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Toward a comprehensive characterization of L subdwarfs

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Abstract

Subsolar metallicity L subdwarfs was discovered over a decade ago, but remain poor understood due to lack of known objects. We started to search for L subdwarfs since a few years ago and have increased the number of known L subdwarfs from 23 to 57. We are following up 33 L subdwarfs with X-shooter on the Very Large Telescope. We are also measuring parallaxes of 20 L subdwarfs with the OSIRIS on the Gran Telescopio Canarias.

1 Introduction

L subdwarfs are a mixture of metal-deficient brown dwarfs and very low-mass stars. They are the first generation objects, and are kinematically associated with the Galactic halo and thick disk. They are fully convective and have lifetimes far in excess of the age of the Universe, thus they are key tracers of Galactic structure and chemical enrichment history. As such, LSDs not only could help us to understand metal-poor ultra-cool atmospheres, they also will help us to understand the structure and evolution of the early Milky Way and the role of metallicity in star formation of the early Universe.

The number density of LSDs in the solar neighbourhood is a few hundred times less than normal L dwarfs. Currently only 23 LSDs are published in the literature (see summary

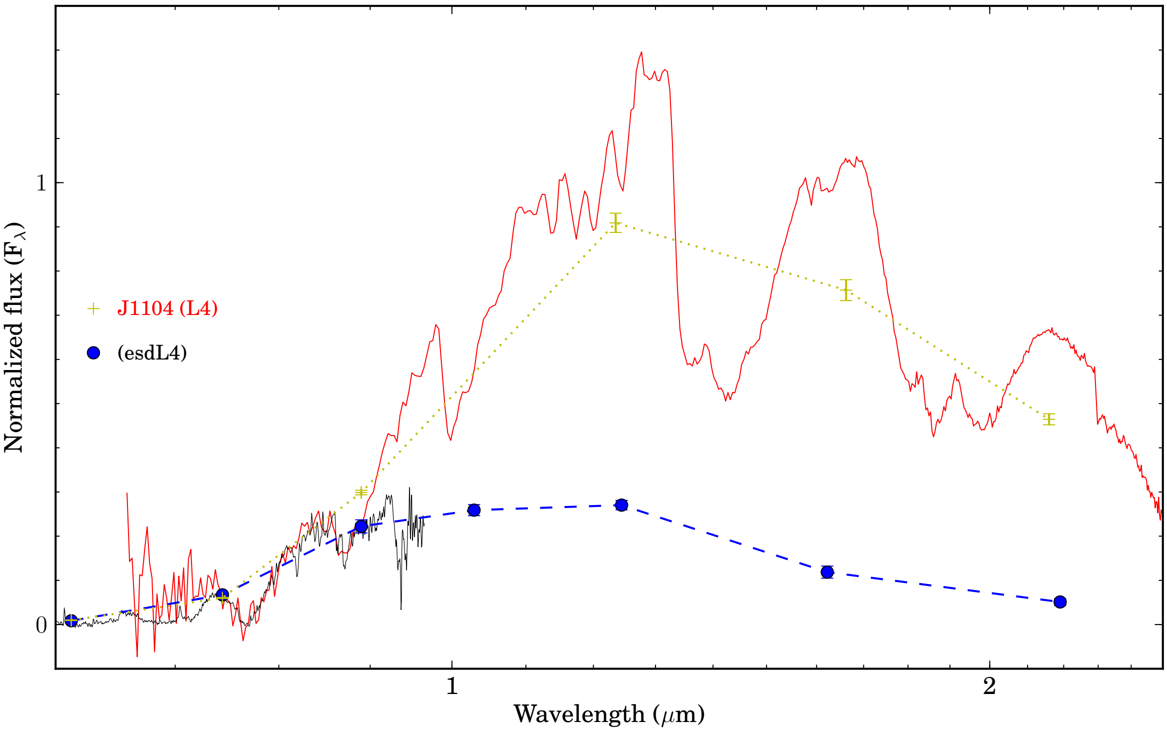

Figure 1: The GTC/OSIRIS optical spectrum and SDSS-UKIDSS SED of a new esdL4 subdwarf, comparised to SDSS-2MASS SED and optical-NIR spectrum of an normal L4 dwarf 2MASSI J1104012+195921 (J1104) [3].

