The Light Elements and Their Evolution
IAU Symposium, Vol. 198, *2000*
L. da Silva, M. Spite, J. R. de Medeiros, eds.

Search for lithium-rich stars among G–K giants with IR–excess

G. Jasniewicz

GRAAL, UPRESA 5024, Université de Montpellier II, CC 72, 34095 Montpellier Cedex 05, France

M. Parthasarathy

Indian Institute of Astrophysics, Koramangala, Bangalore 560 034, India

P. de Laverny

Observatoire de la Côte d'Azur, Dpt. Fresnel, UMR 6528, B.P. 4229, 06304 Nice Cedex 4, France

F. Thévenin

Observatoire de la Côte d'Azur, Dpt. Cassini, UMR 6529, B.P. 4229, 06304 Nice Cedex 4, France

N. Mauron

GRAAL, UPRESA 5024, Université de Montpellier II, CC 72, 34095 Montpellier Cedex 05, France

M. Chadid

ESO, Casilla 19001, Santiago 19, Chile

Abstract. We report here new results about a search for Li-rich stars among 52 G–K giant stars which are known to have near IR excess. Eleven giants have been found to have $\log \epsilon(Li) \geq 1.0$. Five are new Li-rich stars. We suspect circumstellar shells around one of them, HD 219025. There is no clear correlation between Li-richness and rotation, or with binarity.

1. Introduction

This research is based on two observational facts. On the first hand there are a few G–K giant stars which are known to have IR excess, which is not the case of the majority of the giants. The origin of the dust responsible for the IR excess could be: sporadic mass-loss events from these stars (Zuckerman et al. 1995) during a possibly short-lived phase of evolution, a Vega-like disk heated by the star evolving into a giant (Judge et al. 1987; Plets et al. 1997), a hot spot produced by a nearby diffuse cloud (cirrus) locally heated by the star (Jura 1999).

On the other hand there are giant stars with an overabundance of lithium, which is not expected from the standard first dredge-up evolutionary models. From the histogram of Brown et al. (1989, Fig.13), concerning 644 normal field G-K giants, we deduce that only 11% of the stars have $\log \epsilon(Li) \geq 1.0$ in their sample. The theories and/or scenarios of Li enhancement involve: a self production (Sackmann and Boothroyd 1999; Charbonnel & Balachandran 2000) of Li without or with shell detachments, an accretion of planets or brown dwarfs by giant stars (Siess and Livio, 1999), mass and angular momentum tranfers in binary system as suggested by Barrado y Navascués et al (1998) for chromospherically active binary stars, etc...

The main question adressed in this work is: which correlation (if any) is there between IR-excess and Li abundance among late-type giants? This question has been adressed previously by other authors, especially by de la Reza and co-workers (de la Reza et al. 1996, 1997) who propose a scenario linking the high Li abundances of some K giant stars to the evolution of circumstellar shells. Besides, Fekel & Watson (1998) have selected 40 IR-excess giants from the list of Zuckerman et al. (1995) and shown that the percentage of giants with $\log \epsilon(Li) \geq 1.2$ is similar to that expected for normal field giants ; however their conclusion is no more true if we adopt $\log \epsilon(Li) \geq 1.0$ for being Li-rich (see Sect. 3). A work similar to that of Fekel & Watson (1998) has also been simultaneously achieved in a totally independent way by us (Jasniewicz et al. 1999). In this communication new targets have been added to the list of Jasniewicz et al. (1999).

Another question adressed in this communication is the following: is there any evidence for a circumstellar shell around giant stars which are Li overabundant ?

