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ANALYSIS OF THE ECLIPSING BINARY SDSS J1021+1744: A WDMS SYSTEM WITH UNUSUAL DIPS

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ABSTRACT

We present our recent observations of SDSS J102102.25+174439.9, a new eclipsing white dwarf – main sequence WDMS binary with an orbital period of 0.14 days. This system belongs to the post common-envelope binary group as shown by the spectrum from the Sloan Digital Sky Survey. We obtained our data using the ULTRASPEC instrument installed on the 2.4-m telescope at the Thai National Observatory (TNO). Our multi-band observations reveal an unusual and persistent drop in brightness after the primary eclipse. These dips, which appear to show variations in amplitude, also have a complex shape that changes within days. Dips in WDMS systems have been observed on only one other occasion, in the light curve of QS Vir prior to the eclipse of the white dwarf. The dips in SDSS J1021+1744 are unique because they are present at different wavelengths and they occur approximately at similar phases. Hosting a DA white dwarf and an M4 companion star, this system is known to be the only WDMS to show these kind of dips in its light curve. It is possible that these dips are caused by ejected materials from an active companion star, such as in QS Vir. The light curve in the g′ filter exhibits deep and narrow features, implying that the material which passes in front of the white dwarf in SDSS J1021 must be dense and small in size. Furthermore, we try to constrain the stellar and orbital parameters of SDSS J1021+1744 using the Binary Maker 3 software. We use g′ and r′ data for our light curve analysis to have a better approximation for the red dwarf star.

Key words: post common envelope: closed binaries: eclipsing: white dwarf

1. INTRODUCTION

Binary stars are very common and it is known that more than half of the stars in the universe are part of double, triple, or multiple star systems. Binary stars are important because they allow for the direct measurement of stellar masses, radii, and luminosities. There are many types of binary stars, and they are often divided into sub-groups based on their separation, orbital period, or by the condition of their Roche lobes.

White dwarf main sequence binaries are a sub-class of close binaries with orbital periods typically of less than one day. These binaries consist of a white dwarf star accompanied by a low mass main sequence secondary. The systems initially comes from two main sequence stars, where the more massive star evolves faster into a red giant and fills its Roche Lobe. The formation of a white dwarf and main sequence star in a close orbit must involve a complex process known as the common-envelope phase. During this process, the less massive secondary is engulfed by the envelope of the primary due to unstable mass transfer. The resulting systems are usually known as post common-envelope binaries.

Table 1
Observations for SDSS J1021+1744

Date	Filters
07/01/2014	g′
08/01/2014[a]	clear1, clear2
10/01/2014	r′
11/01/2014	z′, i′+z′, r′
12/01/2014	i′+z′, KG5, g′

We observe multi-band, but study r′ and g′ filters. In the other band we can also observe unusual dips.
[a] without filter

2. OBSERVATIONS

In this work, the data for SDSS J1021+1744 were obtained during January 2014 (see Table 1) using the

Table 2
SDSS J1021+1744 parameters from Binary Maker 3

SDSS Name	WD mass ($M_\odot$)	MS mass ($M_\odot$)	WD, T_{eff} (K)	MS star sp type	Period (days)	T0 MJD
SDSS J102102.25+174439.9	0.5±0.05	0.311±0.07	15000±1000	M4.0	0.140359073	56093.90558

