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THE FIELD BROWN DWARFS LUMINOSITY FUNCTION AND SPACE DENSITY FROM THE CANADA-FRANCE BROWN DWARF SURVEY

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Abstract. Since the first discoveries in 1995, hundreds of field brown dwarfs have been found in DENIS, 2MASS and SDSS. The new generation of large-area surveys uses deeper images and probes a larger volume in the Galaxy, increasing the number of known brown dwarfs. Such surveys are the UKIRT Infrared Deep Sky Survey (UKIDSS) and the one we undertook, the Canada-France-Brown-Dwarf Survey (CFBDS). We expect that complete characterization of all our candidates will yield about 100 T and 400 L or very late-M dwarfs, approximately doubling the number of known brown dwarfs. At mid-course of the CFBDS survey, we are able to define an homogeneous sample of 67 brown dwarfs, from the mid-L dwarfs to the far end of the brown dwarfs observed sequence at the T/Y transition, and to derive a luminosity function.

1 Introduction

Thanks to recent and ongoing large scale surveys, hundreds of brown dwarfs have been discovered. Still the luminosity function of field brown dwarfs is poorly constrained. Recently, Cruz et al. (2007) and Metchev et al. (2008) obtained homogeneous sample to study the space density of cool dwarfs (46 L dwarfs and 15 T dwarfs, respectively). In this work we attempt to compute the luminosity function for dwarfs from L5 to the latest T dwarfs, using a sample of 60 objects in this spectral type range, drawn from the Canada-France Brown Dwarf Survey (hereafter CFBDS). We describe the sample including the determination of completeness and contamination, and photometric classification. The luminosity function is given in the last section.

2 Observations and sample

The CFBDS is fully described in Delorme et al. (2008). The i' and z' imaging part of the survey (900 deg^2) is nearing completion to typical limit of $z' = 22.5$. The reddest sources are then followed-up with pointed J-band imaging to distinguish brown dwarfs from other astronomical sources and spectra are obtained for the latest type dwarfs. As the priority was given for the reddest candidates for J-band follow-up, we can now built a complete sample of late L and T dwarf candidates over 16 patches with total area of 520 deg^2. The sample contain all candidates with $z' < 22.5$ and $i' - z' > 2.0$ detected in this area, that is 191 objects that are candidates cooler than L5 on the basis of their $i' - z'$ colour. A classification is made on the basis of the position in the $i' - z'/z' - J$ diagram (Fig. 1, left panel). Based upon this classification, 81 over the 191 objects remain L5 and later dwarf candidates, the others being dwarfs earlier than M8, artefacts or quasars. Still, M8 and early L dwarfs contaminate the sample as their $z' - J$ colours are similar to those of late L dwarfs.

To estimate the completness of the sample, 1 500 000 fake cool dwarfs built on the observed local PSF are added to the original frames. The resulting images go through the analysis and selection pipelines used to

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select true candidates. The completeness is given by the fraction of recovered fake objects at the end of the analysis process. The average completness of the sample is 85%. As shown in Fig. 1 (left panel), our sample selects L5 and cooler dwarfs. However, due to photometric errors, part of these <L5 dwarfs are spread within the $i' - z' > 2.0$ sample. All objects with $z' - J < 2.5$ are removed from the sample. They are artifacts with obviously no J-band detection, quasars and dwarfs with true $i' - z'$ colour lower than 1.3, corresponding to M8 and earlier type dwarfs. The measured magnitudes of fake stars compared to the injected magnitudes is used to compute the contamination by >M8 dwarfs. The total number of contaminants is 30.

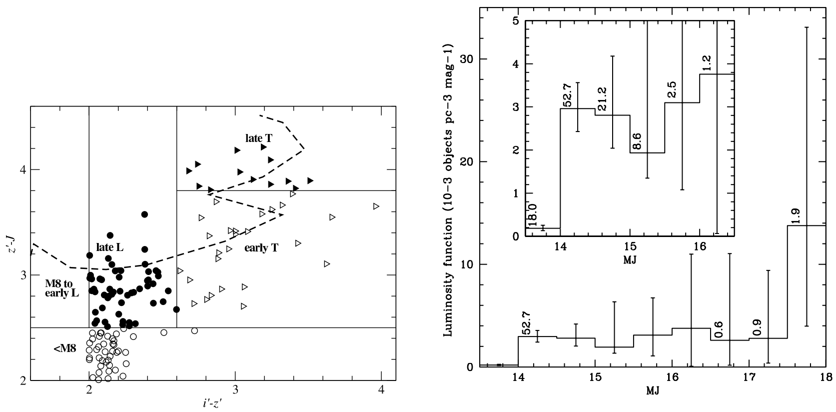

Fig. 1. Left: $z' - J$ versus $i' - z'$ diagram of the brown dwarf candidates in our sample with complete J-band follow-up. Open circles: dwarfs earlier than M8. Filled circles: M8 to L dwarfs. Open triangles: early T dwarfs. Filled triangles: late T dwarfs. The solid lines show the different spectral type regions. Right: Luminosity function in the J band. The number of objects in magnitude bins are also indicated, taking into account completness and contamination

3 Luminosity function

Among the publicly available spectra found in the L and T dwarf data archive, 32 have also measured parallax. They allow us to derive absolute magnitude-colour relations. It appears that the $i' - z'$ colour is a good luminosity estimator for late M and L dwarfs whereas $z' - J$ is better for late T dwarfs. These relations are used to derive photometric distances and a preliminary luminosity function in the z' band, shown in Fig. 1 (right panel). The absolute magnitude of early T dwarfs being nearly constant, this causes a bump in the luminosity function around $Mz' = 17.5$. This corresponds to roughly $M_J = 14$ where such a bump is already known to exist. These results suggest that 6 ± 1 T0.5 to T5.5 dwarfs and 22^{+13}_{-9} T6 to T8 dwarfs are expected in a 10 pc radius sphere around the Sun. To date, 8 T6 to T8 but only two T1 and T2 are found within 10 pc, suggesting that early T-dwarfs are missing in the solar neighbourhood census. The increase of the luminosity function at the faintest absolute M_J is due to 3 T8.5 and cooler dwarfs. This either suggests that many of these extreme objects remain to be discovered in the solar neighbourhood, or that we were lucky finding them. At least 3 additional dwarfs close to the T-Y transition have been discovered in UKIDSS (Burningham et al. 2008, 2009). This could indicate that the strickingly high density of ultracool brown dwarfs found by the CFBDS is not entirely due to a fluke of statistics.

References

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