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Behavior of neutron capture elements in thin and thick disks of the Galaxy

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Y, Zr, Ba, La, Ce, Nd , Sm and Eu abundances are found for 172 of FGK dwarfs belonging to thin and thick disks of the Galaxy (-1.0 <[Fe/H] < 0.3). The studied stars were observed at high resolution, high signal to noise ratio with the ELODIE echelle spectrograph at the Observatoire de Haute-Provence (France). Effective temperatures T_{eff} were estimated by the line depth ratio method and from the H_α line-wing fitting. Surface gravities log g were determined by two methods : parallaxes and ionization balance of iron. The selection of stars was made on kinematic criterion. The relative contributions of s- and r-procesess were evaluated and interpreted through theoretical computations of the chemical evolution of the Galaxy. The considered model reproduces quite well the trend of Sm and Eu with metallicity.

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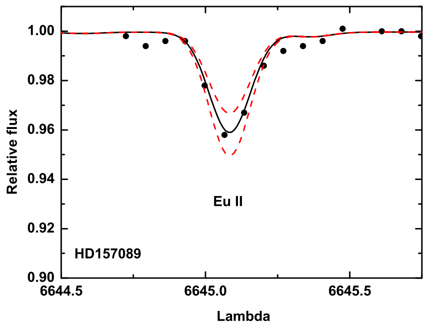

Figure 1: Comparaison of the observed and synthetic spectra for HD 157089 in the region of Eu II line at λ 6645 Å

1. Introduction

The elements following after the iron peak elements, that were formed in the processes of neutron capture, are important from the point of view of nuclear synthesis, as well as of chemical evolution of galaxies. Depending on intensity of a neutron flux two main nuclear mechanisms of their production are considered: the r-process (rapid neutron capture) and the s-process (slow neutron capture). Both these processes operate under the different conditions in objects of different masses and at various stellar lifetimes. It allows one to use the yields of these elements and their abundances to investigate the ways of formation and enrichment by these elements the Galactic substructures and the Galaxy generally.

2. Observations, selection and parameters of program stars

The spectra of 172 stars were obtained in the region of the $\lambda\lambda$ 4400-6800 ÅÅ with S/N of about 100-350 using the 1.93 m telescope at the Observatoire de Haute-Provence (France) equipped with the echelle-spectrograph ELODIE (Baranne et al.[1]) which gives a resolving power of R = 42000. The spectra were processed using software by Katz et al. [2] and Galazutdinov [3].

The selection of the stars was made using the kinematic criterion based on the probability of the star to belong to the thin, thick disk or a Hercules stream (Soubiran & Girard, [4]).

The effective temperatures $T_{\rm eff}$, the surface gravities log g , the microturbulent velocity V_t, and metallicities [Fe/H] of the studied stars were estimated earlier in our paper (Mishenina et al. [5]).

Y, Zr, La, Ce, Nd, Sm abundances are found for the program stars in LTE approximation, using the WIDH9 code and the atmosphere models by Kurucz (Kurucz [6]). Determination of the Eu abundance was made by the STARSP LTE spectral synthesis code (Tsymbal [7]) taking into account the hyperfine structure of this atom. The comparison between observed and calculated spectra for Eu II line are shown in Fig. 1.

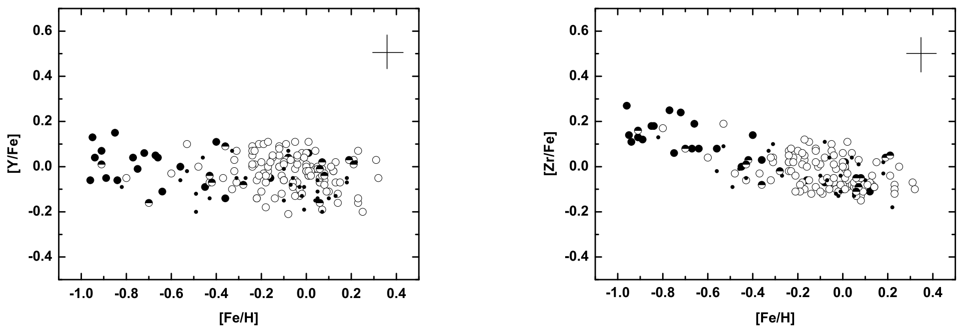

Figure 2: The trends of Y and Zr abundances with [Fe/H]

