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Brown dwarfs in retrogradely precessing cataclysmic variables?

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Abstract. We compare Smoothed Particle Hydrodynamic simulations of retrogradely precessing accretion disks that have a white dwarf primary and a main sequence secondary with observational data and with theory on retrograde precession via tidal torques like those by the Moon and the Sun on the Earth [1, 2]. Assuming the primary does not accrete much of the mass lost from the secondary, we identify the theoretical low mass star/brown dwarf boundary. We find no observational candidates in our study that could qualify as brown dwarfs.

1. INTRODUCTION

Politano & Weisler [3] find that 75% of simulated zero-age Cataclysmic Variables (ZACVs) forming with Brown Dwarfs (BDs) had, once-upon-a-time, solar-type progenitor primaries in binaries with orbital separations less than 3 A.U. According to Politano [4], roughly 15% of all CVs should have formed in this manner. However, these authors did not consider the brown dwarf desert. If the brown dwarf desert is true, then this value could be as low as 1% [5].

A second formation of CVs with BDs is when a low-mass secondary has lost enough mass to the white dwarf (WD) via accretion that its mass has dropped below the hydrogen-burning limit. The now BD-WD binary responds by increasing its orbital period (P_{orb}), and thus these systems are referred to as post-period minimum (i.e., $P_{orb} > \sim 67$ or ~ 80 min) CV systems. Some observational evidence has been found to support these post-bounce systems [5, 6]. If the BD forms after the CV, then these objects do not affect the BD desert.

Of the ∼1600 CVs known, only four have BDs and, of the four, only one is a detached WD-BD binary [5–7]. CVs are notoriously difficult to observationally confirm whether or not the secondary is a brown dwarf. This difficulty is one reason why the confirmed number is so low. We aim to establish whether any of the known CVs that retrogradely precess and that show negative superhumps in their light curves have brown dwarfs.

2. NUMERICAL SIMULATIONS, OBSERVATIONS, AND THEORY

We use the numerical simulation results presented in Montgomery [2] for non-magnetic CV retrogradely precessing tilted spinning accretion disks that have 0.8 solar mass primaries and secondary-to-primary mass ratios within the range 0.35–0.55. The secondary stars are assigned masses above the upper brown dwarf mass limit and are main sequence stars. We use theory on retrograde precession of accretion disks

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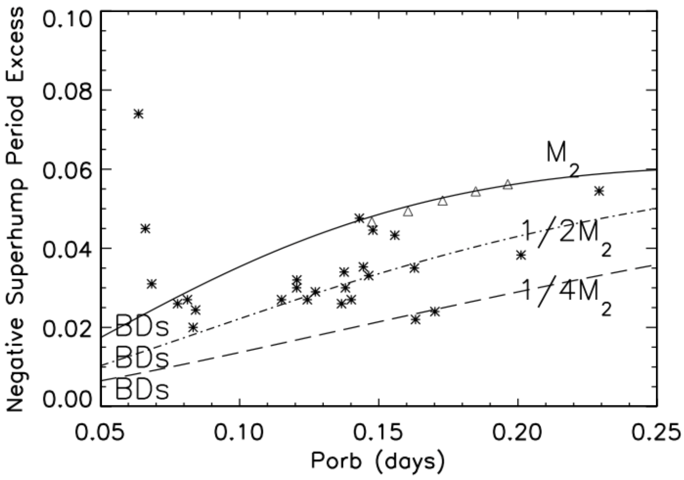

Figure 1. Numerical simulations (triangles), observations (stars) of CV DN systems, and solid theoretical line describing retrograde precession [1, 2]. The dash-dot line and the dash line could explain the majority of CV DN systems if we assume that the secondary ahs lost half its mass and three-fourth its mass, respectively.

presented in Montgomery [1] that is based on the retrograde precession of Earth via tidal torques by the Moon and the Sun. The observational data used in comparisons with the numerical simulations and with the theory is given in Montgomery [1, 2].

3. POTENTIAL BROWN DWARF CANDIDATES IN CVS

In Figure 1, the observational data (stars) and theory (solid line) for white dwarf primaries with main sequence secondary stars are from Montgomery [2]. The numerical simulations (triangles) are from Montgomery [1]. We also show the region of BDs if the primary is 0.8 solar masses. As seen in Figure 1, no potential BD candidates are found in this region.

Also shown in Figure 1 is a hypothetical (and possibly unrealistic) drop in secondary mass. As WDs do not seem to gain much mass over time that is lost by the low mass secondary star [8], we maintain the white dwarf mass at 0.8 solar masses. However, we drop the secondary mass to 1/2 (dash-dot line) and 1/4 (dash line) the original value (solid line) obtained from the secondary mass-period relation in [8]. Even with the drop in mass, all objects maintain stellar masses. Note we do not numerically or theoretically consider different geometrical systems such as disks that progradely and retrogradely precess (e.g, the observational systems with orbital periods less than 0.9 days).

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