2. Targets and observations

The giant stars considered in this research come from various lists of stars with IRAS infrared excess: 29 stars come from Zuckerman et al. (1995), 14 stars from Oudmaijer et al. (1992), 5 stars from Stencel & Backman (1991), and 4 stars from Plets et al. (1997). These 52 objects were extracted from the 4 papers above with the following criteria: spectral type III and visual magnitude $m_V \leq 8.5$. The V-mag threshold was set in order to get high S/N ratio spectra with our instrumentation. Using the HIPPARCOS parallaxes available for 41 stars in our sample, we infer that the selected stars are not pre-main-sequence stars and that most of them are more luminous than the K giant clump (see the loci of some of our stars in the HR diagram by Charbonnel & Balachandran, this conference).

Observations were performed at ESO with the CAT-1.4m + CES spectrograph and a spectral resolution $\lambda/\delta\lambda$=67 000, and at Haute Provence Observatory (France) with the 1.5m telescope and the Aurélie spectrograph with $\lambda/\delta\lambda$=40 000. A few radial velocities were also measured with CORAVEL at OHP.

3. Analysis of spectroscopic data

Lithium abundances were determined by the spectral synthesis method for all the stars (see Lèbre et al. 1999 and Jasniewicz et al. 1999 for a general description). Updated MARCS model atmospheres computed with the code of Asplund et al. (1999) and of Bessel et al. (1998) were used. Considering uncertainties on model parameters, we estimate that the Li and Fe abundances are determined with an uncertainty better than ±0.2 dex.

In our sample of stars, we found 11 Li-rich giant stars ($\log\epsilon(Li) \geq 1.0$), say **21% of Li-rich stars** (see Table 1). Fekel and Watson (1998) have obtained a similar percentage of 20% of Li-rich giants ($\log\epsilon(Li) \geq 1.0$) in their sample of 40 stars from Zuckerman et al. (1995). Thus the rate of Li-rich stars in our modest-size sample of IR-excess giants is higher than the expected one for normal field giants, but we did not investigate the biases which could affect our sample. We also emphasize here the fact there are G-K giant stars with IR-excess without overabundance of Lithium and that, reciprocally, there are Li-rich G-K giant stars without IR-excesses: HD 157457, G8III Barium star; HD 112127, K2.5III possible Barium star; RS CVn stars, etc...

Table 1. **G AND K LI-RICH GIANT STARS**

HD	Sp. type	Teff	V_{rot}	[Fe/H]	$\log\epsilon(Li)$	Comments
HD 30834	K2III	4500	1.0	-0.5	2.4	no RV Var.
HD 80499	G8III	4980	15.0	-0.2	0.9	vis.binary
HD 89221	gG5	4980	1.0	-0.3	1.1	
HD 146850	K3III	4270	1.0	+0.4	2.0	No SB I ?
HD 152786	K3III	4270	1.0	+0.2	1.3	
HD 153751	G5III	5040	25.0	-0.3	1.2	RS CVn
HD 169689	G8III	4950	10.0	-0.2	1.0	SB I
HD 175492	G4III	5280	3.0	-0.2	1.3	SB I
HD 176884	K0III	4800	15.0	+0.2	1.2	no RV Var.
HD 190252	G8III	5200	1.0	-0.3	1.3	
HD 219025	K2III	4500	23.0	-0.1	3.0	RS CVn ?

All stars of Table 1 have far-IR excesses over the stellar continuum of a normal star. Five of them are new Li-rich stars:

HD 80499: IR excess at 25μ: 0.1 mag according to Oudmaijer et al. (1992)

HD 89221: IR excess at 25μ: 0.3 mag (Oudmaijer et al. 1992). Possibly a subgiant ($M_V = 3.7$)

HD 152786: IR excess at 60μ (Zuckerman et al. 1995; Plets et al. 1997)

HD 176884: High rotator with a high far-IR 60μ excess: 2.8 mag (Zuckerman et al. 1995; Plets et al. 1997; Oudmaijer et al. 1992)

HD 190252: IR excess at 25μ: 0.3 mag (Oudmaijer et al. 1992)

4. Search for correlations

- Is there any link between Li-overabundance and binarity ?