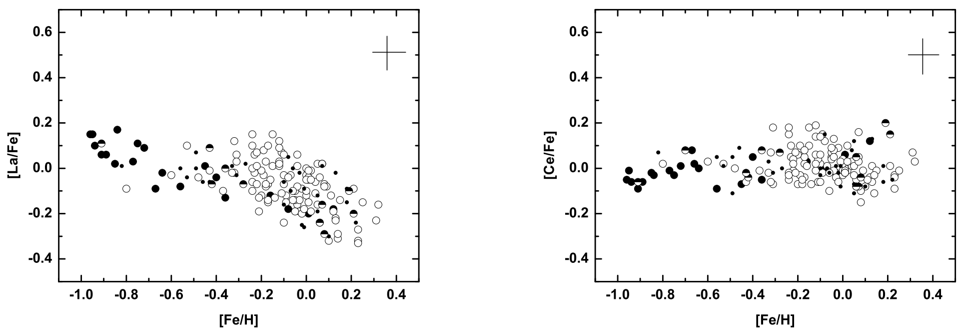

Figure 3: The trends of La and Ce abundances with [Fe/H]

3. Results and conclusions

The dependences of [El/Fe] on [Fe/H] are presented in Figs 2-5. The stars are marked by filled (thin disk) and open (thick disk) symbols, half-filled (a group of Hercules) and small black (unclassified) circles. As one can see from these figures, the behavior of the abundances of the n-capture elements with metallicity differs for various elements. Thus, the light s-process elements - Y and Zr demonstrate different trends with [Fe/H] (Fig.2,3): the dependence of [Y/Fe] on [Fe/H] is not observed, but we see an increase of Zr abundance with decreasing [Fe/H] below -0.3.

This shows that even in the case of elements with similar origin an individual approach in the study of their enrichment is needed.

[La/Fe] shows a slight and common for three substructures trend with [Fe/H]. The deficiency of La abundance at [Fe/H] > 0 is more evident for the stars of the thin disk and a group of Hercules than for the thick disk. Ce abundance behaves similarly in all substructures, there is no any trend with [Fe /H].

[Nd/Fe] at [Fe/H] <-0.3 for all substructures shows higher values than that at [Fe/H] > -0.3, and the Nd abundance increases with decreasing [Fe/H]. [Sm/Fe] demonstrates some increase of its abundance with decreasing metallicity for all substructures and the higher values for the thick disk stars.

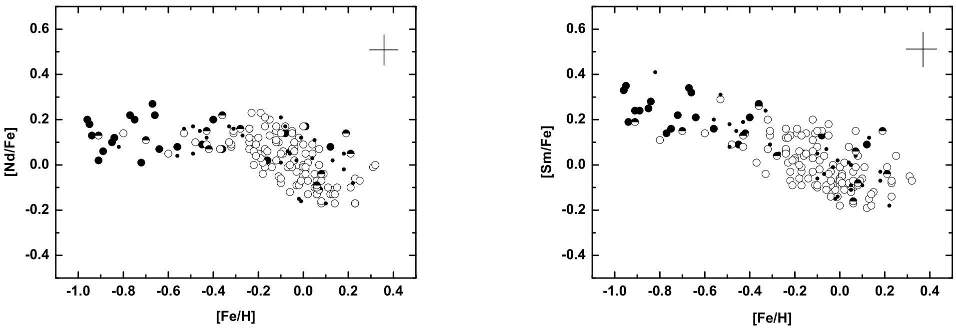

Figure 4: The trends of Nd and Sm abundances with [Fe/H]

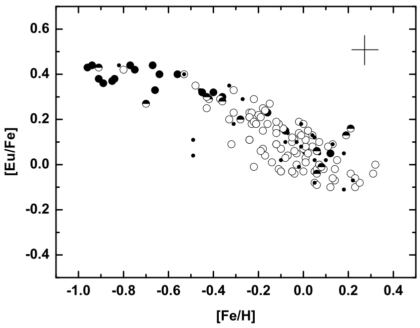

Figure 5: The trend of Eu abundance with [Fe/H]

Europium, the element formed predominantly in r-process, shows a marked trend with [Fe/H] and a slight increase of abundance for the thick disk stars.

