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White Dwarf - M Dwarf Pairs in the Sloan Digital Sky Survey (SDSS)

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Abstract.
Using spectra and color cuts in the Sloan filter system, we have identified 83 White Dwarf - M dwarf pairs in the Sloan Digital Sky Survey (SDSS). The blue portion of the spectrum is fit with white dwarf models as a function of temperature. The best fit is then subtracted off to extract the M-dwarf spectrum. Many of these objects show strong Hα emission, an indicator of M-dwarf chromospheric activity. We have extracted a list of white dwarf temperatures, M-dwarf spectral types, and Hα equivalent widths, and we compare the activity level of these irradiated systems with the field M star population. If a portion of this activity is due to irradiation from the white dwarf companion, then we are studying binaries at a wide range in separations, from loosely bound systems to close binary pre-CVs. This hypothesis is being tested with a spectroscopic follow-up of SDSS objects by looking for (orbital) periodicity in the systems with the highest activity levels, using the ARC 3.5m telescope at Apache Point Observatory (APO).

1. Introduction

Approximately two thirds of all stars are found in multiple systems, usually binaries. The later evolutionary stages of binaries can be quite dramatic – e.g. type Ia Supernovae, cataclysmic variables (CVs). The evolution of the system is highly dependent on the masses involved, but the effect of a binary environment on the properties and evolution of the individual stars is not well understood. We investigate here the effects of irradiation and rotation rate on the magnetic activity level of low-mass M-dwarf secondaries. Our sample includes white dwarf primaries at a wide range in temperatures and separations, as well as a range in M-dwarf spectral types. The results presented here are part of a larger paper on the WD/M pairs in the SDSS (Raymond et al 2001).

2. The Sloan Digital Sky Survey

The SDSS database (Gunn et al 1998; York et al 2000) is an excellent resource for finding WD/M pairs, including pre-interacting systems. Using color cuts in the Sloan filter system (Fukugita et al 1996) we have found 83 WD/M binaries, as shown in Figure 1. There are 30 of these systems in the June 2001 SDSS Early Data Release (Stoughton et al 2001). With the wealth of data being acquired by

Sloan, we are guaranteed to find many more of these systems in the very near future.

3. Results

We have accumulated spectral information for 83 different objects, including the white dwarf temperatures, Hα equivalent widths, and spectral types of the M-dwarf companions. A sample spectrum is shown in Figure 2. The average WD temperature from the model fits is 15000K, slightly higher than the average for field WDs, which is 12000K. The average spectral type for the WD/M pairs is M2.5. The average after WD model subtraction is M4. The difference between these averages is a natural consequence of decreasing the continuum in the model subtraction, and therefore increasing the strengths of the spectral indices. Roughly 65% of the total systems show Hα in emission, indicating magnetic activity, which is a larger fraction than that observed by the Palomar/MSU survey (Hawley et al. 1996) for a typical spectral type of M4 (see Figure 3). The actual activity levels (as measured by Hα eqw) are comparable to the PMSU sample (see Figure 4).

4. Future Work

We are currently using the 3.5 m telescope at Apache Point to look for velocity shifts in the spectra of the most active of these objects. We expect to find that more active systems will have higher orbital velocities, indicating close binaries. Population models by de Kool (1992) indicate that about 10% of WD/M pairs should be close enough to become interacting, with periods of about 4 hours. Data has been recently taken and analysis is underway.

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References

Fukugita, M., Ichikawa, T., Gunn, J. E., Doi, M., Shimasaku, K. & Schneider, D. P. 1996, AJ, 111, 1748

Gizis, J. E. et al. 2001, AJ, 120, 1085

Gunn, J. E. et al. 1998, AJ, 116, 3040

Hawley, S. L., Gizis, J. E. & Reid, I. N. 1996, AJ, 112, 2799

Hubeny, I. & Lanz, T. 1995, ApJ, 439, 875

Kirkpatrick, J. D., Henry, Todd J., McCarthy, & Donald W., Jr. 1991, ApJ Supplement Series, 77, 417

de Kool, M. 1992, A&A, 261, 188

Raymond, S. et al 2001, in preparation

Reid, I. N. & Hawley, S.L. 2000, *New Light on Dark Stars*, Springer–Praxis Publishing

