STATISTICAL EQUILIBRIUM OF THE LITHIUM IN DIFFERENT METALLICITY DWARF ATMOSPHERES WITH $T_{eff} = 5770$ K, $\lg g = 4.44$

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ABSTRACT. Results of computations of the lithium statistical equilibrium in atmospheres of T_{eff} = 6270, 5770, 5270 and lg g = 4.44 dwarfs of metallicities $[\mu] = -0, -1, -2, -3$ are discussed. It is shown that NLTE corrections are less then 0.1 dex for abundances of lithium observed in these stars.

Key words: Stars: atmospheres, lithium abundance, solar – like dwarfs.

Model atmospheres of these stars were computed by SAM1K program (Pavlenko and Yakovina 1994). The blocking effect due to radiation absorption by atom and ion lines was taken into account by opacity sampling method.

The model atom consists of 19 levels of Li I, and the ground state of Li II. Selfconsistent system of statistical equilibrium and the radiative transfer equation were solved by partial linearization method. The blocking effect in the frequencies of bound-free transitions due to radiation absorption by lines of atoms and ions has been taken into account. 70 bound-bound and bound-free transitions were involved into computations.

The collisional excitation rates were computed by formula

$$C(i,j) = Ce(i,j) + Ch(i,j) \cdot q, \quad (1)$$

where Ce and Ch are probabilities of $i \rightarrow j$ transition due to inelastic collisions with free electrons and hydrogen atoms correspondingly. For the time parameter q is poor defined (see Steenbock and Holweger 1984): $0 < q < 1.0$. In this paper we give results obtained for $q = 0$ and $q = 1$.

A comparison of LTE and NLTE equivalent widths for lines of resonance doublet 670.8 nm and subordinate doublet 610.3 nm are given below.

We would like to admit the following results:

a) the sign and values of abundance corrections due to NLTE effects in resonance doublet 670.8 nm depends on model atmosphere structure, transition rates due to inelastic collisions with atomic hydrogen, and the abundance of lithium.

b) for subordinate line 610.3 nm the sign and values of abundance corrections are positive always.

c) in wide range of abundances ($1.0 < \varepsilon(Li) < 3.5$) the Lithium abundance corrections due to NLTE effects are less then 0.1 dex for solar type dwarfs. So the classical results of Spite and Spite (1982) cannot be changed taking into account the NLTE in lithium lines.

d) the dependence of our results on parameter q is not crucial.

e) our computations show that the dependence of NLTE corrections for lithium abundances on the metallicity of solar like stars is rather weak then strong.

To explain latest result we compare the temperature structutes of Z0 and Z3 models. It is well known result, that gradient temperature in the model atmosphere depends from metallicity. In model Z3 that gradient is lowered in comparison with Z0 model. The difference between T_r - radiative (excitation) temperature

Table 1. The ratio W(LTE)/W(NLTE) computed for Li I 670.8 and 610.3 mn lines. W(LTE) and W(NLTE) - equivalent widths of lines computed in LTE and without LTE correspondingly. Abundances of Li are given in the scale where $\varepsilon(H) = 12$. There are results for two model with $T_{eff} = 6270$, $\lg g = 4.44$. One of them (Z0) has solar metallicity, in the second model (Z3) $[\mu] = -3$.

Lines		670.8 nm				610.3 nm			
Model	abund	Z0		Z3		Z0		Z3	
	Lith.	q=0	q=1	q=0	q=1	q=0	q=1	q=0	q=1
	1.00	1.042	.997	1.110	0.939				
$T_{eff} = 6270$,	1.50	1.040	.995	1.105	0.937	1.101	1.055	1.210	1.055
$\lg g = 4.44$	2.00	1.032	.989	1.093	0.931	1.100	1.054	1.211	1.054
	2.50	1.008	.968	1.055	0.910	1.100	1.054	1.211	1.055
	3.00	0.943	.913	0.962	0.854	1.097	1.051	1.209	1.054
	3.50	0.834	.818	0.817	0.758	1.087	1.042	1.198	1.048

Table 2. The W(LTE)/W(NLTE) ratio computed for Li I 670.8 and 610.3 mn lines. Model atmospheres 5270/4.44, metallicities are 0 and -3.

Lines		670.8 nm				610.3 nm			
Model	abund	Z0		Z3		Z0		Z3	
	Lith.	q=0	q=1	q=0	q=1	q=0	q=1	q=0	q=1
T_{eff}=5270,	1.00	1.226	1.137	1.293	0.999	1.199	1.116		
$\lg g = 4.44$	1.50	1.198	1.116	1.269	0.991	1.198	1.116	1.242	1.011
	2.00	1.123	1.056	1.205	0.967	1.196	1.114	1.242	1.011
	2.50	.9817	0.9383	1.072	0.907	1.192	1.111	1.243	1.012
	3.00	.8509	0.8327	0.895	0.819	1.176	1.097	1.236	1.011
	3.50	.8101	0.8092	0.781	0.772	1.126	1.054	1.208	1.000

and T_e in model Z3 is smaller than in model Z0. So the intensity of NLTE effects in model does not increase dramatically despite lower opacities in the frequencies of bound-bound and bound-free Li I transitions.

More details for 5770/4.44 models atmosphere will be given in the paper (Pavlenko 1994). We admit only, that for the Sun abs($\Delta\varepsilon$(Li))< 0.05 dex has been obtained. Semiempirical model atmospheres have shown less pronounced NLTE effects in comparison with theoretical ones. For large abundances of lithium $\varepsilon(Li) >$ 3.2 dex the NLTE effects for resonance lines should be larger: ($\Delta\varepsilon$(Li)< −0.2 dex).

References

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