OPTICAL SPECTRA OF L-DWARFS

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ABSTRACT. Theorertical spectra of L-dwarfs ($T_{eff} < 2200$ K) were computed for a grid of the "dusty" C-model atmospheres of Tsuji (1998). To fit the observed spectra of L-dwarfs we used two additional (evristic) suggections:

- molecular densities of TiO and VO governed the visible spectra of M-dwarfs are reduced due to the *extra* depletion of V and Ti atoms into grains in atmospheres of $T_{eff} < 2200$ K;
- There are (a few) additional opacity κ sources in L-dwarf atmospheres;

A few kinds of $\kappa = f(\lambda)$ dependences were used to get "the better fit" of observed spectra of L-dwarfs. We show:

- We may fit the observed sequence of L-dwarf spectra using in the frame of our simple model
- Observad sequence of the L-dwarf spectra is *the temperature* sequence.
- At firt time, the region of 860 nm contained CrH bands is well fitted.
- There are a few possibilities to get the reliable fits to the observed spectra.
- In the frame of our approah we have found the solution even for the case of Gl229B.

Key words: late brown dwarfs, stellar spectra, lithum abundances.

In this paper we intend to provide an interpretation of the optical (6400–9100 Å) spectra of the very cool dwarfs recently discovered. Using Tsuji's (1998) "dusty" model atmospheres in LTE (C-models, i.e. computed for the "dust-gas" segregation phase). Chemical equilibrium is computed for more than 100 molecular species. Opacity sources included in our computations are described in Pavlenko et al. (1995, 1999), Pavlenko (1998). Note: at first time, CrH band feature at 860 nm has been well fitted in all L-dwarf spectra. Furthermore, we show, that additional opacity

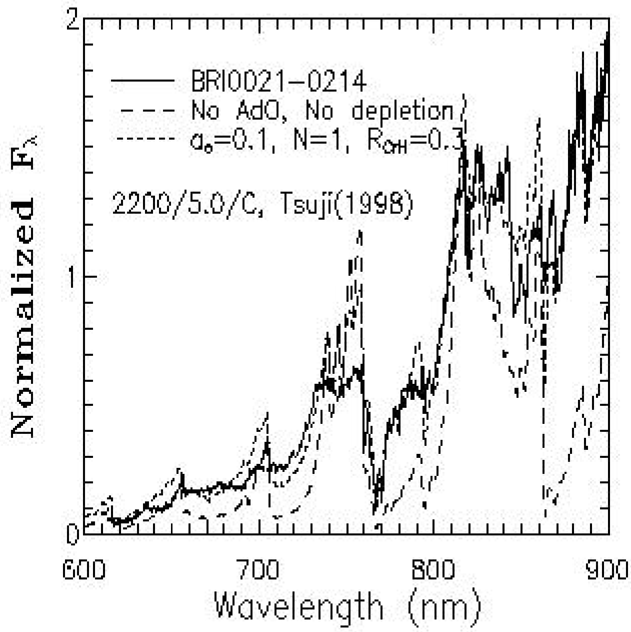

Figure 1: Comparison of the observed spectrum of BRI 0021–0214 with computations adopting Tsuji's model atmospheres of Teff = 2200 K and log g = 5. We notice that the discrepancy between the observed and the computed spectra is minimized by implementing additional opacity with $a_o = 0.1$.

sources have to be incorporated in the spectral synthesis procedure in order to fit the overall shape of our data for objects cooler than M8. This extra opacity can be described as a potential law of the form $a_o\ (\nu/\nu_o)^N$. Note, it may be caused by dust scattering and/or absorption. In contrary to Pavlenko et al. (1998) paper (in which B-models of Tsuji (1996) models were used) we found that the better fit for the C-models may be found for N = 1 - 4, i.e. scattering by aerosol. For same cases (for example, BRI0021-024, see Fig. 1) we got "the better fits" for N=1. Still to be here in the frame of selfconsistentcy we show results obtained mainly for the N=4. (see Fig.2 for Kelu1).