Stoughton, C. et al. 2001, in preparation

Szkody, P. et al. 2001 , submitted to AJ

York, D. G. et al. 2000, AJ, 120, 1579

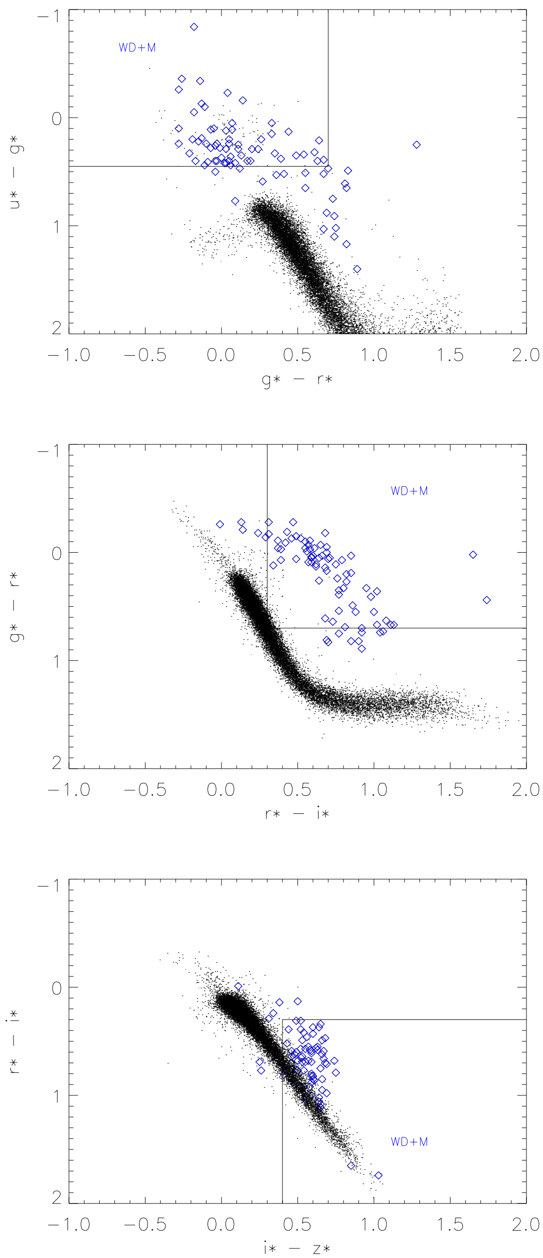

Figure 1. SDSS color-color plots of our 83 WD/M pairs. The diamonds are the WD/M binaries while the small dots are stars defining the stellar locus. Objects are selected which have blue colors at shorter wavelengths (hot WDs) and red colors at longer wavelengths (M-dwarfs).

