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Classification Photometry for Ten dM Planet Hosts

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Abstract. Spectral classifications and color temperatures based on narrow-band TiO/CN photometry are given for ten dM stars that are known to be planet hosts.

Keywords. stars: late-type, stars: classification, techniques: photometric

1. Introduction

As the search for extra-solar planets continues, lower main-sequence stars of spectral type M have proved to be a fertile hunting ground, albeit with a lower detection rate than that of solar-type stars. Owing to their small masses, M dwarfs are relatively easily moved by orbiting companions, and the immediate solar neighborhood contains numerous M dwarfs that are comfortably bright for accurate radial-velocity work with large telescopes.

In an effort to improve the basic data for the particular M dwarfs that have been found to host planets, I have been observing them on my system of narrow-band TiO/CN classification photometry. The data yield precise spectral classifications tied to the MK system and color temperatures that can be calibrated in terms of effective temperature.

2. The photometric system

My 8-color narrow-band photometric system, originally defined for use with photomultipliers, measures the strongest bands of TiO, VO, and CN, as well as clean continuum points, in the 7000–11000 Å spectral region. It was designed for the study of M-type stars of all luminosities; one of its original objectives was to obtain internally consistent spectral classifications for M dwarfs on the same TiO-based scale as for giants and supergiants (Wing 1973). Recently the system has been used to identify a set of standard stars that define the mean solar-neighborhood main sequence from type K4 V to M6 V (Wing & van der Bliek 2009). Details of the photometric system and its calibrations are given in MacConnell, Wing, & Costa (1992) and in Wing (2011).

Currently observations are obtained with a CCD and a set of six large-format filters that are nearly identical to the first six filters of the original 8-color system. A set of new (fainter) standard stars has been developed for use with the CCD.

3. Observations

The observations discussed here were obtained at the CTIO/SMARTS 0.9-m telescope in Chile. Ten dM stars known to have planets have been observed to date and are listed in Table 1 with their common, GJ, and LHS names. These do not represent a complete list of known dM planetary hosts; rather, they are the ones that were known to me, and accessble from Chile, at the times of my observing runs.

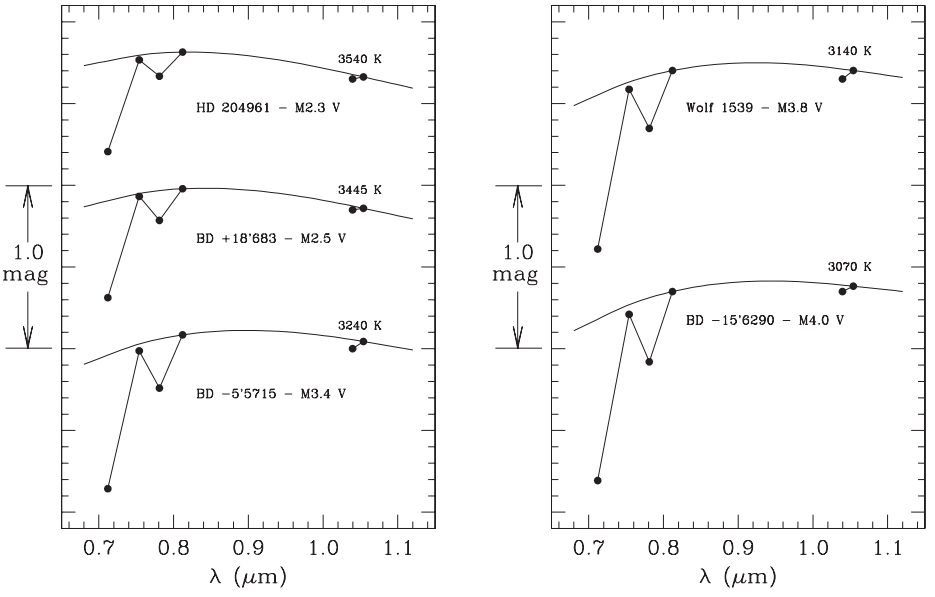

Figure 1. Six-color photometry, reduced to an absolute flux system and plotted on a magnitude scale with an arbitrary zero point for each star, is shown for 5 dM stars known to be planetary hosts. The color temperature of the fitted BB continuum is shown above each spectrum. The spectral types are from the depression due to TiO in the first filter, relative to the continuum.

