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Dust in Intermediate Polars: Light Curves from the Spitzer Space Telescope

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Abstract. Here we present Spitzer 4.5 μm light curves of two intermediate polars (IPs) – DQ Her and EX Hya – obtained with Cycle 6 observations. Our initial evaluation of the light curves of DQ Her and EX Hya shows that these two IPs exhibit similar behavior as that seen in non-magnetic systems (specifically WZ Sge). The binary eclipses seen in the Spitzer light curves of DQ Her and EX Hya are about three times longer than their optical counterparts, indicating that a reservoir of dust extends beyond the outer edge of the optically visible accretion disk.

Keywords: cataclysmic variables, infrared observations
PACS: 97.10.Gz, 97.30.Qt, 97.80.Gm

1. MAGNETIC AND NON-MAGNETIC CVS AS SEEN WITH SPITZER

Recent Spitzer observations have shown two modes of "dustiness" in cataclysmic variables (CVs). Non-magnetic CVs have a large reservoir of dust located inside the binary, just beyond the outer edge of the optically visible accretion disk (Howell et al. 2008). This was evidenced in WZ Sge observations, in which the binary light curve eclipse is ~ 3 times longer in the IR 4.5 μm light curve as compared to the eclipse in the optical light curve. This indicates that much of the mid-IR emission is located within the binary.

Brinkworth et al. (2007), Hoard et al. (2007), and Howell et al. (2006) present Spitzer observations of magnetic CVs, in which circumbinary disk components are needed to fit SEDs of the target objects. Specifically, the 8.0 μm point is fit well only with the inclusion of the circumbinary disk in the SED model.

This apparent dichotomy in the dustiness of CVs motivated us to add intermediate polars (IPs) to the list of CVs observed with Spitzer. Possessing both an accretion disk and magnetically controlled accretion, IPs display observational characteristics of both non-magnetic and magnetic CVs. As dust has been linked to CV evolution, dust properties of IPs will allow us to have a more complete picture of CV evolution, and also allow us to understand where IPs fit into the evolutionary scenario of CVs.

2. 4.5 μm LIGHT CURVES OF EX HYA AND DQ HER

Figure 1 presents our 4.5 μm Spitzer light curves of EX Hya (left panel) and DQ Her (right panel). Details of the observations are given in Table 1. Both of these light curves exhibit a longer eclipse at $\phi = 0$ as compared with the eclipses seen in the optical light curves (see, e.g., Belle et al. 2005 for EX Hya and Zhang et al. 1995 for DQ Her). Table 2 gives the extent of the eclipses in binary orbital phase.

Also of interest are the eclipse "wings" that extend from $\phi = 0.75 - 0.90$ and $\phi = 0.11 - 0.36$ in the DQ Her 4.5 μm light curve. The temporal extent of the binary eclipses, as compared with their optical counterparts, and the eclipse wings clearly reveal the presence of dust associated with the outer edge of the accretion disk.

TABLE 1. Spitzer Observation Log

	P_{orb} (min)	K (mag)	Observation Date (UT)	Total Observation Time (sec)
EX Hya	98	11.69	2009 Aug 18	7,007
DQ Her	279	13.09	2009 Aug 23	19,459

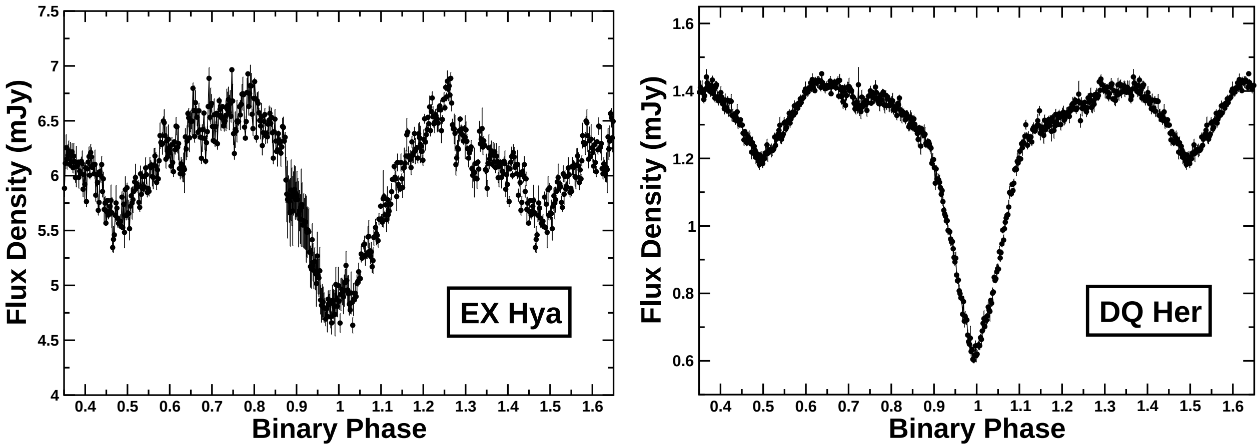

FIGURE 1. Left: EX Hya 4.5 μm light curve. Right: DQ Her 4.5 μm light curve. The large temporal extent of both binary eclipses at $\phi = 0.0$ indicates that there is a large reservoir of dust located just beyond the optically visible accretion disk.

TABLE 2. Optical and IR eclipse lengths in binary phase.

	ϕ_{eclipse}	
	Optical	4.5μ**m**
EX Hya	$0.92-0.10$	$0.79-0.25$
DQ Her	$0.92-0.10$	$0.89-0.11$

3. COMPARISON WITH SPITZER OBSERVATIONS OF MAGNETIC AND NON-MAGNETIC CVS

The data presented here show a strong resemblance to those of the non-magnetic CV, WZ Sge. The eclipses in the Spitzer light curves of both EX Hya and DQ Her are longer than in the optical. For EX Hya, the 4.5 μm eclipse is ~ 2.5 times longer in orbital phase, and for DQ Her, the 4.5 μm eclipse is ~ 3 times longer, similar to what is found for WZ Sge.

These data suggest that most accretion disks can be expected to have a reservoir of dust extending beyond the outer edge of the optically visible accretion disk, which is undetectable in the optical and near-IR ("dark matter" in accretion disks!).

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