Photometric study of ultracool dwarfs and M dwarfs: preliminary results

Gergana M. Belcheva[1], Evgeni P. Ovcharov[2], Antoaneta E. Antonova[2]
[1] Department of Physics and Astronomy, University of Sussex
[2] Department of Astronomy, University of Sofia, BG-1164, Sofia
G.Belcheva@sussex.ac.uk, gbelcheva@uni-sofia.bg, evgeni@phys.uni-sofia.bg, tan@arm.ac.uk
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Abstract. We present preliminary results of V, R, I photometric observations of 7 late type dwarfs of spectral types from M4 to T7. These dwarfs have little or no previous optical photometric studies and are part of a long-term program studying the activity at the bottom of the Main Sequence and the brown dwarf regime. We have obtained R and I magnitudes for all 7 dwarfs as well as V magnitudes for 3 of them. This is the first step towards characterization of their photometric properties and monitoring for variability which in turn will give us information of the physical nature of their atmospheres.
Key words: cool stars, brown dwarfs, photometry, activity

Introduction

Magnetic activity has been found to increase steadily for main sequence stars with spectral types later than M3, reaching $\sim 80\%$ for $\sim$ M7 spectral type (West et al. 2004). For cooler stars, including ultracool late-type M, L and T dwarfs, the strength and frequency of detection of activity indicators such as Hα drop sharply, so that few field objects later than L5 exhibit any detectable optical emission. Similar trends are found for the quiescent X-ray emission (Fleming et al. 2003). Yet flaring activity in both Hα and X-rays has been detected from a number of L and T dwarfs as far as T6.5 (Burgasser et al. 2003, Liebert et al. 2003). Since these stars are fully convective, the mechanism allowing them to maintain active chromospheres and coronas is not yet clear. Photometric observations and in particular the detection of photometric variability may be an instrument for determining the physical nature of ultracool dwarf atmospheres. In particular, if detected, it may provide important information for surface features such as magnetic spots and/or dust clouds and their stability. Here we report the first results of V, R and I band photometric observations of 7 late-type dwarfs.

1. Target selection.

The sample of 7 dwarfs presented here (Table 1) is a subset of a larger sample of M, L and T dwarfs that comprises: (a) active M dwarfs of spectral types M4 to M6, recently classified on the basis of their spectra and detected Hα emission (Kacharov et al. 2012) and (b) nearby ultracool dwarfs of spectral types in the range M 7 to T7 that have been probed for activity signatures in the radio band (Antonova et al. 2012). For all of the above dwarfs very little or no optical information and CCD-photometry has been found in the literature.

For Dw-1, 5, 6 and 7 the only optical photomeric information we found are the R magnitudes reported by Kacharov et al. (2012) (shown in Table 2). Dw-22 is a M7.5 dwarf with previously measured V = 17.96, R = 17.0 and I = 13.7 magnitudes (Monet et al. 2003). It also has reported high v.sin i = 33 km s^{-1} and detected Hα emission (Reiners and Basri, 2010). Dw-14 and Dw-27 are L4.5 and T6 dwarfs respectively that have no optical magnitudes found in the literature.

Таблица 1. Sample of objects

ID	Spectral Type	Other ID	RA(J2000.0) hh:mm:ss	DEC(J2000.0) dd:′:″
Dw-1	dM6e		19:48:36.1	-14:30:48
Dw-5	dM4.5e		19:47:43.4	-14:22:40
Dw-6	dM6e		19:43:50.6	-14:48:23
Dw-7	dM6e		19:44:06.0	-14:51:31
Dw-14	L4.5	2MASS J18212815+1414010	18:21:28.2	+14:14:01
Dw-22	M7.5	2MASS J17571539+7042011	17:57:15.4	+70:42:01
Dw-27	T6	2MASS J21543318+5942187	21:54:33.2	+59:42:18

2. Observations and data reduction

The images were obtained using the 2m Ritchey-Chretien-Coude (RCC) telescope of the Rozhen National Astronomical Observatory (NAO) by a VersArray 1300B CCD camera. Observations were carried out on three consecutive nights - 23, 24 and 25 August 2011, but only data from the last two nights were taken into account due to bad atmospheric conditions on 23 August. Typical target exposure times were 1000 s and 600 s for V and RI bands respectively while standards exposure times were 180 s and 120 s for V and RI bands. For the brightest dwarf (Dw-22) the exposures are shorter: R - 120 s, I - 30 s. Standard IRAF routines were used to perform the data reduction and photometry.