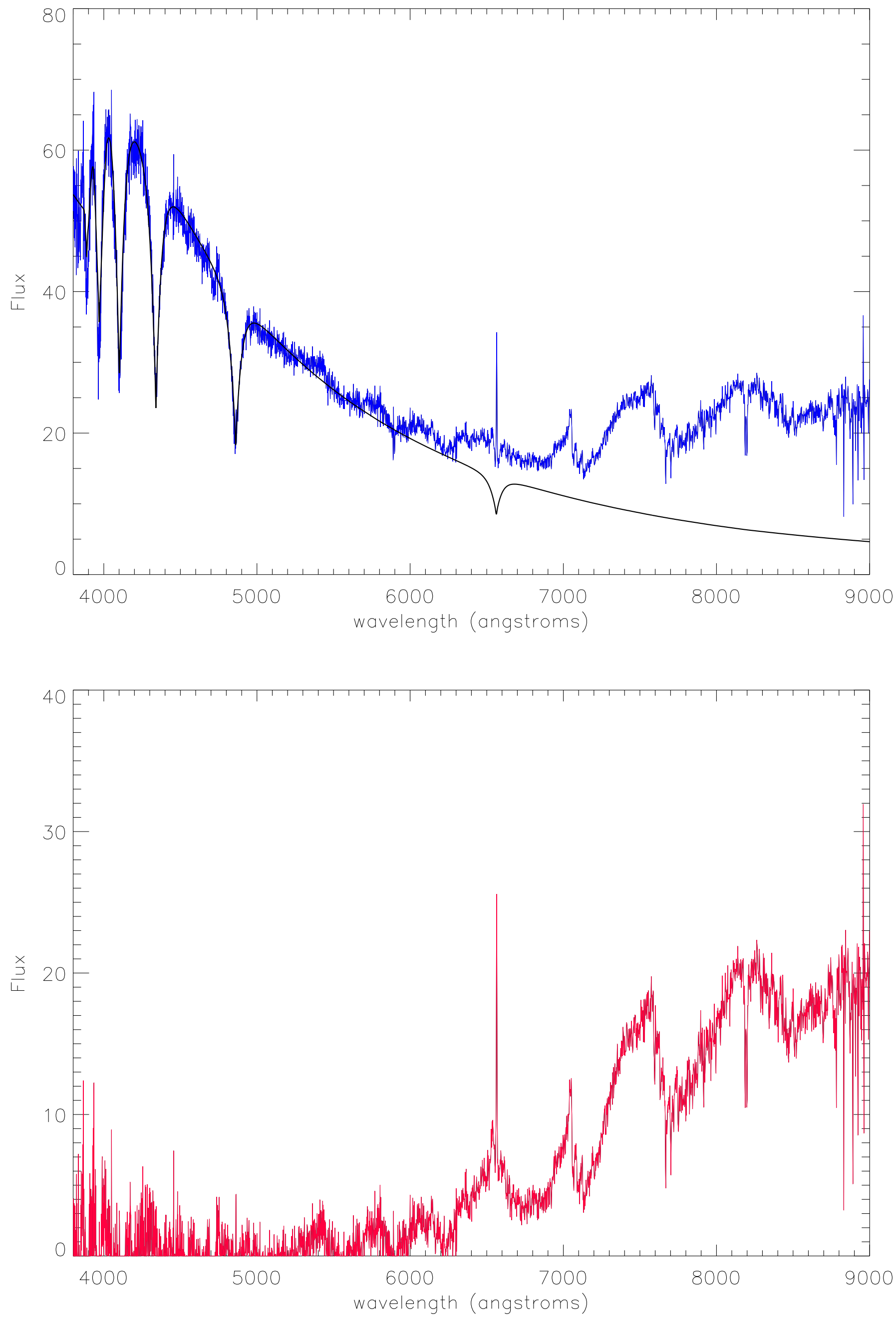

Figure 2. The upper spectrum is of object SDSSp J112909.50+663704.4, fit between 3800 and 5000Åwith a 18000K white dwarf model. The model is subtracted to extract the M-dwarf companion spectrum, which has a spectral type of M4.5. The flux is in units of 10^{-17} erg s^{-1} cm^{-2}Å^{-1}. The WD models are by Hubeny & Lanz 1995.

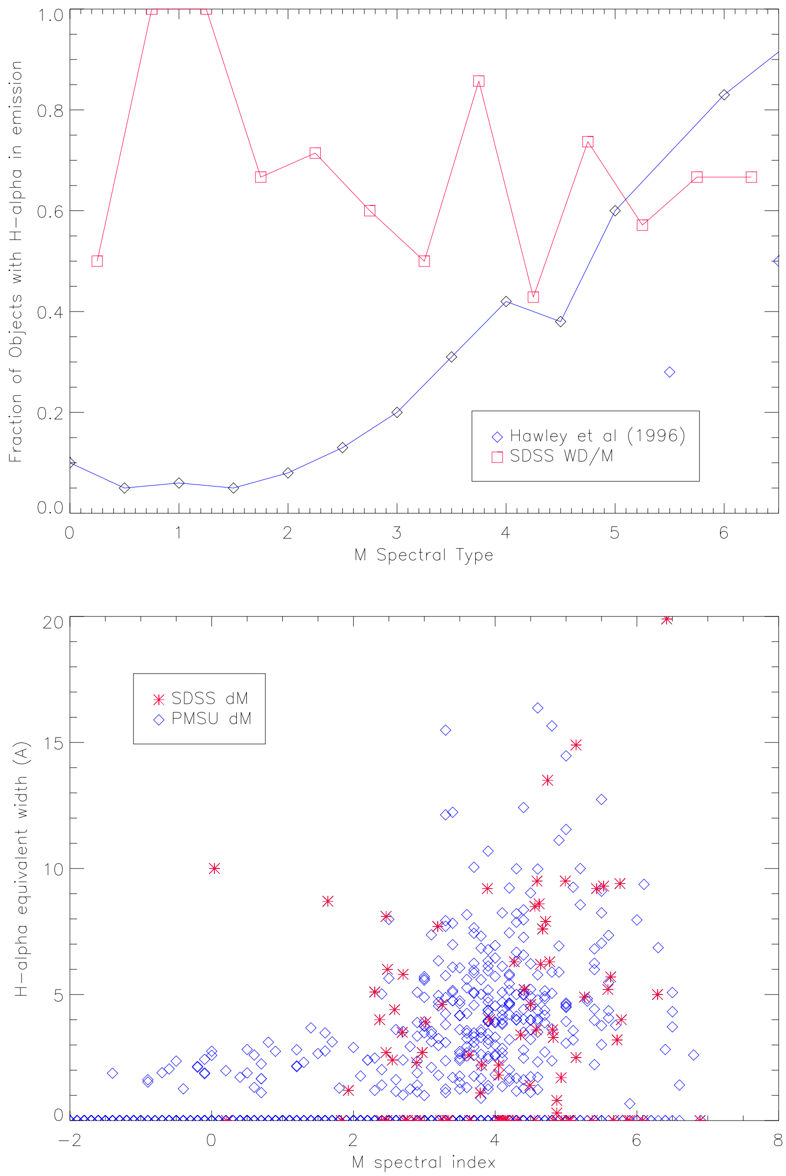

Figure 3. top: The fraction of M-dwarfs which are active (i.e. show Hα in emission) for the SDSS WD/M sample (red) and the PMSU sample (blue, Hawley et al. 1996). The activity level of M dwarfs is generally higher in WD/M binaries than for field M-dwarfs, especially for earlier spectral types. bottom: The activity level of the extracted M-dwarfs is comparable to that found in the PMSU survey. However, more early-type M-dwarfs appear to be active in binaries, and a larger total fraction is active.