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Parallaxes of ultra cool brown dwarf calibrators

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Abstract. Brown dwarfs are extremely important objects for our understanding of stellar and planetary formation and evolution. Lying at the limit of the coolest stars, they are poorly understood and the atmospheric models of are not yet reliable. Beyond this population, very cool brown dwarfs (T_{eff} ~ 300 K) were recently discovered constituting new spectral classes. A precise distance is the fundamental parameter to be able to correctly derive their masses, ages and thus calibrate the atmospheric models of this type of object. In 2012 we started an observational program to measure the trigonometric parallax of 5 such extreme objects recently detected prototypes of cool brown dwarfs. Observations started at the 4.1m SOAR/Spartan telescope and will continue until the end of 2014. Here we present an overview on the development of this project.

Key words. Stars: brown dwarf – Stars: trigonometric parallax – Stars: formation

1. Introduction

Ultra Cool Brown Dwarfs (UCBD) are extremely interesting objects since they lie at the limit of the coolest stars and the giant planets and are yet poorly understood. To physically understand these objects a fundamental parameter is necessary: the distance.

The obvious candidate for precise distances is the satellite Gaia, recently launched in December 2013 and that will provide absolute parallaxes with unprecedented precision up to magnitude G=20. Although it is difficult to evaluate the exact number of UCBD that Gaia will observe, we already know that it will be only a handful and in the very cool regime (spectral types later than L5) probably less than few tens (Sarro et al. 2013). Moreover, the final release of Gaia's catalogue, is only foreseen for 2021.

Since the UKIDSS survey (Lawrence et al. 2007) and the WISE observatory (Wright et al. 2010) are in activity, there have been many discoveries of UCBD with spectral types later than T6. To correctly characterize these objects and to perform calibrations of the atmospheric

Table 1. List of Targets of the brown dwarf SOAR/Spartan trigonometric parallax project.

Id	RA	DE	Spt	2MASS-J	Note
2M0041353-562112	00:41:35.39	-56:21:12.77	M7-9	14.7	BD system
WISE J0254+0223	02:54:09.00	+02:23:59.00	T8-9	15.8	Very close
UGPS J0722-0540	07:22:27.00	-05:40:30.00	T9	16.5	
Omega centauri	13:26:47.00	-47:28:46.00			Spartan calibration
WISE 1541-2250	15:41:00.00	-22:49:55.00	Y0	21.2	350K?
WISE J1741+2533	17:41:24.00	+25:53:20.00	T9-10	16.5	Very close

models (imprecise in this temperature range), reliable distances are needed.

From the several ways to measure astronomical distances to stellar and substellar objects, only the trigonometric parallax does not depend on astrophysical assumptions. Albeit it is time demanding, while spectroscopy or the photometry may lead to quicker distance estimates, such methods may be very inaccurate, and different from the trigonometric parallax as illustrated in Table 7 of Cushing et al. (2011).

2. Parallax Project at the SOAR/Spartan

In 2012 we started a trigonometric parallax program on the Southern Astrophysical Research 4.1 m telescope (SOAR) located in Cerro Pachon (Chile). We are using the recent Spartan near IR camera with high spatial resolution mode (66 mas/pixel, FOV 5'x5') to observe extreme UCBD that can constitute interesting calibrators of the ultra cool brown dwarfs regime. We present this list in Table 1. The trigonometric parallaxes of our targets should be measured with a 1-5 % precision.

The observations started in 2012.6 and may continue up to 2015, for the reliable separation of proper motions and parallaxes. About eight observational epochs per year are devoted to these objects, with a mean of 9 hour of observations per epoch. Parallel observation of M30 are frequently performed to calibrate the Spartan camera, as well as to monitor any instrumental distortions.

3. Images preprocessing

We have tested a wavelet and variance stabilizing pre-processing (Zhang et al. 2008) of our images and observed a improvement of the repeatability of measurements. Test with simulations are under development to perform a detailed assessment to check if this preprocessing introduces systematic distortions in the images (and thus systematic errors in the astrometric measurements). There is an significant increase of the number of detected objects in the treated images. If we confirm the astrometric precision increase we will use this method for an improved parallax measurement of our targets, not only via a reduced noise on the faint targets, but also via an increased number of the field stars that define the local reference grid used for measuring the target's parallax.

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