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Lithium Abundances in Solar-Type Stars[1]

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Abstract. We report Li abundances from the λ6707 line for 19 nearby dwarf and subgiant solar-type stars. The unevolved stars in this sample present high (> 2.00) Li abundances. We found a few cases of subgiant stars which present high Li content. The Sun seems to be part of a population of nearly unevolved stars which have depleted their Li to a high degree: all other metal-normal, near ZAMS stars in our sample show higher than solar Li content. There seems to be no correlation of the degree of Li depletion with mass, atmospheric parameters or state of evolution: as an example we found a star (HR1532) almost identical to the Sun in its state of evolution and atmospheric parameters, but with over ten times the solar Li abundance. We propose that different histories of angular momentum distribution at star birth, and/or post-birth angular momentum evolution, may account for these differences.

1. Analysis and Results

Observations have been performed at the OPD[1], using the coudé spectrograph of the 1.60 m telescope was used to obtain S/N > 200, 0.20Å resolution spectra of 19 solar-neighborhood, solar-type stars. The observed spectral regions cover approximately 100Å each, centered at λ6050, λ6150 and λ6707. The Sun was observed as a star by way of lunar spectra, with the same setup. Atmospheric parameters T_{eff}, log g, [Fe/H] and microturbulence velocities were obtained from the detailed analysis, differential with respect to the Sun, of the excitation & ionization equilibria of Fe (over 25 Fe I lines in average, 2 Fe II lines). We have also derived log g from absolute magnitudes based on HIPPARCOS parallaxes: excellent agreement was obtained between the two approaches. Luminosities were obtained by applying the bolometric corrections of Habets & Heintze (1981). Mean errors of the parameters thus obtained are: 70 K for the excitation T_{eff}, 0.30 dex and 0.06 dex for, respectively, the ionization and evolutionary log g ; 0.07 dex for [Fe/H] and 0.15 km/s for the microturbulent velocities. The lithium abundance was derived from the λ6707 doublet by spectral synthesis of the ob-

[1]Based on observations collected at the Observatório do Pico dos Dias (OPD), Brazil, operated by the CNPq/Laboratório Nacional de Astrofísica .

served line profiles, using a program kindly made available by Monique Spite (Observatoire de Paris- Meudon). The error in the determination is estimated as 0.10 dex.

Table 1. Atmospheric parameters, Fe, Li abundances and luminosities for the program stars.

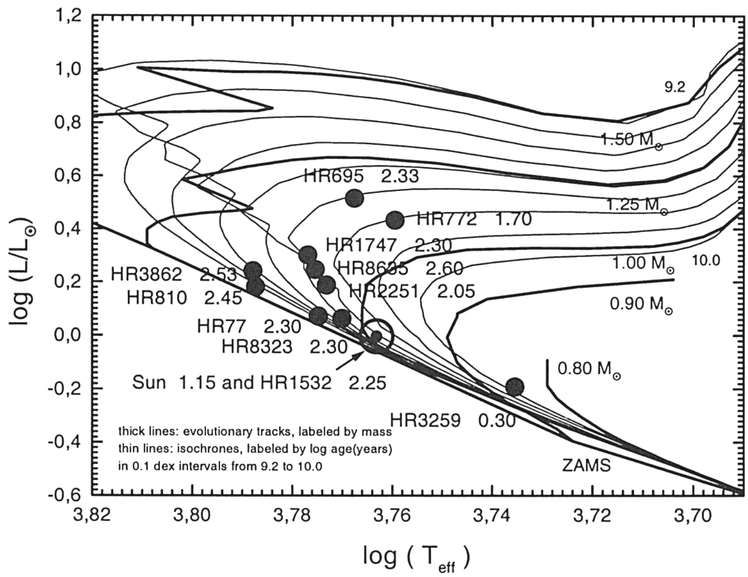
HR	$T_{\rm eff}$	log g_{ion}	log g_{evol}	$\xi_{km/s}$	[Fe/H]	log $L/L_\odot$	log N(Li)
173	5270	3.75	3.84	1.35	-0.70	0.48	0.00
914	5020	3.66	3.60	0.93	-0.57	0.67	0.60
3138	5830	4.40	4.35	0.79	-0.27	0.08	0.30
8501	5750	4.27	4.32	1.30	-0.25	0.05	1.70
6998	5500	4.43	4.47	0.34	-0.16	-0.15	-0.50
1747	5960	4.21	4.25	1.67	-0.10	0.30	2.30
3862	6130	4.33	4.35	1.50	-0.08	0.24	2.53
77	5970	4.48	4.46	1.08	-0.07	0.07	2.30
SUN	5780	4.44	4.44	1.30	+0.00	0.00	1.15
3259	5380	4.38	4.45	1.07	+0.00	-0.19	0.30
2251	5950	4.36	4.32	1.47	+0.01	0.19	2.05
695	5830	3.87	4.01	1.37	+0.03	0.51	2.33
8635	5940	4.19	4.28	1.37	+0.04	0.25	2.60
8323	5900	4.48	4.42	1.08	+0.07	0.06	2.30
772	5710	4.00	4.05	1.53	+0.09	0.43	1.70
1532	5740	4.36	4.47	1.06	+0.09	-0.03	2.25
810	6130	4.42	4.43	1.74	+0.11	0.18	2.45
8700	5890	3.92	4.02	1.79	+0.19	0.53	2.55
1536	5990	4.30	4.12	1.61	+0.27	0.43	2.78
1856	6020	3.73	3.69	2.19	+0.27	0.99	1.20

2. Evolutionary State and Lithium Abundances

We have examined the distribution of Li abundances with state of evolution by plotting the stars in the theoretical HR diagrams of Schaerer et al. (1993 and references therein), roughly corresponding to metallicities of [Fe/H] = -0.37, +0.03 and +0.33. We show only the diagram corresponding to solar metallicity stars (figure 1). The metal-rich and metal-normal unevolved stars have preserved most of their Li, in contrast to the Sun, which is the only unevolved Li-poor star. The Sun may thus be considered part of a population of stars which have strongly depleted their Li (Pasquini et al. 1994). It has been suggested by King et al. (1997) that different histories of Li depletion for stars with very similar masses may be linked to the formation of a planetary system: as an example they cite the binary system 16 Cyg AB, both components being very solar-like (the B component being the planet harboring one), but differing in their Li content by a factor of $\sim$ 5.We note that, in our sample, HR1532 is almost identical to the Sun in mass and atmospheric parameters but is more than ten times Li-richer than the Sun.

We have found a few cases of Li-rich subgiant stars. This may be understood by the "ressurgence" scenario (Dravins et al. 1993), in which the subgiant

Figure 1. Theoretical HR diagrams for the near solar metallicity stars. labeled with HR numbers and Li abundances.



star dredges up to the surface Li that has been preserved below the convectively unstable surface layers, or else by the fact that these stars have maintained their Li abundance owing to low levels of depletion while on the main sequence (Randich et al. 1999). We have found that the metal-poor stars that are not yet subgiants are appreciably more Li-poor than their metal-richer peers. This may be explained by their being quite old stars: all of them lie in a narrow mass interval (0.80-0.90 $M_\odot$). They seem to have undergone different histories of Li depletion even among themselves, judging by their large Li abundance dispersion. The subgiant metal- rich and metal-normal stars have high to moderately high Li content, but the two metal-poor subgiants have much lower Li abundances. Whether they represent stars for which no "ressurgence" phenomenon was at work, or simply stars which depleted their Li while still close to the main-sequence, may not be decided with our current understanding.

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