THE CHEMICAL COMPOSITION PECULIARITIES OF G,K GIANTS

Mishenina T.V.
Astronomical Observatory, Odessa State University,
Odessa 270014 Ukraine

ABSTRACT. The review of the observed chemical composition in different groups of G, K - giants with peculiarities in spectra is presented. The old and young disk giants, Ba- and CH- stars, CN-week and CN-strong giants, R stars, Li-strong giants, SMR stars have been discussed.

Key words: stars:abundances - stars:atmospheres - stars:evolution

Introduction

G,K giants are evolved stars. Elemental abundances in these stars represent the chemical composition of matter whith that star formed and are test nucleosynthesis process and mixing events.

Among the giant stars of types G and K, a some stars have been observed to have Ba II, Sr II, Li I lines, CN and/or CH bands of abnormal intensity in their spectra. Such stars were divided into a few separate groups. The peculiar groups include (1) stars with Ba II, Sr II strong lines - Ba-stars, (2) giants with Li strong lines - Li-strong, (3) stars having the CN bands definitely weaker than the average for stars of the same temperature and luminosity - CN-week, (4) - stars with CN excess - CN-strong, (5) stars with CH strong bands - CH-giants and CH-subgiants, (6) strong individual atomic line stars having the metallicity excess - SMR-stars. What is the chemical composition of these group stars? What are causses of their peculiarities? That questions which we will be solved.

In this little survey we examined the G,K giant peculiar groups and connection with other groups of stars having similar metallicity, temperatures and luminosities.

Table 1 summarizes the elemental abundances of different groups of G,K stars.

Metallicity [Fe/H]

The one of main parameters of the chemical composition (with the exception of H and He) is metallicity (in the usual notation $[Fe/H] = \log (Fe/H)_* - \log (Fe/H)_\odot$). The values of [Fe/H] reflect the metallicity of interstellar matter from which the stars formed and characarize their population-membership in the Galaxy. As can see from Table 1 the different peculiar groups of G,K giants have the metallicity within the metallicities of disk dwarfs (Edvardsson et al., 1993) and therefore belong to disk of the Galaxy. However taking into account the kinematic characteristics of disk giants Hartwick & McClure (1980) considered the old disk stars with large space motions ($V_{tot} > 65$ kms^{-1}) and young disk giants with $V_{tot} < 65$ kms^{-1}.

There are also other determinations of subsystems of the Galaxy (Spite 1992, Norris 1994), but the notation of Hartwick & McClure (1980) have been used in paper of Cottrell & Sneden, 1986. The authors carried out the study the old disk giants and found $<[Fe/H]> =$ -0.45. Recently, Shetrone et al. (1993) reanalysis the papers of Cottrell & Sneden (1986), Lambert & Ries (1981) and Kjaergaard et al. (1982) and were found for the young disk $<[Fe/H]> = +0.04$ and for the old disk giants - $<[Fe/H]> = -0.52$. Ba-stars and CH-subgians have metallicity close to the old disk giants or to the thin old disk giants by Spite (1992); we have eliminated CH-giants since their $[Fe/H] < -1.00$. CN-week stars have intermediate metallicity of disk. Li-strong, CN-strong have [Fe/H] as one of the young disk giants. SMR-stars have metallicity higher than 0.2 dex. Taylor (1991) SMR status confirmed only for 31 Aql. Are these stars only moderately metal enriched with respect to the Sun, or do they constitute a distinct sybsystem with metallicities substancially above that of the Sun? Rich (1988) was studied K bulge giants and obtained that the mean value of $[Fe/H] > 0.3$ dex. Gratton & Sneden (1990), Cayrel de Strobel (1991) proposed that bulge giants and SMR stars belong to a distinct sybsystem with $[Fe/H] >> [Fe/H]_\odot$. McWilliam & Rich (1994) found that the mean [Fe/H] is -0.25 for the bulge. They perform an abundance analysis for 11 stars from Rich (1988) ranging from [Fe/H] = -1 to 0.45. The authors find that one of the most metal-rich Baade's window stars has approximately the same metallicity as the disk giant μ Leo. Note, that Taylor (1996) reconside the list of SMR stars and μ Leo no get the SMR status with highres reliable degree.