Additionally, we find that the depletion factors for with TiO and VO molecular densities exceed that provided by their own gas-dust transition phase (Pavlenko 1998). Only assuming a strong Ti and V (EXTRA) de-

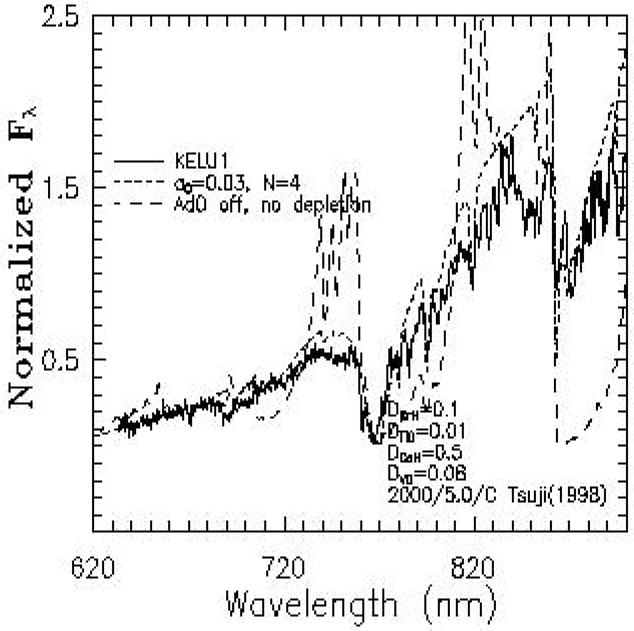

Figure 2: Comparison of the observed spectrum of Kelu 1 with synthetic spectra adopting Tsuji's C-model atmospheres of Teff = 2000 K, log g = 5. Dotted line stands for a computation with complete depletion of Ti and V into grains. Note the poor fit on the spectra. Solid line denotes a computation incorporating an opacity source (a_o = 0.03) and different depletion factors R for molecules with respect to chemical molecular equilibrium.

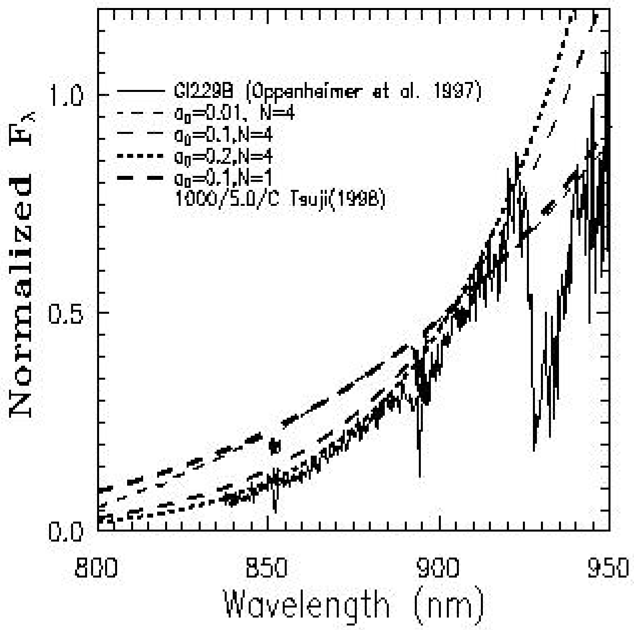

Figure 4: Comparison of the observed spectrum of Gl229B (Oppenhaimer et al. 1997) with synthetic spectra adopting Tsuji's model atmospheres of Teff = 1000 K, log g = 5. Dotted line stands for a computation with didderent AdO parameters. We remark that the slope of the overall shape of the observed data is well reproduced. Only Cs I lines are visible at wavelengths bluer than 900 nm.

