DEPLETION OF TiO AND SPECTRA OF THE COOLEST BROWN DWARFS

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ABSTRACT. This study was performed in the context of the "lithium test" for brown dwarfs proposed by Rebolo et al. (1992). We consider the formation of lithium dust species in atmospheres of the coolest stars and substellar objects.

Perspectives on the "lithium test" for the latest M-dwarfs with dusty atmospheres are discussed. Synthetic spectra computed for dusty (Tsuji 1996a) model atmospheres of the coolest M-dwarfs do not show any TiO bands!

Key words: brown dwarfs, lithium abundances, synthetical spectra

Introduction

Low luminosity M-dwarfs close to the bottom of the Main Sequence are the best brown dwarf candidates in young clusters of the solar neighborhood. Rebolo et al.(1992) put forward the idea of *lithium test* for identifying these substellar objects.

Implementation of dust provides drastic changes in the physical state of uppermost layers of atmospheres of the coolest M-dwarfs (see Tsuji et al. (1996a,b), Allard et al. (1996, 1997)). The two largest effects are:

– the temperature structure of model atmosphere may be affected.

– the equation of state should take into account the solid and/or liquid particle formation.

Procedure

The most important change made in this work consists of the new treatment of the molecular-dust equilibrium. Namely, we suggest, that *the specific pressure* $P_i = n_i * k * T$ *cannot exceed the saturation pressure* P_i^{sat} for i-th species. Molecular number densities n_i we get from the solution of the system of ionization-dissotiation equilibria equations. Note, the approach gives a lower limit of the impact of the dust formation on the spectra of the coolest dwarfs.

We use two grids of model atmospheres:

– "non-dusty" models with $T_{eff} > 2700$ K computed by Allard and Hauschildt (1995: AH95) in the frame of classical approaches.

– "dusty" models with $T_{eff} < 2700$ K computed by Tsuji(1996a).

Results

TiO. In the atmosphere of the $T_{eff} = 1800$ K dwarf $P(TiO) >> P_{sat}$ (Fig.1). That means the TiO exists here in the non-molecular form mainly! Moreover, we find oversaturated regions for TiO in the model atmosphere of comparative hot stars with T_{eff} =3100 even for log g = 3.5! Obviously, this effect should give strong impact on the treatment of opacity computations in the coolest model atmospheres.

An importance of the TiO depletion for a realization of the lithium test is obvious. In fact the TiO depletion process improves the feasibility of using of the "lithium test" to tell substellar objects from stars.

Silicon and carbon. Very promising for the forthcoming studies seems the conclusion that in the underphotospheric layers the graphite and silicon dust may be formed.