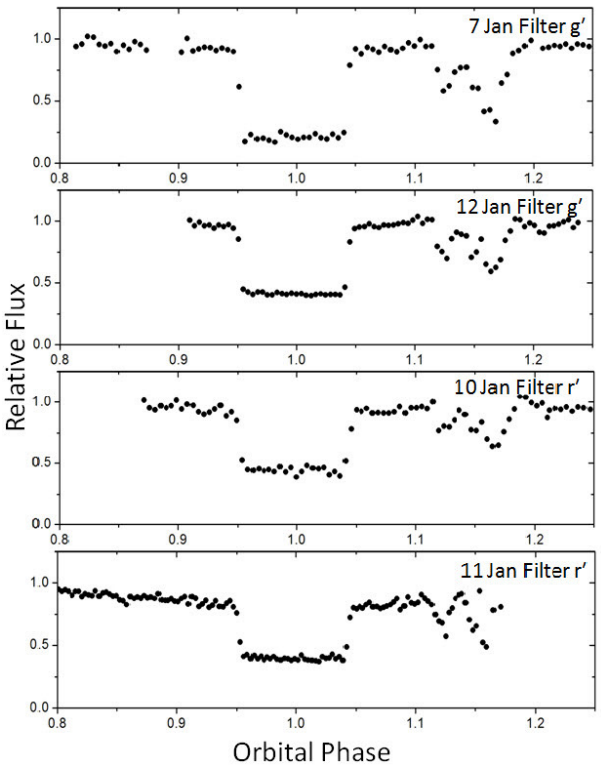

Figure 1. The system was observed in g′ and r′ filters with ULTRASPEC. Unusual dips show the change of relative flux with time. The g′ observations are deeper than r′ as WD is pimarily observed in the g′.

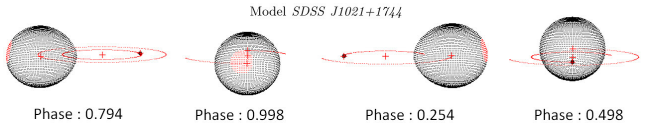

Figure 2. Model Orbital phases of SDSS J1021+1744. The red point on the surface is a spot by program Binary Maker 3.

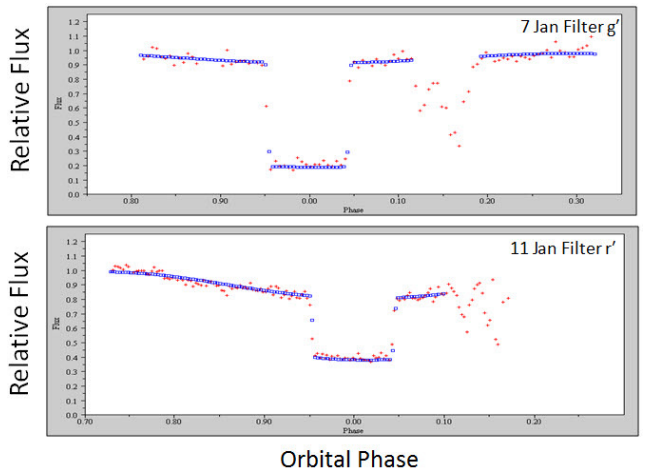

Figure 3. The light curve of SDSS J1021+1744 from ULTRASPEC on 7 Jan in g′ filter and 11 Jan in r′ filter, with Binary Maker 3.

Thai National Telescope (TNT) which is a 2.4 meters Ritchey-Chretien alt-azimuth drive with ULTRASPEC, which has been available at Thai National Observatory (TNO) since November 2013 (see Figure 1).

The Thai National Observatory is located near the summit of Doi Inthanon, the highest point in Thailand. At 2457 meters above sea level, the observatory is above much of the surrounding weather, and is beyond the light pollution from large cities.

3. DATA ANALYSIS

In this work, we analyse the data using differential photometry with ULTRASPEC (Dhillon et al. 2014) and IRAF software and we model the binaries system using *Binary Maker 3* (see Figure 2 and Figure 3).

4. DISCUSSION

The unusual dips of SDSS J1021+1744 are possibly the result of material obscuring the white dwarf. This could be a disk of material around the white dwarf star. Further investigations are needed to understand the cause of the dips.

5. CONCLUSIONS

We observed g′ and r′ bands with ULTRASPEC for SDSS J1021+1744, analyzed the data with IRAF, and modelled the data using Binary Maker 3.0. We find the main sequence mass to be 0.311±0.07 $M_\odot$, the mass ratio ∼ 0.622±0.008, the temperature of the white dwarf 15000±1000 K, and the main sequence star's temperature 3220±100 K with an inclination of 83° (as shown in Table 2).

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