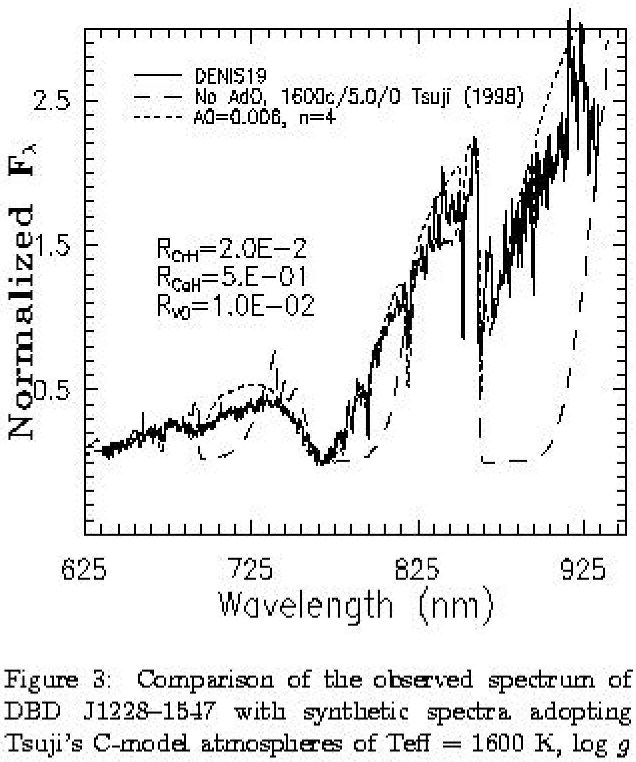

Figure 3: Comparison of the observed spectrum of DBD J1228–1547 with synthetic spectra adopting Tsuji's C-model atmospheres of Teff = 1600 K, log g = 5. Dotted line stands for a computation with complete depletion of Ti and V into grains. Note the poor fit on the spectra. Solid line denotes a computation incorporating an opacity source (a_o = 0.03) and different depletion factors R for molecules with respect to chemical molecular equilibrium.

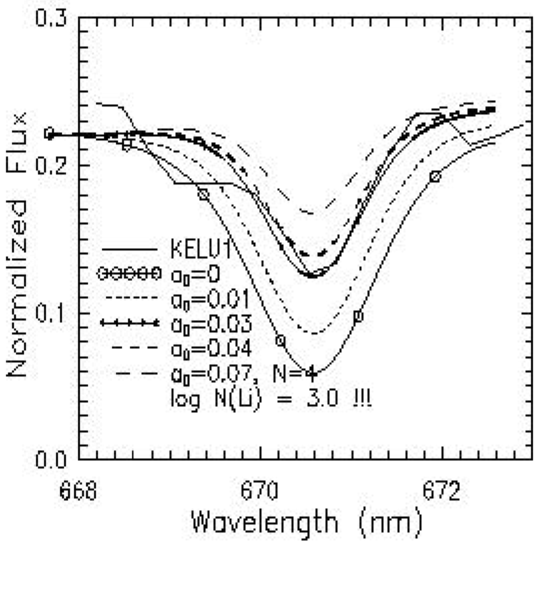

Figure 5: Fit computed for different a_o Li I resonance doublet profiles (λ 670.8 nm) to Kelu 1 spectrum. We got the better fit for log N(Li)=3.0.

pletion into grains we can reasonably fit the shape of the observed spectra.

The most striking features in the spectra (pseudo-equivalent widths of roughly several hundreths to more than 1000 Å) are well fitted in our computations (Figs 2 and 3) and it can be undoubtly attributed to the KI + Na I resonance doublets. Furthemore, both blue and red wings of the KI lines can only be modeled when the extra opacity is considered in the computations.

Our approach allows to find the solution even for the extreme case of H-dwarf[1] Gl229B (Fig. 4).

Other alkaline absorptions (from Li, Rb and Cs) are also present. We have investigated the impact of the additional opacity on the formation of the absorption lines of alkalies. In particular, lithium is severely affected by any extra source of opacity. The larger the opacity, the more veiled the lithium line becomes (Fig. 5). Therefore, weak lithium lines in the coolest brown dwarfs do not necessarily imply a depletion of this light element.

Finally, we claim that the observed sequence of the L-dwarf spectra is *the temperature sequence*:

Object	Teff	log g
BRI0021-024	2200	5.0
Kelu1	2000	5.0
DBD J1228–1547	1600	5.0
DBD J0205 1159	1400	>5.0
Gl229B	1000?	>5.0???

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[1]H-dwarfs occupy the intermediate mass region between L-dwarfs and gint planets