

Li I LINE λ 460.3 nm IN SPECTRA OF SUPER LITHIUM-RICH CARBON STARS

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ABSTRACT. Subordinate Li I line λ 460.3 nm is quite strong and sensitive on lithium abundances at $\log N(\text{Li}) = 3-5$ that are typical in atmospheres of super lithium-rich AGB giants. However, this line cannot be a good indicator of lithium abundances due to severe blending, especially by line Fe I λ 460.294 nm. On the other hand, a sensitivity of calculated blend containing Li I line λ 460.3 nm on $\log N(\text{Li})$ increases for more complete system of continuum opacity sources in the blue and if use this indicator for metal-deficient stars.

Key words: AGB stars: WZ Cas: lithium abundance indicator: subordinate Li I lines.

Super lithium-rich AGB stars (SLR, $\log N(\text{Li}) \geq 4$) are of great cosmological interest, because ones belong to the main suppliers of lithium into interstellar media. Resonance Li I line λ 670.8 nm is very strong in spectra of SLR stars. Besides, there are some strong subordinate Li I lines in optical and near IR regions formed by transitions from a level 2p. Four strong lines of this series lie in $\lambda\lambda$ 450-820 nm, namely, $\lambda\lambda$ 812.6, 610.4, 497.2 and 460.3 nm. From Abia et al. (1999) and Yakovina & Pavlenko (2001) computations follow that Li I lines $\lambda\lambda$ 812.6 and 610.4 nm are saturated in spectra of SLR C-stars and therefore they are rather non sensitive on lithium abundance. Li I lines $\lambda\lambda$ 497.2 and 460.3 nm are quite sensitive on $\log N(\text{Li})$, but really only Li I line λ 497.2 nm can be good lithium abundance indicator due to severe blending of the line λ 460.3 nm. The last almost coincides in wavelengths with strong Fe I line λ 460.294 nm. Furthermore, it lies in region of strong bands $\Delta v = -2$ of CN violet system. Li I line λ 460.3 nm is blended mainly by the band 0-2 with head at $\approx \lambda$ 460.6 nm. We investigate if there are any conditions for blend at λ 460.3 nm which make one more sensitive on $\log N(\text{Li})$.

For the first time subordinate triplet Li I λ 460.3 nm was considered by Abia et al. (1999). But estimation of $\log N(\text{Li})$ was not derived due to not perfect fit of synthetic spectra to observed spectrum of C-star in this region. To improve the fit we refine line lists for region near Li I line λ 460.3 nm. Then we consider one as indicator of lithium abundance. The

Table 1: The parameters of triplet Li I λ 460.3 nm. (Kupka et al. 1999).

Wavelength[nm]	log gf	Ei[eV]	Transition(i->k)
460.2826	-0.613	1.848	2p 2P - 4d 2D
460.2894	-0.353	1.848	2p 2P - 4d 2D
460.2897	-1.313	1.848	2p 2P - 4d 2D

triplet line parameters are listed in Table 1. We use the observed spectrum of WZ Cas (C9.2J) kindly provided by C.Abia (see (Abia et al. 1999) for more details).

Synthetic spectra were computed in LTE approach by the program WITA6 (Pavlenko 2000). Continuum opacities for a case of carbon-rich atmospheres were used. Then, we implement additional continuum absorption to account of unidentified yet sources by increasing of continuum opacity by factor κ . Parameters of the used model atmosphere (see Eriksson et al. 1984) are: $T_{\text{eff}}/\log g/[\mu] = 3000/0./0.$, $C/O=1.007$. We adopt oxygen and nitrogen abundances from the atmosphere model. Carbon abundance was refined using fits to observed spectrum. Microturbulence velocity $V_t = 2.5$ km/s and isotopic ratio $^{12}\text{C}/^{13}\text{C} = 5$ were used (see Abia et al. 1999).

We compile line list using atomic lines from (Abia et al. 1999) and molecular lines from CD-ROM N18 of Kurucz (1993-1994). Molecular line list includes lines of A-X and B-X systems of CN, D-A system of C_2 , A-X and B-X systems of CH and A-X system of MgH. The list of atomic lines was verified by a fit to spectrum of the Sun (Fig.1a). Atlas of solar spectrum (Kurucz et al. 1984) and solar atmosphere model from Kurucz (1993-1994) were used. Some atomic lines were taken from Bell's tape kindly provided by T.Kipper. Fit of λ 460.3 nm region to observed spectrum of WZ Cas is quite good (Fig.1b). The differences of the observed and synthetic spectra are caused mainly by the lack of precision and completeness of used molecular line lists,

especially C_2 lists.