Table 1. The elemental abundances of different groups of G,K stars

	[Fe/H]	Li	$^{12}C/^{13}C$	[C/Fe]	[N/Fe]	[O/Fe]	[C/O]	[s-elem]
1.Normal (1)	-0.09	+0.1	18	-0.24	+0.38	+0.01	0.28	solar
Giants		(3)						(4)
2.Old Disk(5)	-0.45	-0.12						
Giants (6)	-0.52		15	-0.09	+0.02	+0.11		
3.Young Disk	+0.04		22	-0.22	+0.24	-0.04		
Giants (6)								
4.Ba-stars(7)	-0.5	+0.56	5-20	+0.06	+0.47	+0.17	0.19-	
							0.59	
(8)	-0.20	-0.01						0.4(Y),0.8(Ba)
5.CH-subgians	0 -0.4						0.40-	0.2-
(9)							2.00	2.0
6.Li-strong								
(10)	0.0	2.14	9-24	-0.26	+0.12	-0.03		
7.CN-week								
(11)	-0.20	-0.55	5-28	-0.27	+0.21	+0.05	0.30	solar
8.CN-strong								
(12,13,14)	+0.02	+0.09		-0.17	+0.25	-0.08	0.46	solar
9.R stars								
(15)	near		7	+0.6	+0.38	+0.02	1.6	0.2
	solar							
10.SMR-stars								
μLeo (16)	+0.34		18	-0.15	+0.60	+0.02		0.3
	+0.15							
(1)	+0.11		18	-0.09	+0.55	+0.17		
31 Aql (17)	+0.32	+1.20		-0.12	+0.22	-0.02		0.3
11.Bulge (18)	+0.3					near		near
Giants(19)	-0.25					solar		solar
12.Disk dwarf	+0.20-							
(20)	-0.90							

Notes:1- Lambert & Ries, 1981 (32); 2- Kjaergaard et al., 1982 (34);
3- Braun et al., 1989 (644); 4- Gopka et al., 1991;
5- Cottrell & Sneden, 1986 (34); 6- Shetrone et al., 1993 (31);
7- Barbuy et al., 1992 (11); 8- Zacs, 1994 (17);
9- Smith et al., 1993 (9); 10 -Berdyugina & Savanov, 1994 (8);
11-Luck,1991 (30); 12-Mishenina et al., 1995 (5);
13-Mishenina & Kutsenko,1996 (3); 14-Mishenina & Tsymbal,in press(9);
15- Dominy, 1984 (11); 16- Gratton & Sneden, 1990 (1);
17- Mishenina, 1996 (1); 18- Rich, 1988 (88);
19- McWilliam & Rich, (12); 20- Edvardsson et al., 1993 (189).

Our study of SMR star 31 Aql (Mishenina 1996) show that this star have metallicity larger than that solar, and the abundance patterns for 31 Aql follow to that of metal-rich disk dwarfs. So, the metal-rich stars are exist, but it is necessery to study the question about their belonding to a distinct sybsystem.

Li and CNO abundances

The Li and CNO abundances changed during the evolution of the star. The standard stellar evolution models (Iben 1967, VandenBerg 1992 etc) predicted convective dilution of Li of factors of 30-60 in ordinary disk giants. Though the "primordial" abundance of log A(Li) = 3.0 (Rebolo et al 1988), Li have destructed significantly before the onset of subgiants convective envelope dilution. The solar value of log A(Li) = 1.02 (star of the MS), thus the disk giants ought to have log A(Li) $<<$ 1.00. Braun et al., 1989 carried out the Li abundance determinations for 644 giants. The authors found the mean value of log A(Li) = +0.1. This result agrees with the canonical theory for giants. But, they also found a few stars with log A(Li) $>$ 2.0. The evolutonry status of giants with high lithium abudances have been discussed in work of Berdyugina & Savanov (1994). The authors found that giants with larger Li abudance are on the first ascent of the giant branche, the other giants it possible are in the phase of helium burning in the core.

The predictions of internal stellar nucleosynthesis followed by convective mixing on the RGB, the first dredge-up, indique that the red giant relative to its main progenitor should have the following abundances:
- a reduced ^{12}C abundance; - a lower isotopic abundance ratio $^{12}C/^{13}C$ to about 25 or 30 from an assumed initial solar ratio of 89; - a higher ^{14}N abundance; - a very similar ^{16}O abundance (Iben 1967).

As can see from Table 1 the total CNO abundances (except Ba-, CH-, R stars) confirm the general prediction from stellar evolution theory that first-ascent red giants mix CN-processed material to their surfaces via their deep convective envelopes. Problems for standard stellar evolution exist as the $^{12}C/^{13}C$ ratios in many giants are less than 20. Two possible mechanisms have been hypothesized to account for the low values of $^{12}C/^{13}C$: 1) mass loss or 2) internal mixing. Recent calculations of Charbonnel (1994) suggest that the extra-mixing process occurs in giants with $M < 2 M_{\odot}$.

Ba-, CH-, R stars have the overabundances of carbon and CN-strong giants are sligtly C-rich (C/O $>$ 0.5). Ba-giants and CH-subgiants have also overabundant s-process elements.

