Mem. S.A.It. Vol. 84, 983

Memorie della

The T dwarf population in the UKIDSS LAS

C. V. Cardoso[1,2], B. Burningham[2], L. Smith[2], R. Smart[1], D. Pinfield[2], A. Magazzù[3], F. Ghinassi[3], and M. Lattanzi[1]

[1] Istituto Nazionale di Astrofisica – Osservatorio Astrofisico di Torino, Strada Osservatorio 20, 10025 Pino Torinese, Italy, e-mail: `cardoso@oato.inaf.it`

[2] Centre for Astrophysics Research, Science and Technology Research Institute, University of Hertfordshire, Hatfield AL10 9AB, UK

[3] Telescopio Nazionale Galileo – FGG-INAF, Rambla J.A. Fernández Pérez 7, 38712 Breña Baja, Spain

Abstract. We present the most recent results from the UKIDSS Large Area Survey (LAS) census and follow up of new T brown dwarfs in the local field. The new brown dwarf candidates are identified using optical and infrared survey photometry (UKIDSS and SDSS) and followed up with narrow band methane photometry (TNG) and spectroscopy (Gemini and Subaru) to confirm their brown dwarf nature. Employing this procedure we have discovered several dozens of new T brown dwarfs in the field. Using methane differential photometry as a proxy for spectral type for T brown dwarfs has proved to be a very efficient technique. This method can be useful in the future to reliably identify brown dwarfs in deep surveys that produce large samples of faint targets where spectroscopy is not feasible for all candidates. With this statistical robust sample of the mid and late T brown dwarf field population we were also able to address the discrepancies between the observed field space density and the expected values given the most accepted forms of the IMF of young clusters.

Key words. Stars: Low mass – Brown Dwarfs – Surveys

1. Introduction

We aim to conduct a census of the T brown dwarf population in the solar neighbourhood contained in the UKIRT Infrared Deep Sky Survey (UKIDSS; Lawrence et al. 2007) namely the Large Area Survey (LAS).

The previous studies of the late T brown dwarf population in the field show a lack of brown dwarfs with a slope of the Mass Function of $\alpha < 0$ (e.g., Burningham et al. 2010; Kirkpatrick et al. 2012) derived from the comparison with the predictions of Deacon et al. (2006), that is in clear disagreement with the value derived from cluster studies that measure $\alpha \sim 0.6$ (e.g., Bastian et al. 2010; Lodieu et al. 2012; Alves de Oliveira et al. 2012, and references therein). Our goal is to improve the statistical robustness of our spectral type distribution in order to establish the cause of the discrepancy. The sample that has been spectroscopically followed up as been presented in Burningham et al. (2013). Here we focus in the brown dwarf candidates that have been identified through methane photometry.

Send offprint requests to: C. V. Cardoso

2. T brown dwarf candidates

2.1. UKIDSS LAS and SDSS

To identify the T brown dwarf candidates we have performed photometric cuts using the infrared data from the UKIDSS and the z' photometry from the Sloan Digital Sky Survey (SDSS; York et al. 2000). The selected candidates had:

- $J - H < 0.1$ and either no detection in the K, or $J - K < 0.1$.
- $z' - J > 3.0$ or undetected in SDSS within $2''$.
- Detected in Y and J, but undetected in H and K, with $Y - J > 0.5$ or $J < 18.5$.

2.2. TNG photometric follow-up

We have then applied a 3-step photometric follow-up procedure to the initial candidates based in photometry acquired at the Telescopio Nazionale Galileo (TNG). Objects with SDSS observations skipped to step 3 directly.

1. To screen out solar system objects with similar colours to T dwarfs we have taken a short J band observation (data from NICS; Baffa et al. 2001).
2. z'-band exposure for removal of M dwarf contaminants that will have $z' - J \sim 2.0$ (data from DOLoRes; Molinari et al. 1997).
3. To distinguish between late L and T brown dwarfs we used methane photometry (CH_4s, CH_4l), that allows us to convert the photometry into accurate spectral typing down to late T dwarfs (data from NICS).

2.3. Methane differential photometry

Due to their intrinsic faint nature, brown dwarfs are objects that need to be spectroscopically followed up in large telescopes, making it difficult to have follow-up observations of the complete sample. We have used our CH_4s – CH_4l photometry as a proxy for spectral type, following the technique described by Tinney et al. (2005).

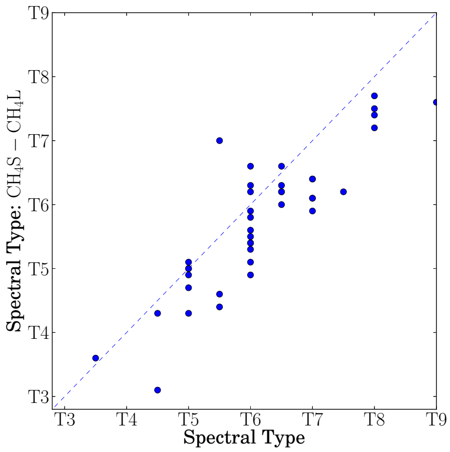

Fig. 1. Comparison between the spectral types of the T brown dwarfs of our sample and the spectral types estimated using the CH_4 colours and the technique described by Tinney et al. (2005). This plot shows that the spectral types estimated using this method are underestimated.