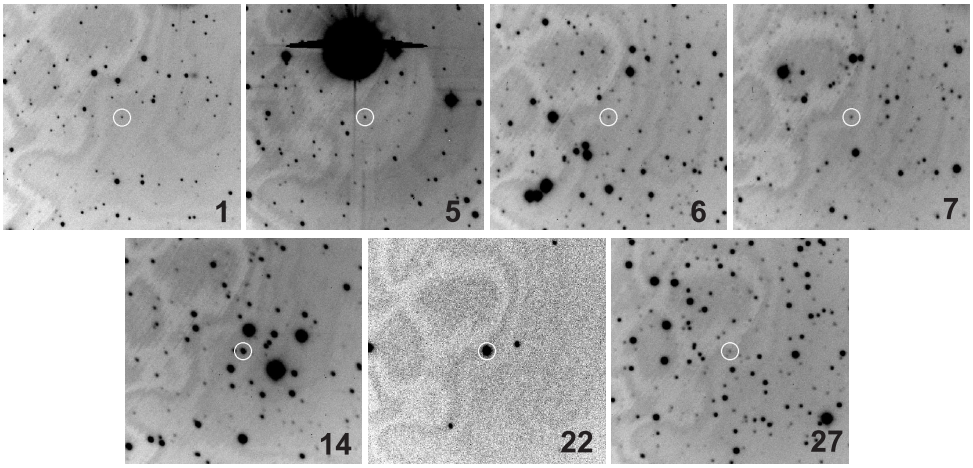
3. Photometric calibration and Results

The calibration for dwarfs Dw-1, Dw-5, Dw-14, Dw-22 and Dw-27 (Table 1) was performed using Stetson's photometric standard fields of NGC6823 and NGC7790 (Stetson 2000). The IRAF photometric calibration package photcalc was used. The transformation equations for V, R and I bands are:

$$V = v - 0.03532 - 0.0000831(v - r) + 0.6662053Xv + 0.015104UTv \quad (1)$$

$$R = r + 0.15789 - 0.00035398(r - i) + 0.5150857Xr + 0.010440UTr \quad (2)$$

$$I = i + 1.01676 + 0.0023312(r - i) + 0.3261336Xi + 0.031639UTi \quad (3)$$



Фиг. 1. Finding charts of the dwarfs, taken with the 2m RCC. Images are in I band. The field of view is 2 x 2 arcmin.

where X is the airmass and UT is the universal time. The rms of the calibrations is less than 0.03 mag. The results for dwarfs Dw-6 and Dw-7 are obtained using photometric data from DENIS Consortium (2005) and Massey et al. (2007). The obtained VRI magnitudes of the dwarfs are presented in Table 2.

Таблица 2. Standard V, R, I magnitudes with errors for the dwarfs in our sample.

ID	V mag	V_{err} mag	R mag	R_{err} mag	I mag	I_{err} mag	R^* mag
Dw-1	23.033	0.171	21.209	0.044	19.604	0.034	21.495
Dw-5	22.857	0.112	20.865	0.045	19.366	0.035	20.780
Dw-6			21.881	0.090	19.965	0.046	22.188
Dw-7			21.377	0.062	19.743	0.040	21.788
Dw-14	22.117	0.164	18.892	0.012	16.918	0.006	
Dw-22			15.884	0.003	13.793	0.004	
Dw-27			22.845	0.103	19.948	0.047	

* R magnitudes taken from Kacharov et. al 2012 with typical error 0.24 to 0.25 mag.

Conclusion

We report the first I band photometric observations for 6 of the 7 targets, as well as the first V band observations for 3 of the targets. Also, for 2 targets

we have first R band photometric magnitudes, while for the 4 earlier type M dwarfs we have obtained more accurate R magnitudes than the ones reported by Kacharov et al. 2012. Only for Dw-22 there were previous observations in all three bands: V= 17.96, R = 17.0, I = 13.7 (Monet et. al. 2003). The comparison with our results gives a good agreement for the I magnitude while there is a difference in the R magnitude of ≈ 1.12 mag. Monet et al. (2003) obtain their data from scans of Schmidt plates which are not sensitive enough in the R band, thus possibly introducing a large error. Alternatively, it is possible that the dwarf was in an active state during our observation. Unfortunately, we have a single R band image of this dwarf and can not confirm if this is the case. However, we plan to perform a long term monitoring to study the optical variability of the whole sample. For this we plan to use observations with both 2m RCC and 50/70 cm Schmidt telescopes of the NAO Rozhen.

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