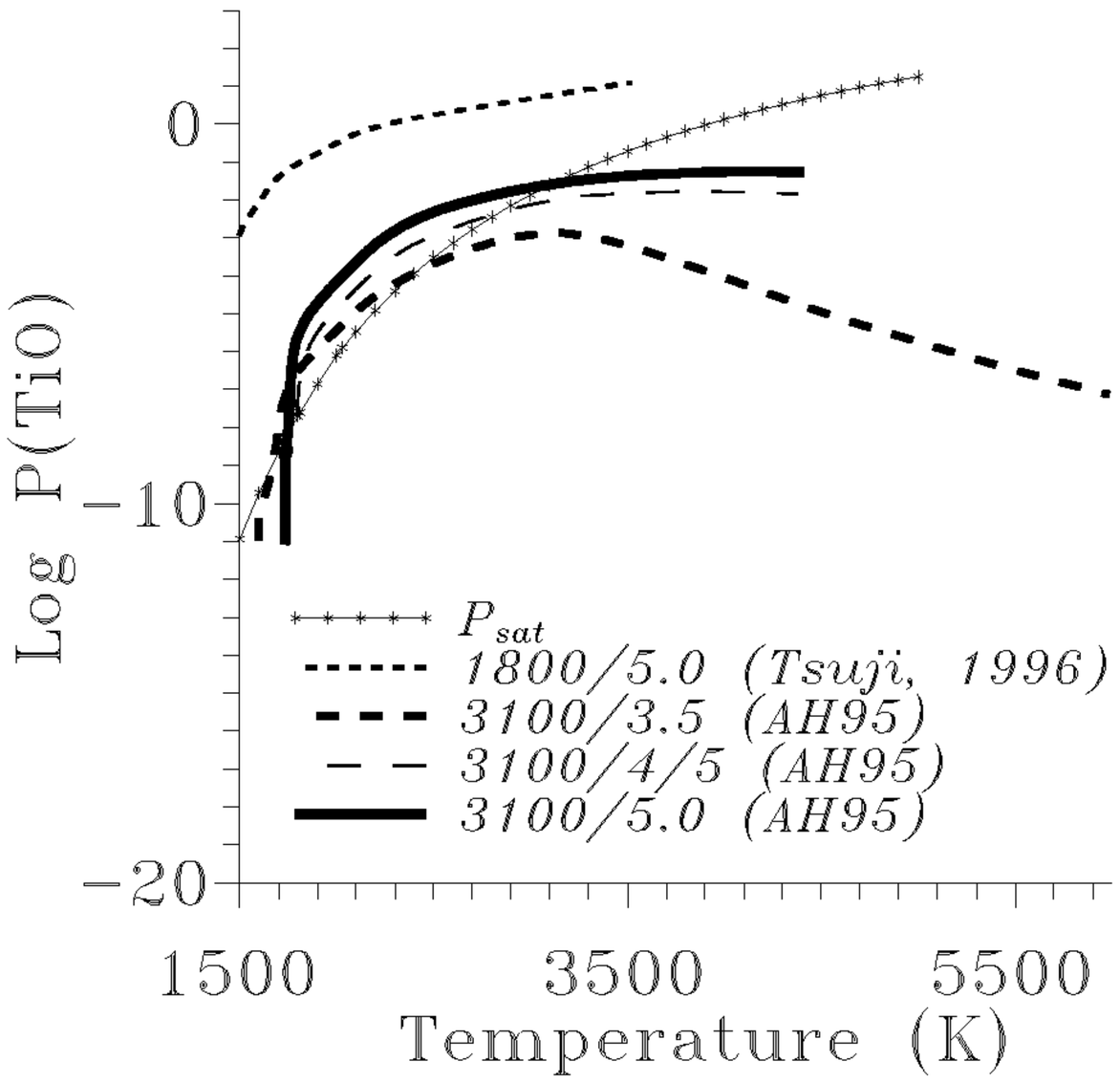

Figure 1. P_{TiO} and P^{sat}_{TiO} pressures in coolest model atmospheres

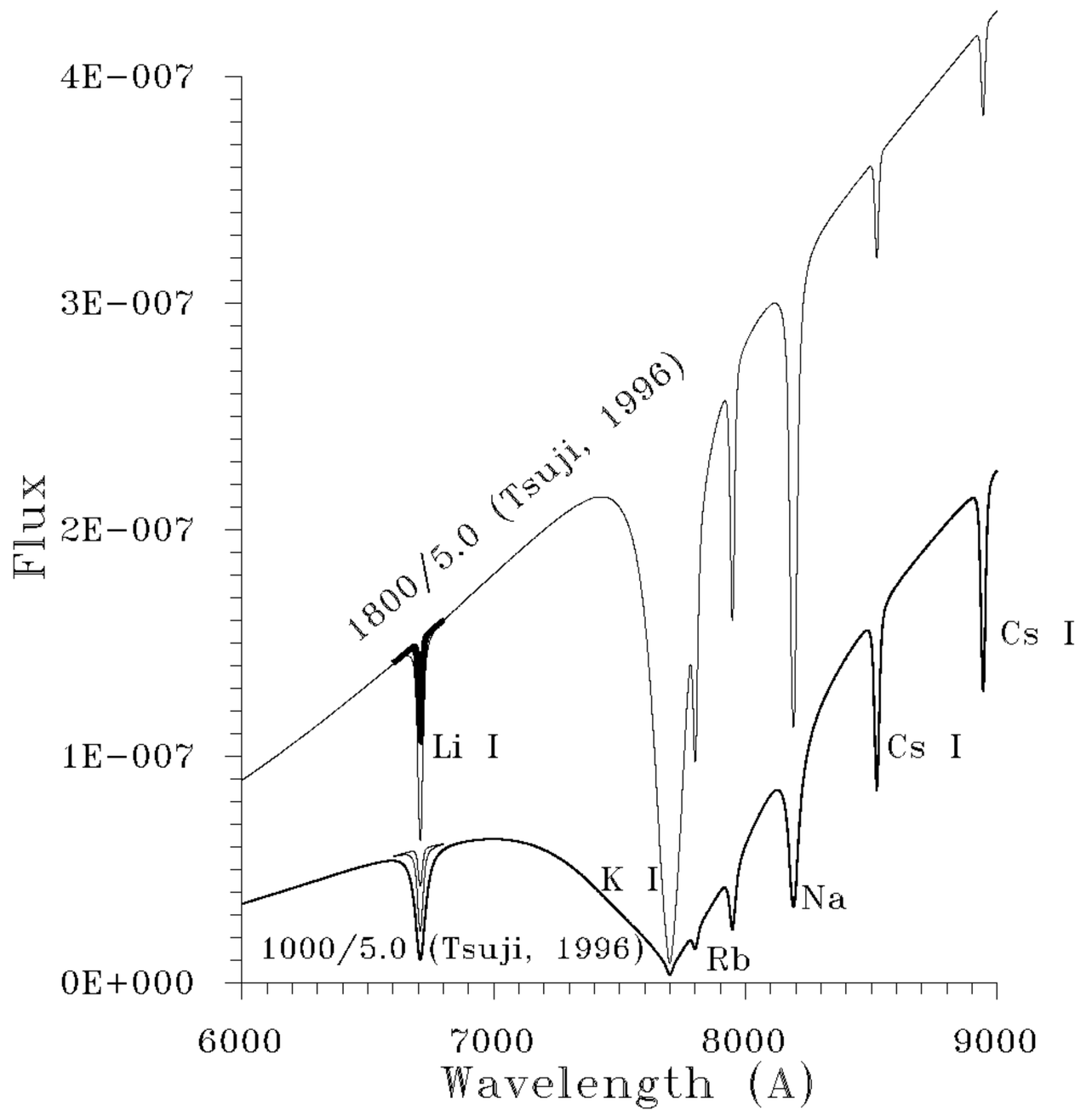

Figure 2. "GD 165 B-like" theoretical spectra computed for 1000/5.0 "dusty" model of Tsuji (1996a) taking into account the complete depletion of VO and TiO. The strongest alkali line positions are labeled in the Fig.

Conclusions

Finally, let me point out a few iportant results:

- Li atoms and lithium-contained molecules exist in the coolest model atmospheres in the *undersaturated* regime mainly. *In principle* the lithium dust formation processes cannot affect the Li I line strength.
- TiO molecules are oversaturated even for T_{eff} = 3100 K and log g =3.5. So the molecular TiO densities should be depleted by the grain formation processes.
- Flux distributions in spectra of the coolest M-dwarfs are severely affected by the TiO depletion. TiO depletion processes reduce its bands strength. Li lines do not disappear under the TiO bands (see Pavlenko 1997 for details).
- Moreover, taking into account a complete depletion of TiO (and VO ?!) we get the "GD 165B - like" (Kirkpatrick et al. 1993) flux distribution in the visible spectrum (Fig.2).
- The yield of the TiO depletion depends on the depth in atmospheres as well on log g. With decreasing log g the relative strength of lithium lines even increases.

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