  Some Li rich giant stars are known to be members of binary systems:
  HD 169689 and HD 175492: spectroscopic binaries, the first one being of Algol type (P=385 days).
  HD 153751: high rotating RS CVn eclipsing binary, P=39.48d according to de Medeiros and Udry (1999).

  The case of HD 219025 is uncertain: it is a high rotating active star, possibly a RS CVn eclipsing binary, with a very high far-IR excess 60μ. This star is similar to the Li-rich star HD 233517. A link between these stars and the FK Comae-type stars (probably resulting from coalescence of binaries) is an open question.
  A possible link between high rotational velocity, Li abundance and engulfing of planets are discussed by Siess and Livio (1999).

  In return, some Li-rich giant stars are not known as binaries (at least short period binaries). Some of them are:
  HD 9746: Chromospherically active star with Prot=2,36days, presently not known as a binary.
  HD 30834 and HD 176884: no radial velocity variations.
  HD 146850: Li-rich according to Fekel and Watson (1998) and Jasniewicz et al. (1999). Detected RV variable by Fekel and Watson (1998); not in this work.

  Thus, the correlation between Li-richness and binarity is not clear.

- There is also no clear relation between Li abundance and $^{12}C/^{13}C$ ratio in Li-rich giants (da Silva et al. 1995). According to Jasniewicz et al. (1999), the $^{12}C/^{13}C$ ratio ranges from 6 to 28 similar to that found for normal K-giants.

- Fekel and Balachandran (1993) suggest a connection between rapid rotation and high Li abundance in giants. Besides, Li abundance does not depend on age for giant components of chromospherically active binary systems, but is closely related to stellar rotation (Barrado y Navascués et al. 1998).
  From the other hand, the 12 Li-rich giants selected by de Medeiros et al. (1996), except for one star, show normal rotational velocities with respect to typical Li-normal giants (de Medeiros et al. 1996).
  Using the data from this work (V_{rot} from CORAVEL) concerning IR-excess giants and data from a list of Li-rich K giant stars taken from literature, we find no clear correlation between Li abundance and rotation.

5. Search for circumstellar gas of IR-excess giants

According to the de la Reza et al. (1996, 1997) scenario, G-K giants might suffer episodic mass loss events in connection with Li production. This mass loss would produce IR emitting dust. If this is true, it is plausible that for some of these giants the expanding circumstellar gas can be detected through resonance absorption lines such as the NaI doublet. Typically, if the envelope has a mass loss rate of 10^{-8} $M_{\odot}\,yr^{-1}$, an expansion velocity of 50 km s^{-1}, an inner radius of 10 R_* or ~250 $R_{\odot}$ and a fraction of NaI of only 1 percent of total Na, one expects a NaI D1 equivalent width of ~0.6 Å, which is well detectable. Absorption sodium lines may also be expected in alternative scenarios, as in the case of evaporating Vega-like icy discs, or circumbinary discs, or a local interstellar cloud.

Consequently, we acquired high-resolution spectra (R=40 000) of the NaI doublet for a group a Li-rich and Li-normal giants taken from our sample of IR-excess giants. This group comprises 7 Li-rich and 21 not Li-rich stars. We searched for both blue and red-shifted absorption components. We detected 13 stars with a clear blue or red-shifted component, and 5 with a distorded photospheric profile.

A difficult issue is how to distinguish the interstellar or circumstellar origin of any absorption component. In order to evaluate statistically the occurence of interstellar lines, we searched for hot stars which could be as close angularly as possible to each giant star, and for which interstellar lines are documented. Generally, 2 or 3 such hot stars were found within about 3 degrees. This angular separation represents 6 pc at a distance of 100 pc, and corresponds to an average size for diffuse interstellar clouds. Analysis of photometric and spectroscopic data on the hot stars allowed to locate them either beyond or in front of the cool giant, and to evaluate if common insterstellar features (with similar velocities) can be expected. Indeed, a careful examination of each case led us to conclude that the NaI absorption components are probably of interstellar origin in the large majority of giants. However, we noted that the high galactic latitude Li-rich star HD 219025 (b_{gal}=46 °; K2III) displays prominent blue-shifted NaI components with expansion velocity of 48km s^{-1} for which a circumstellar origin appears plausible, although this is not definitively established.

