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CLOSE-IN STELLAR COMPANIONS IN CLOSE BINARY STARS

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ABSTRACT

Close binary stars are so close that one component has an effect on the evolution of the other. But how do they form and evolve? This is an unsolved problem. One speculation is that the binary is a part of a hierarchical triple and its orbit shrinks due to interaction with the third component. Therefore, searching for and investigating tertiary components, especially close-in ones, in close binary stars are important for understanding their origin, as well as to test theories of star formation and stellar dynamical interaction.

Key words: binaries: close – binaries : eclipsing – Stars: individual (DI Hya, V384 Ser, V401 Cyg)

1. INTRODUCTION

There are a few methods to search for and investigate a third body; including high angular resolution observations, spectroscopic methods, light-travel time effects, third light, and eclipses between the third body and binary components. Carter et al. (2011); Derekas et al. (2011)), and so on. Usually, in order to obtain reliable detections and to determine the parameters of a third body, more than one method is needed for an observed system.

2. THREE BINARY STARS ARE MONITORED

In this paper, in order to search for and investigate close-in stellar companions, three close binaries were monitored. The light-travel time effect was used to search for and investigate stellar companions. The observations of DI Hya were carried out using the PI 1024 TKB CCD photometric system attached to the 1.0-m Cassegrain reflecting telescope at Yunnan Observatories (YNOs) in China. The complete $BVRI$ light curves of the W UMa-type binary V384 Ser were obtained using the 85-cm telescope at Xinglong station in China (Blattler & Diethelm (2002); Kazarovets et al. (2006)). We obtained light curves of the spectroscopically triple system V401 Cyg by using the 60-cm telescope at Xinglong station in China (Rucinski et al. (2002); D'Angelo et al. (2006)). Using all reliably observed times of minimum light obtained by us and those collected from the literature, variations of the observed-calculated $(O-C)$ curves were analyzed with the least squares method. It was found that the orbital periods of these three binaries have short-period cyclic variations, and they were analyzed for light-travel time effects due to the presence of suspected close-in third companions. The parameters of these suspected bodies are listed in Table 1.

3. SUMMARY

Based on the newly observed times of minimum light and those collected from the literature, the $(O-C)$ diagrams for three close binaries (DI Hya, V384 Ser and V401 Cyg) were constructed. It was shown that the orbital period of all three binaries have short-period cyclic variations. These changes were analyzed for the light-travel time effect through the presence of close-in third bodies. These bodies may play an important role in the formation and evolution of close binary stars due to interactions with the binary stars during: 1) early star formation and stellar dynamical interaction, 2) later stellar interaction through Kozai cycles (Kozai (1962)).

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Table 1
Parameters of the suspected third body

Star	Amplitute (days)	P_3 (years)	e_3	M_3 (solar mass)	d_3 (AU)
DI Hya	0.0034	1.46	0	1.15	1.45
V384 Ser	0.0033	2.84	0.29	0.37	2.0
V401 Cyg	0.0045	3.43	0.22	0.65	2.4

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