The calculations of preliminary chemical evolution model (thick line) are shown in the metallicity ranges -4.0 <[Fe/H] < 0.0 (Fig.6) and -1.5 <[Fe/H] < 0.0 (Fig.7).

It was assumed in the model that the yields of r-nuclides are in order to reproduce their solar abundances and s-nuclides are not destroyed when going through stars. Additional observations (Frebel [8]; Francois et al. [9]) for the poor-metal stars were used. The considered model reproduces quite well the trend of Sm and Eu with [Fe/H] in the region of metallicity from -1 to 0.0.

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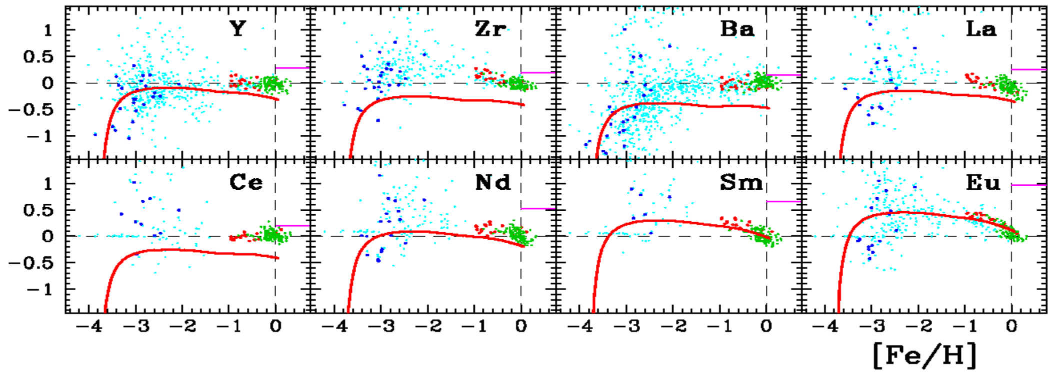

Figure 6: The calculation of chemical evolution model in the metallicity range -4.0 <[Fe/H] < 0.0

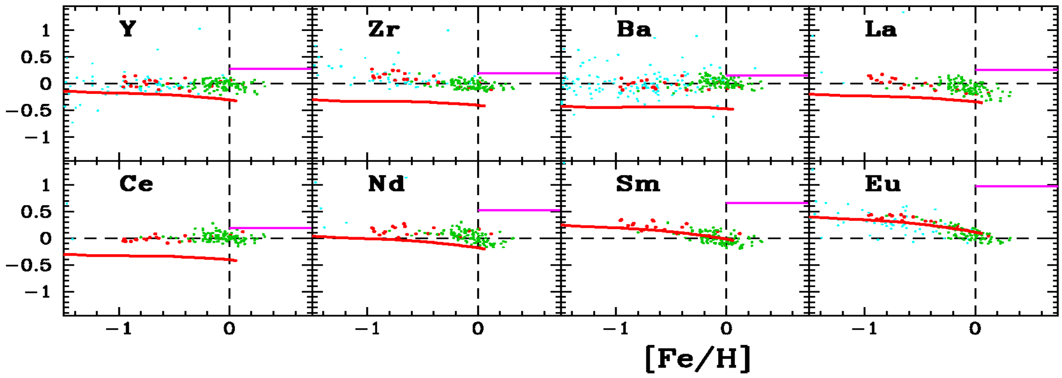

Figure 7: The calculation of chemical evolution model in the metallicity range -1.5 <[Fe/H] < 0.0

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