According the evolution theory in stars less than about 2.3 $M_{\odot}$, ignition of ^{4}He by the triple-alpha process occurs in a stellar core in which the electrons are degenerate. When degeneracy in the core is lifted, the core expands and quiescent core He-burning is established at a lower luminosity than the star had reached at the tip of the first ascent RGB. The role that the He core-flash may play in producing surface abundance changes is still an open question. Quasistatic models of the core-flash (Iben 1967) do not lead to the mixingof the products of He-burning into the H-rich envelope, however, Despain (1982) speculates that convective overshooting might lead to contact between the core and envelope. For the explanation of R stars - hot carbon stars Dominy (1984) suggests that the core He-flash with rapid core-rotation may provide the source of C-rich low-luminosity giants. Such rapid mixing inhibits $^{13}C(\alpha,n)^{16}O$ and thus none, or very few, neutrons are liberated with no subsequent s-processing. The theory and modeling of the core flash deserves much future attention. Recently Keenan & Heck (1994) suggest that CN-strong giants are marginal R stars. The found C overabundance for CN-stong stars (Mishenina & Tsymbal 1996) may be the support to the hypothesis of Keenan & Heck (1994).

A probable understanding of the Ba star phenomenon was McClure at al. (1980) discovery that all Ba stars are binaries with white dwarf companions, and that the abundance peculiarities are due to mass transfer from the companion during its pre-white dwarf evolution, presumably as a cool star. The stars on the AGB are the carbon giants. The dredge-up of ^{12}C during this phase of evolution (the third dredge-up) will produce carbon stars at luminosities log $L/L_{\odot} > 4.1$ and s-process enriched stars at log $L/L_{\odot} > 4.3$ (Iben & Truran 1978). For CH-subgiants Smith et al. (1993) show evidence of mass transfer onto main-sequence companions and judging by value of C abundance these stars probably are progenitors of Ba-giants.

Conclusion

The G-, K- giants by metallicity belong to young and old disk, SMR stars probable belong to metal-rich population of disk.

The Ba-giants, and CH- subgiants phenomena are mass transfer products. The R stars possible have undergone a core helium flash and some of CN-strong giants are probable marginal R stars.

The Li-rich giants probable reflect the Li overabundance in matter whith these stars formed.

Referenses

Barbuy B. et al.: 1992, *A&A*, **262**, 216.
Berdyugina S.V., Savanov I.S.: 1994, *Pis'ma Astron. Zh.*, **20**, 740.
Braun J.A. et al.: 1989, *AJSupl*, **71**, 293.

Cayrel de Strobel G.: 1991, *Conference on Evolutionary Phenomens in the Universe in Honour of the 80th Birthday of Livio Gratton*, 27.
Charbonnel C.: 1994, *As.Ap*, **282**, 811.
Cottrell P.L., Sneden C.: 1986, *As.Ap.*, **161**, 314.
Despain K.H.: 1982, *ApJ*, **253**, 811.
Dominy J.F.: 1984, *AJSupl*, **55**, 27.
Edvardsson B. et al.: 1993, *As.Ap.*, **275**, 101.
Gopka V. F. et al.: 1991, *Pis'ma Astron. Zh.*, **17**, 368.
Gratton R.G., Sneden C.: 1990, *As.Ap.*, **234**, 366.
Hartwick F.D.A., McClure R.D.: 1980, *ApJ*, **235**, 470.
Iben I.: 1967, *AJ*, **147**, 624.
Iben I., Truran J.W.: 1978, *ApJ*, **220**, 980.
Keenan, P.C., Heck, A.: 1994, *Revista Mexicana de Astronomia y Astrofisics*, **29**, 103.
Kjaergaard P. et al.: 1982, *As.Ap.*, **115**, 145.
Lambert D.L., Ries L.: 1981, *ApJ*, **248**, 222.
Luck R.E: 1991, *ApJSupl*, **75**, 579.
McClure R.D., Fletcher J.M., Nemec J.M.: 1980, *ApJLett*, **238**, L35.
McWilliam A., Rich R.H., 1994: *AJSupl*, **91**, 749.
Mishenina T.V.: 1996, *As.Ap.Supl*, **116**, in press.
Mishenina T.V. et al.: 1995, *As.Ap.Supl*, **113**, 333.
Mishenina T.V., Kutsenko S.V.: 1996, *Kinematika i Fizika nebesnyh tel*, in press.
Mishenina T.V., Tsymbal V.V.: 1996, *Pis'ma Astron. Zh.*, in press.
Norris J.: *Unsolved problems of the Milky Way, ed.Blitz, P.Teuben*, 353.
Rebolo R. et al.: 1988, *As.Ap.*, **192**, 192.
Rich R.M.: 1988, *AJ*, **95**, 828.
Shetrone M. et al.: 1993, *PASP*, **105**, 337.
Spite M.: 1992, *The Stellar Populations of Galaxies*, 123.
Smith V.V. et al.: 1993, *AJ*, **417**, 287
Taylor B.J.: 1996, *AJSupl*, **102**, 105.
VandenBerg D.A.: 1992, *AJ*, **391**, 685
Zacs L.: 1994, *A&A*, **283**, 937.