6. Conclusions

In order to study a possible link between Li overabundance and IR excess, a sample of 52 G-K giants *with IRAS infrared excess* has been considered. High resolution spectra of the LiI λ6707 line were obtained, revealing that 11 stars, i.e. ~20%, are Li-rich with $\log \epsilon(Li) \geq 1.0$. Our sample is certainly not homogeneous and may suffer from various biases, but it can be noted that the above fraction is identical with that found by Fekel and Watson (1998) in a similar study. This fraction is also twice the fraction of Li-rich stars found from a sample of *normal* giants, according to the study of Brown et al.(1989).

With the goal of investigating the de la Reza scenario of a mass loss event connected with Li production, a search for NaI circumstellar absorption lines has also been carried out on a subsample of 28 giants. It seems that most of the observed NaI lines towards these objects can be due to intervening interstellar clouds, since they also appear with same velocities towards hot stars located within a few degrees. An interesting exception could be HD 219025 (K2III) which is very Li-rich ($\log \epsilon(Li) = 3.0$), and might possess circumstellar Na lines.

Acknowledgments: We thank very much Corinne Charbonnel for very fruitful discussions on the text at the Conference.

References

Asplund, M., Gustafsson, B., Kiselman, D., & Eriksson, K. 1999, A&A, 318, 521

Barrado y Navascues, D., de Castro, E., Fernandez-Figueroa, M.J., Cornide, M., & Garcia Lopez, R.J. 1998, A&A, 337, 739

Bessell, M.S., Castelli, F., & PLez, B. 1998, A&A, 333, 231

Brown, J.A., Sneden, C., Lambert, D.L., & Dutchover, E.Jr 1989, ApJS, 71, 293

Charbonnel, C., & Balachandran, S. 2000, this volume

da Silva, L., de la Reza, R., & Barbuy, B. 1995, ApJ, 448, 410

de la Reza, R., Drake, N.A., & da Silva, L., Torres, C.A.O., & Martin, E.L. 1997, ApJ, 482, 77

de la Reza, R., Drake, N.A., & da Silva, L. et al. 1996, ApJ 456, 1150

de Medeiros, J.R., & Udry, S. 1999, 346, 532

de Medeiros, J.R., Melo, C.H.F., & Mayor, M. 1996, 309, 465

Fekel, F.C., & Balachandran, S. 1993, ApJ, 403, 708

Fekel, F.C., & Watson, L.C. 1998, AJ, 116, 2466

Jasniewicz, G., Parthasarathy, M., de Laverny, P., Thévenin, F. 1999, A&A, 342, 831

Judge, P.G., Jordan, C., & Rowan-Robinson, M. 1987, MNRAS, 224, 93

Jura, M., 1999, ApJ, 515, 706

Lèbre, A., de Laverny, P., de Medeiros, J.R., Charbonnel, C., & da Silva ,L. 1999, A&A, 345, 936

Oudmaijer, R.D., van der Veen, W.E.C.J., Waters, L.B.F.M., Trams, N.R., Waelkens, C., & Engelsman E. 1992, A&AS, 96, 625

Plets, H., Waelkens, C., Oudmaijer, R.D., & Waters, L.B.F.M. 1997, A&A, 323, 513

Sackmann, I.J., & Boothroyd, A.I. 1999, ApJ, 510, 217

Siess, L., & Livio, M. MNRAS, 308, 1133

Stencel, R.E., Backman, D.E. 1991, ApJS, 75, 905

Zuckerman, B., Sungsoo, S.K., & Liu, T. 1995, ApJ, 446, 79