LTE and NLTE LITHIUM ABUNDANCES IN ATMOSPHERES OF LITHIUM RICH RED GIANTS

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ASTRACT Results of the computations of the statistical balance of lithium in atmospheres of a sample lithium rich G-K giants are discussed. Investigations were performed for 20-level model lithium atom by complete linearisation method. Blocking effect due to the radiation absorption by atoms, ions and molecules was taken into account. The abundances of lithium in atmospheres of 13 red giants have been reconsidered taking into account NLTE effects.

Key words: red giants: NLTE: lithium abundances

PROCEDURE

To solve the system of statistical balance and radiative transfer equations (NLTE problem) for 20-level lithium atom we followed the modification of the linearization method proposed by Auer and Heasley (1976). Opacity in frequencies of lithium bf and bb transitions were computed taking into account continuum, atomic and molecular absorptions. Our computation procedure was described elsewhere (Pavlenko 1989, 1992, 1995, 1996). In the frame of this investigation we compare the new NLTE results and obtained by Pavlenko (1989, 1992) for 6-level lithium atom. The system of ionization-dissociatiom equilibrium equations was solved in the frame of LTE for 98 species.

MODEL ATMOSPHERES

We used the model atmospheres of red giants computed by SAM71 program (Pavlenko 1991). Molecular opacity due to 21 molecular bands absorption was taken into account by JOLA approximation (see details in Pavlenko et al. 1995). The comparison of the newest Kurucz's (1993) model atmospheres and computed by SAM71 shows a good agreement ($\Delta T < 50K$ at given depths).

RESULTS

We note a few important items(see Pavlenko 1996 for details):

– NLTE curves of growth (COG) of lithium lines are significantly different for given G-K giants. The value of the NLTE abundance correction $\Delta_{\rm nlte} = logN_{nlte}(Li) - logN_{lte}(Li)$ varies in large scale: from -0.4 dex (for HD 112127) up to 0.2 dex(for Cappella B).

– In the case of G-K giants with $T_{\rm eff} < 4500$ K the NLTE curves of growth of lithium lines are much less sensitive to $T_{\rm eff}$ and μ parameters in comparison with LTE.

– Results obtained for 20-level and 6-level model atoms of lithium agrees well enough.

Using results of LTE & NLTE computations of curves of growth we reconsidered lithium abundances in atmospheres of a few lithium rich red giants taking into account NLTE effects (Table 1).

DISCUSSIONS

Our investigation shows the different impact of the NLTE effects on Li I resonance and subordinate lines. The NLTE abundance corrections $\Delta_{\rm nlte}$ for Li I subordinate lines are always positive. For resonance Li I lines we have found the NLTE correction sign and values depend on the effective temperature, lithium abundance, metallicity(see also Pavlenko (1991, 1992, 1995), Carlsson at al. 1994).

The NLTE COG's show weaker dependence on μ and log g which usually are not known for many giants with high accuracy (Pavlenko 1996, see also Pavlenko & Magazzu 1996).

For saturated resonance lines NLTE effects shift lithium abundances toward lower values. In same cases (HD9746, HD112127) this effect may weak or even cancel the problems of interpretation of high lithium abundances in red giant atmospheres.

Anyway, *NLTE computations give more confident results of Li abundance determination in red giant atmopspheres.*

Effects of spherical geometry, chromospheres, inhomogeneity of the stellar atmosphere were not considered in this study. So we may treat these results as a necessary step towards better understanding of the Li lines formation processes in atmospheres of red giants.

Table 1. Lithium abundances in G-K giant atmospheres

Star, HD	T_{eff}	$\log g$	$[\mu]$	Ref.	$\log N(Li)$ LTE	NLTE	Δ
787	4220	1.5	0.07	1	1.8	1.71	-0.09
9746	4420	2.3	-0.13	1	2.7	2.40	-0.30
30834	4190	1.5	-0.17	1	1.8	1.73	-0.07
108471	4970	2.8	-0.02	1	2.0	2.07	0.07
112127	4340	2.1	+0.31	1	2.7	2.30	-0.40
120602	5000	3.0	-0.07	1	1.9	1.98	0.08
126868	5440	3.2	-0.25	1	2.3	2.34	0.04
148293	4640	2.5	+0.23	1	2.0	2.14	0.14
183492	4700	2.4	+0.08	1	2.0	2.15	0.15
205349	4480	0.6	0	1	1.9	1.89	-0.01
Capella A	4800	2.6	0	2	0.86	1.03	0.17
Capella B	5550	2.9	0	2	3.10	2.94	-0.16
9 Boo	4200	1.0	0^4	3	2.00	2.10	0.10

1- Brown et al. (1990), 2- Pilachowski & Sowell (1992),
3- Yakovina (1985), 4- Boyarchuk et al. (1991).

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