Table 1. Results from 6-color photometry.

Star	GJ	LHS	$I(104)$	$T_{\rm color}$	Spectral Type
HD 204961	832	3685	5.72	3540 K	M2.3 V
BD +18°683	176	196	6.94	3445	M2.5 V
BD –5°5715	849	517	6.97	3240	M3.4 V
BD –7°4003	581	394	7.18	3410	M3.4 V
BD –15°6290	876	530	6.40	3070	M4.0 V
Ross 905	436	310	7.43	3310	M3.0 V
Wolf 1539	179	—	8.35	3140	M3.8 V
GJ 317	317	2037	8.44	3265	M3.8 V
GJ 1214	1214	3275	10.30	2790	M4.6 V
Hip 79431	—	—	8.04	3285	M3.3 V

The planets of six of these stars — BD –5°5715, BD –15°6290, Ross 905, Wolf 1539, GJ 317, and Hipparcos 79431 — were discovered by the precise Doppler measurements of planet search programs at Keck Observatory (e.g. Howard *et al.* 2010). The family of planets belonging to BD –7°4003 were discovered with the HARPS spectrograph at La Silla, starting with Bonfils *et al.* (2005). The planet of HD 204961 was found at the Anglo-Australian Telescope (Bailey *et al.* 2009) and that of BD +18°683 at the Hobby-Eberly Telescope (Endl *et al.* 2008). The planet of GJ 1214 has been observed in a variety of ways including transit observations (Charbonneau *et al.* 2009).

4. Results

The six-color "spectra" of five of the target stars are shown in Figure 1. The photometry has been reduced to a system of absolute fluxes and is plotted on a magnitude scale.

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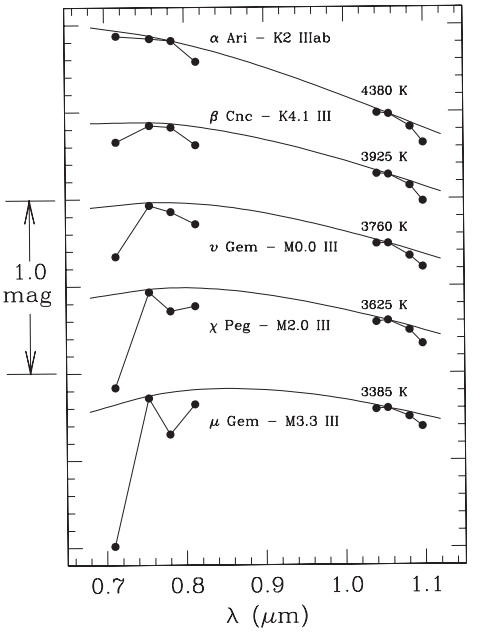

Figure 2. A sequence of giant stars, for comparison. Note that filter 4 is depressed in these stars – by CN, which is not present in the dwarfs. These bright stars were observed with an S-1 photomultiplier, the long-wavelength sensitivity of which allowed inclusion of two additional filters near 1.1 microns to measure the (0,0) band of CN. From Wing (2011).

Blackbody curves fitted to the best continuum points (here filters 4 and 6) define a continuum with respect to which the depressions in other filters are measured.

Spectral types are based on a calibration of the depression at the first filter, which measures a strong band of TiO. The CN molecule, which depresses filter 4 when present, is vanishingly weak in M dwarfs (see the spectra of giant stars shown in Figure 2).

The results are given in Table 1. Here $I(104)$ is the flux in filter 5 at 10350 Å expressed as a magnitude zeroed to the flux of Vega (α Lyr), and $T_{\rm color}$ is from the blackbody fit.

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