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A SEARCH FOR LITHIUM IN BROWN DWARF CANDIDATES

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ABSTRACT

We are conducting a search for lithium in very low mass objects with the aim of discriminating between stellar and substellar objects. Lithium is expected to be preserved in brown dwarfs with $M/M_{\odot} \leq 0.06$, while it is known to be efficiently destroyed in low mass stars. In this paper we present high resolution observations in the region of the λ 6708 Li I resonance line of 5 very low mass dwarfs. In none of them lithium is detected, implying a Li destruction in their atmospheres of about four orders of magnitude. Our results suggest that these objects are probably very low mass stars rather than brown dwarfs.

INTRODUCTION

Very low mass stars (0.2-0.08 $M/M_{\odot}$) are thought to be fully convective and, since they reach the internal temperatures for efficient lithium burning before settling on the Main Sequence, we expect Li to rapidly disappear from their atmospheres. However, the maximum central temperature of these stars decreases the lower the mass. Below a certain mass no lithium burning should occur. Using a polytrope as a rough approximation to describe a brown dwarf (BD) interior (see Stevenson 1991), it can be shown that the limiting mass for lithium burning is about 0.07 $M/M_{\odot}$. A more refined estimate taking into account the cross section of Li (p,α) reactions (Caughlan & Fowler 1988) and the interior densities and temperatures of BDs (D'Antona & Mazzitelli 1985), leads us to the conclusion that this limiting mass must be close to 0.06 $M/M_{\odot}$ (Magazzù, Martín & Rebolo 1992). Such value is only slightly below the minimum mass for stable hydrogen burning ($M/M_{\odot} \sim 0.08$). Rebolo, Martín & Magazzú 1992 have claimed that a strong λ 6708 Li I resonance doublet should be present in the spectrum of brown dwarfs with a cosmic Li abundance (the Li abundance of young stars and the interstellar medium). We proposed that the detection of this feature is an observational test to discriminate between very low mass (VLM) stars and brown dwarfs.

Considering these expectations, we have conducted a search for Li in several VLM objects, namely GL 65A, GL65B, GL 406 and Gl 473AB. They were selected from the compilation by Burrows, Hubbard & Lunine 1989, who

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give mass estimates of 0.11 $M/M_\odot$ for GL 65 A and B, of 0.08 $M/M_\odot$ for GL 406, and of 0.06 for each component of GL 473. We note that this last object has an astrometric mass determination by Heintz 1989, giving 0.06 and 0.05 $M/M_\odot$ for each component. The small error bar ($\pm$0.01 $M/M_\odot$) assigned to this determination make GL 473AB very strong candidates for being substellar objects. The effective temperature of all these objects are in the range 2600-2800 K, and therefore we expected to detect the presence of lithium in their atmospheres.

OBSERVATIONS

The spectra were obtained with the 2.5 m Isaac Newton Telescope and the 4.2 m William Herschel Telescope at La Palma. The reciprocal dispersion was between 0.22 and 0.37 Å/pixel. In Figure 1 we plot the spectra of GL 473 AB and GL 406 in the Li region. We also plot for comparison the spectrum of UX Tau C, the coolest component of the pre-main sequence triple system UX Tau (Magazzú, Martín & Rebolo 1991), where a strong Li feature is clearly seen in contrast with the other two objects. The similarity of the molecular bands in the three spectra indicates that they also have similar effective temperatures.

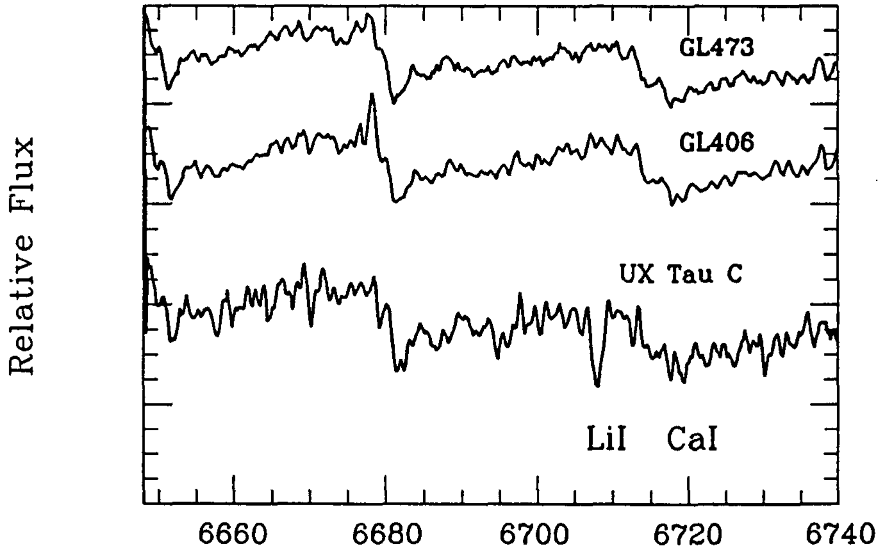

Fig. 1. Observed spectra of the very cool dwarfs GL 473AB and GL 406. The bottom spectra corresponds to the coolest component of the pre-main sequence triple system UX Tau. Note that the LiI line is detected only in UX Tau C.

ANALYSIS

Using recently produced model atmospheres for brown dwarfs (Allard 1990) and a spectral synthesis technique, we were able to reproduce most of

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the features in a region 20 Åaround the Li doublet. We adopted models of solar metallicity, high gravity (log g=5) and effective temperatures 2750 and 2500K, adequate to cover the range of our program objects. Several Li abundances were considered in the computations. The comparison between synthetic and observed spectra allowed us to establish an upper limit of log N(Li)=-1.5 (in the scale log N(H)=12) on the atmospheric lithium abundance in these objects. From the work by Tsuji (1973) it is not expected that any significant fraction of Li is bounded in molecular form (LiH, LiO, LiCl, etc.). It is unlikely that molecular effects prevent the formation of the Li doublet.

DISCUSSION AND CONCLUSIONS

The present abundance of Lithium in our objects is probably a factor 10^4 lower than their initial abundance. While such a large depletion in the case of GL 65 A and B, and GL 406 is consistent with their estimated masses, it is particulary striking that GL 473 AB, one of the best brown dwarf candidates, has not preserved a detectable amount of lithium in its atmosphere. Either each of the components has larger masses than measured using astrometric techniques (i.e. $M \geq 0.06\ M_\odot$), or else the predictions of maximum internal temperature and central density (the critical parameters concerning lithium destruction) for such low masses may have to be revised. It is important to remark that while the non-detection of the lithium resonance line in very cool high gravity objects cannot give a definitive answer on its substellar nature, the detection of the lithium feature can be certainly used as a criterion for positive identification of real brown dwarfs.

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