in Table 6 of [5]. LSDs have different characteristics from L dwarfs. LSDs have strong metal hydrides, weak or absent metal oxides, and enhanced collision-induced H_2 absorption (CIA H_2). LSDs are not well understood due to a lack of known examples to constrain metal-poor atmosphere models. Thus we started projects to identify and characterise LSDs.

2 Identification of new L subdwarfs

Current large-scale optical and near-infrared (NIR) surveys like SDSS and UKIDSS have the capability to identify LSDs photometrically and astrometrically. We confirmed 34 new LSDs in a cross-match between SDSS and UKIDSS (Zhang et al. 2014 in preparation) through low-resolution optical or NIR spectra with a suite of large telescopes (GTC, VLT). We assign spectral types of LSDs by comparing their optical spectra with that of L dwarfs. Fig. 1 shows spectrum of and new esdL4 subdwarf confirmed with GTC/OSIRS. Suppressed NIR SED of the esdL4 subdwarf is due to enhanced CIA H_2 which is a main features of L subdwarfs.

3 Optical-NIR spectroscopic follow up

Ultra-cool atmospheric models have been created and used for the studies of ultracool atmospheres of brown dwarfs and giant planets. LSDs are rare and have generally been confirmed with low resolution optical or NIR spectra. We are following up bright LSDs with X-shooter which provides medium-resolution optical and NIR spectra, this will allow us to have more detailed study of the physics of LSDs through comparisons with the latest metal-poor models [6, 1]. Thus we could establish the physical properties (e.g. effective temperature, chemical abundance, gravity) of our LSD sample.

The majority of cool subdwarfs have radial velocities (RVs) between -300 and 240 km/s [7]. Most of LSDs do not have RV measurements because they only have low resolution spectra. RVs of some known LSDs have been measured but with very large uncertainty (30-50 km/s). This limits our understanding of their Galactic orbits and population membership (thick disk vs halo). X-shooter has capability to measure RVs of LSDs with precision of a few km/s. By cross-correlating of targets with RV standards with similar spectral types, we expect to achieve RV measurements with precisions of $\sim$2 - 5 km/s [4].

4 Parallaxes with GTC/OSIRIS

Parallax is a fundamental parameter of astronomy. Currently only five LSDs have parallax measurements. Parallaxes will allow us to measure the bolometric luminosity of LSDs, and with effective temperature estimated from atmosphere models, providing us with information on the radii of brown dwarfs. Distribution of radii of halo and disk brown dwarfs at different ages will provide a test of evolutionary models.

We started a programme to obtain parallaxes of 20 LSDs with GTC/OSIRIS. These 20 targets are selected from the 52 L subdwarfs which do not have parallaxes, and they all have estimated distances less than $\sim$100 pc according to [7]. With parallax information we would be able to use the relationship between absolute magnitude and spectral type to test classification schemes of spectral types and metallicity classes. The relationship between absolute magnitude and spectral types of LSDs with well defined spectral types and parallaxes will be the primary method for distance determination for future discoveries in large scale surveys. Since known LSDs are relative close, we could get tighter constraints on their UVW space velocities. Then we could use them to probe the structure and evolution of the Galactic halo (e.g. Figure 4 of [2]).

5 Summary

We have identified 34 new LSDs, bring the number of known LSDs to 57. We are following up 33 LSDs with optical-NIR medium resolution spectra for model comparison and radial velocity measurement. We also started a project to obtain parallaxes of 20 LSDs, quintupling the number of parallax measured LSDs. Combine all these projects we aiming to achieve a comprehensive characterisation of the L subdwarfs. Further more, L subdwarfs could be used to understand metal-poor ultra-cool atmospheres, and kinematical and chemical evolution of the Milky Way.

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