Sensitivity of Li I line λ 460.3 nm profile and λ 460.3 nm blend on $\log N(\text{Li})$ for different κ and $[\mu]$ and fit of this blend to the observed spectrum of WZ Cas are shown in Fig.2. Fig.2a shows the modelled Li line itself. Fig.2b illustrates the blend at λ 460.3 nm for case $\kappa=1$ (no additional opacity) and $[\mu]=0.0$ (solar metallicity). Cases of $\kappa=5$, $[\mu]=0.0$ and $\kappa=5$, $[\mu]=-1.0$ are shown in Figs. 2c and 2d, respectively. We see, that sensitivity of the blend on $\log N(\text{Li})$ is rather weak in case 2b) and essentially rises if additional opacity sources are implemented (Fig.2c). Note, $\kappa=5$ was chosen from the best fit to the observed spectrum of WZ Cas. Fig.2d shows that this Li abundance indicator is more suitable for metal-deficient stars.

We cannot use the line Li I λ 460.3 nm for $\log N(\text{Li})$ determination because the computed blend's core is too deep in comparison with the observed one (Fig. 2c). This can be explained by different reasons: a) used gf of line Fe I λ 460.294 nm is too high, b) too rough model atmosphere and adopted approaches, c) NLTE effects in Fe I line λ 460.294 nm. Note, that NLTE correction to $\log N_{\text{LTE}}(\text{Li})$ from line λ 460.3 nm is $\Delta \log N(\text{Li})=+0.1$ for used atmosphere model (cf Abia et al. 1999). Then, we use $\log gf=-2.220$ for line Fe I λ 460.294 nm from Blackwell et al. (1980) as the most exact. It is the lowest value among known gf.

Fig.2 shows, that the λ 460.3 nm blend is the most sensitive on lithium abundance at $\log N(\text{Li}) = 3-4$. It cannot be used yet for lithium abundance determination in SLR AGB stars, but a situation can be improved in the case of more precise calculations. This indicator is more suitable for metal-deficient stars.

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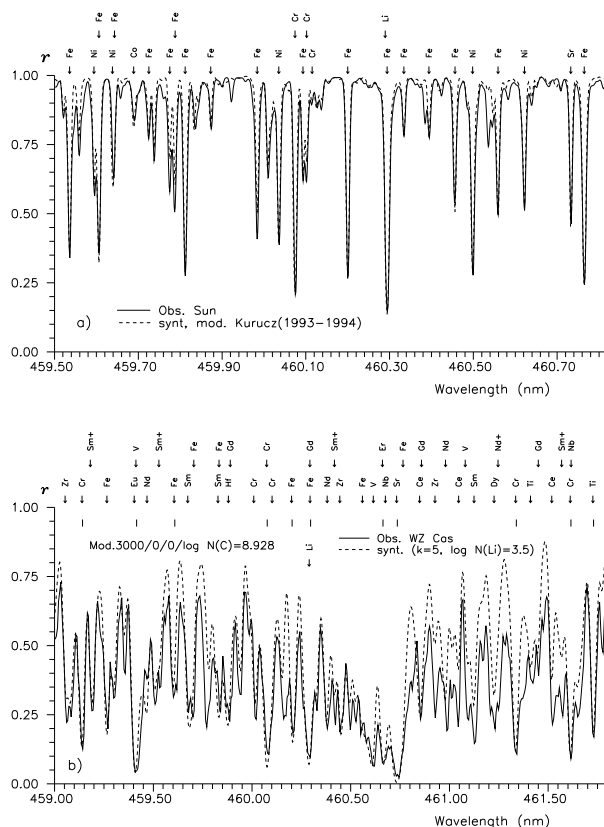


Figure 1: Fits to observed spectra (solid lines) of the Sun (a) and WZ Cas (b). The synthetic spectra are showed by dashed lines. Vertical strokes mark positions of strong atomic lines used for connection of observed and synthetic spectra.

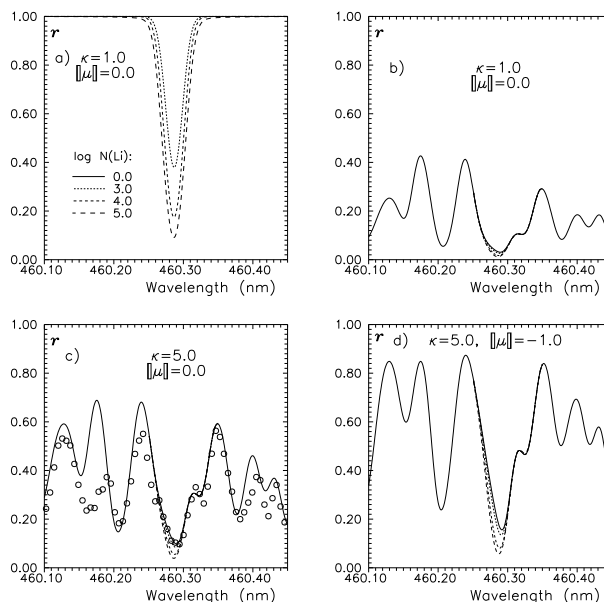


Figure 2: Sensitivity of the Li I triplet λ 460.3 nm and the blend containing one on $\log N(\text{Li})$ for different κ and metallicity. $\log N(\text{Li}) = 0.0, 3.0, 4.0, 5.0$. Observed spectrum of WZ Cas is shown by circles.