a Nasmyth focus that has a field view of $1.^{\circ}27 \times 1.^{\circ}27$ and can observe objects as low as 13.5 mag [9, 10]. It is very useful to monitor eclipsing binaries and variable stars without interruption because of the slow rotation of the Moon [8]. The data processing was done with a special data processing method developed by Meng et al. because LUT works in lunar daytime for sufficient power supply [10]. The calibration of those photometric data was given by Wang et al [11].

2. LUT light curves and photometric analysis

Complete LUT light curves of AI Dra, TW Dra and V548 Cyg are displayed in figures 1-3. As shown in these figures, the light curves are all EA-types. We analysed light curves by using W-D 2013 method. The solid lines in figures show the theoretical light curves, open circles are the observations obtained with LUT. Our photometric solutions show that these three binaries are all semi-detached binaries with the secondary components fills their critical Roche lobes, which indicates that a mass transfer from the secondary component to the primary one should happen.

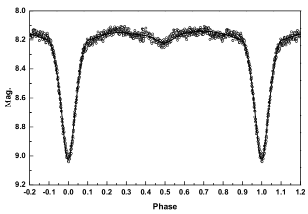

Figure 1. Light curve of AI Dra.

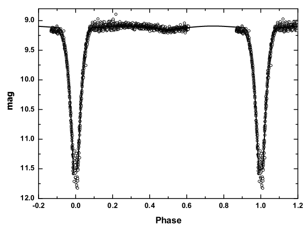

Figure 2. Light curve of TW Dra.

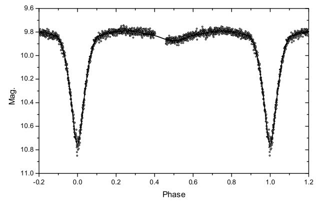

Figure 3. Light curve of V548 Cyg.

Based on all available data, the orbital period changes of three binaries were carried out. A secular increase + two cyclical variations and a secular increase + three cyclical variations are found in the O-C diagram of AI Dra and TW Dra, respectively. Three cyclic variations in the O-C diagram are obtained in V548 Cyg. The secular increase in the orbital period of the system can be interpreted as being the result of mass transfer from the secondary component to the primary one, which is consistent with the results of light-curve solutions. Cyclic variations can be interpreted by the LTTE via the presence of additional companions [12]. No obvious long-term changes in the orbital period of V548 Cyg were found indicating that the contributions of the mass transfer and the mass loss due to magnetic braking to the period variations are comparative.

Acknowledgments

This work is supported by the Chinese Natural Science Foundation (Nos. 11403095, 11133007, 11325315), Yunnan Natural Science Foundation (2014FB187), and the Strategic Priority Research Program "The Emergence of Cosmological Structures" of the Chinese Academy of Sciences, Grant No. XDB09010202.

References

[1] Schilt J and Hill S J 1938 *Contributions from the Rutherford Observatory of Columbia University New York* **31** 1
[2] Geyer E, Reim W, Remus G and Plattner D 1955 *Kleine Veroff. Remeis Sternw* 12
[3] Pickering E C 1910 *Harvard College Obs. Circ.* **159** 3
[4] Zhang X B, Luo C Q and Fu J N 2013 *Astrophys. J.* **777** 77
[5] Tkachenko A, Lehmann H and Mkrtichian D 2010 *Astron. J.* **139** 1327
[6] Zejda M, Mikulášek Z and Wolf M 2008 *Astron. Astrophys.* **489** 321
[7] Hoffmeister C 1949 *Erg. Hefte z.d. AN* **12** 1, 7
[8] Cao L *et al* 2011 *Science China Physics, Mechanics and Astronomy* **54** 558
[9] Wen W-B *et al* 2014 *Research Astron. Astrophys.* **14** 1674
[10] Meng X-M, Cao L, Qiu Y-L, Wu C, Wang J, Han X-H, Deng J-S, Xin L-P, Cai H-B and Wei J-Y 2015 *Astrophys. Space Sci.* **358** 47
[11] Wang J *et al* 2015 *Research Astron. Astrophys.* **15** 1068
[12] Liao W-P and Qian S-B 2010 *Mon. Not. R. Astron. Soc.* **405** 1930