Using this technique we detected that the later objects of our sample have their spectral type underestimated by the fit (see Fig. 1). To correct for this effect we performed a new fit covering the spectral range T3 – T8, using the 41 targets of our sample with both spectra and methane colours (see Fig. 2). The new fit shows a good agreement between the methane derived spectral types and their actual spectral types. The data show indications that the differential methane colour across the spectral types T6 and T7 reaches a plateau and is not represented by the fit, increasing the scatter around the fit for this spectral range.

From the total sample there are 72 objects that have methane photometry and have not been followed up spectroscopically. Of these 72 objects, 49 are likely to be T brown dwarfs, of which 3 are T0–T2 and with a larger uncertainty in their classification, 25 are early T3–T4 dwarfs, and 21 later than T5 brown dwarfs. The rest of the objects are distributed between stars (7), L and M dwarfs (7+8) and one galaxy (Cardoso et al., in prep.).

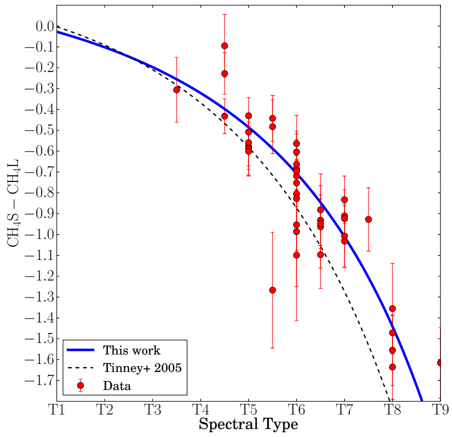

Fig. 2. Methane colour variation in function of spectral type for the 41 objects from our sample with both spectra and methane colour. The plot also shows the comparison between the fit from Tinney et al. (2005, dashed line) and our new fit (full line).

2.4. Spectroscopic follow-up

From our initial sample we have retrieved 76 new late T dwarfs that have been confirmed spectroscopically (Burningham et al. 2013).

The UKIDSS LAS survey has, so far, detected 171 spectroscopically confirmed T dwarfs (discussed in detail in Burningham et al. 2013), including objects from the literature (Pinfield et al. 2008; Tsvetanov et al. 2000; Burgasser et al. 2004; Chiu et al. 2006; Lodieu et al. 2007; Burningham et al. 2008; Chiu et al. 2008; Delorme et al. 2008; Burningham et al. 2009; Kirkpatrick et al. 2011; Scholz et al. 2012).

Our methane differential photometry study adds 49 T dwarfs candidates to the detections of UKIDSS LAS, making this survey the most efficient tool on the detection of T brown dwarfs to date.

3. Conclusions

We presented the last results of the UKIDSS LAS follow-up of T brown dwarfs in the field.

We identified 49 new T brown dwarfs candidates using differential methane photometry.

We have confirmed with our sample the possibility of using methane photometry as a good proxy for spectral type. This technique can be applied in future surveys to retrieve in an automated way reliable and quick spectral classification of T brown dwarfs without having to use large telescopes.

Acknowledgements. Based on observations made under project A22TAC_96 and A26TAC_68 on the Italian Telescopio Nazionale Galileo (TNG) operated on the island of La Palma by the Fundacion Galileo Galilei of the INAF (Istituto Nazionale di Astrofisica) at the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofisica de Canarias. Cardoso is funded by the TNG Very Large Program: "The field luminosity function of brown dwarfs down to planetary masses".

References

Alves de Oliveira, C., et al. 2012, A&A, 539, A151
Baffa, C., et al. 2001, A&A, 378, 722
Bastian, N., et al. 2010, ARA&A, 48,339
Burgasser, A., et al. 2004, AJ, 127, 2856
Burningham, B., et al. 2008, MNRAS, 391, 320
Burningham, B., et al. 2009, MNRAS 395, 1237
Burningham, B., et al. 2010, MNRAS, 406, 1885
Burningham, B., et al. 2013, MNRAS, 433, 457B
Chiu, K., et al. 2006, AJ, 131, 2722
Chiu, K., et al. 2008, MNRAS, 385, L53
Deacon, N., et al. 2006, MNRAS, 371, 1722
Delorme, P., et al. 2008, AJ, 139, 2566
Kirkpatrick, D., et al. 2011, ApJS, 197,19
Kirkpatrick, D., et al. 2012, ApJ, 753, 156
Lawrence, A., et al. 2007, MNRAS, 379, 1599
Lodieu, N., et al. 2007, MNRAS, 379, 1423
Lodieu, N., et al. 2012, A&A, 548, A53
Molinari, E., et al. 1997, Mem. Soc. Astron. Italiana, 68, 231
Pinfield, D., et al. 2008, MNRAS, 390, 304
Scholz, R. D., et al. 2012, A&A 541, A163
Tinney, C., et al. 2005, AJ, 130, 2326
Tsvetanov, Z. I., et al. 2000, PASP, 115, 389
York, D. G., et al. 2000, AJ, 120, 1579