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Cu, Ba and Y in FGK main-sequence stars from the HARPS sample

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Abstract. It is well known that at a given [Fe/H] below solar metallicities the thick disk stars are more enhanced in their α-element abundances than the thin disk. We report prelminary results for abundances of Cu, Ba and Y in a sample of 762 stars observed with the HARPS spectrograph. Precise and homogeneous abundance analysis reveals interesting trends related to Galactic Chemical Evolution. Significant differences between the thick and thin disk populations are found for [Cu/Fe], [Y/Fe] and [Ba/Fe]. When comparing the abundance distributions in thick and thin disks, we found that Ba and Y are underabundant, while Cu is overabundant in thick disk stars at all metallicities. We found smooth and distinct abundance trends that for the thin and thick disks are clearly separated.

Key words. Stars: abundances – Stars: atmospheres – Stars: Population I – Galaxy: abundances

1. Introduction

Currently most frequently discussed formation scenario for the thick disk is an ancient merger event between the Milky Way and a companion galaxy. In this event the stellar population of the thin disk that was present at that time of the merger event was kinematically heated to the velocity distributions and dispersions that we see in today's thick disk.The thin disk stars, on average, are younger than the thick disk stars. Recently our group has performed a uniform and detailed abundance analysis of 12 refractory elements (Na, Mg, Al, Si, Ca, Ti, Cr, Ni, Co, Sc, Mn, and V) for a sample of 1111 FGK dwarf stars from the HARPS GTO planet search program (Adibekyan et al. 2012).We found that the chemically separated (based on the Mg, Si, and Ti abundances) thin- and thick disks are also chemically disjunct for Al, Sc, Co, and Ca. Some bifurcation might also exist for Na, V, Ni, and Mn, but there is no clear boundary of their [X/Fe] ratios. Abundances of heavy elements in these stars help to set contrains on different formation models. However, the nucleosynthesis mechanisms and the relative contributions of different sources by Cu, Ba and Y enrichment are still uncertain. The probable sources of enrichment by these heavy elements are different objects, such as the massive stars, low- and intermediate-mass stars, and Type Ia and Type II supernovae. These sources can contribute in different ways to enrichment by these elements for thick and thin disks. Therefore, the dependences of elemental abundances [X/Fe] vs. metallicity [Fe/H] for thin and thick disks can differ. In this article we report preliminary results of abundance ratios of these elements in a large sample of solar-type stars from the HARPS radial velocity survey.

2. Observations and analysis

Our stellar sample consists of 762 main-sequence stars with temperatures between 5200 and 6700 K. The signal-to-noise ratio of the spectra exceeds 100 in more than 90% of these stars. HARPS spectra have a resolving power 115.000. Stellar parameters were taken from our previous articles (Sousa et al. 2011a, 2011b) and the equivalent widths were measured using the ARES software (Sousa et al. 2007). Elemental abundances were derived from a model-atmosphere analysis of equivalent widths (EWs) measured in high-resolution HARPS spectra. The derived abundances are based on the following spectral lines: CuI 5218 Å, BaII 5853 and 6141 Å, YII 4883 and 5087 Å. Atomic parameters of these lines were taken from the article of Nissen and Schuster (2011). As discussed by Nissen and Schuster (2011), the splitting of the hyperfine components of these lines are less than 1 mÅ and can be safely neglected in connection with the determination of Ba, Cu and Y abundances. Profiles of spectral lines have gaussian shapes. However, we are planing to varify these statemnts in the future with more detailed calculations. The equivalent widths of these lines range from about 5 to 90 mÅin our stellar sample. The Y and Ba abundances derived from the two lines agree with a rms difference of 0.05 dex. We note that this spectral database has been used by our group to study chemical abundance trends of many α and Fe-group elements in thick/thin disk stars (Adibekyan et al. 2012).

3. Results and conclusions

In Figure 1 we show the abundance trends of Cu, Ba and Y relative to Fe and H in 762 stars from the HARPS sample. Before making these plots, we have carried out several tests to check that the abundance values of these elements are reliable (e.g. they do not depend on stellar parameters etc.). Non-LTE corrections have been neglected. The figures show that Cu/Fe is clearly enhanced in the thick disk stars and in transient objects independent on their metallicity. We have used kinematic criteria of Bensby et al. (2004) to separate thick, transient and thin disk stars. Thin and thick disk stars are clearly separated in our figures and show different trends. The trend [Cu/Fe] vs [Fe/H] is very interesting pointing on different sources of Cu in different metallicity regimes.There is seem to appear a change in a slope at [Fe/H]= -0.2. The opposite effect is observed for Ba. Note that the [Ba/Fe] ratio is smaller in the thick disk stars and transient objects compared to thin disk. Similar underabundance is found on the [Ba/H] plot. The trend of Y vs Fe/H is different from that of Ba and Cu. However, we again see a clear underabundance of Y/Fe in the thick disk stars. It is also important to stress that we observe an extension of thick/thin disk differences up to the metallicities +0.3 (like Adibekyan et al. discovered for α and many Fe-group elements).

The s-process contributions to the solar composition is for Ba 81% (Arlandini et al. 1999) and for Y 74% (Travaglio et al. 2004). In the s-process the neutron flux is low, which means that the radioactive isotopes will have time to β-decay between the neutron-captures. Possible sites for the s-process are the atmospheres of stars on the asymptotic giant branch (AGB stars). If this is the case, then the enrichment of the s-process elements to the interstellar medium probably occur on a timescale similar to elements originating in SN Ia. The thin disk [Ba/Fe] trend shows a prominent rise from the lowest [Fe/H] until reaching solar metallicities, after which it starts to decline. The [Y/Fe] trend for the thin disk is similar but shows a considerably larger scatter and not such a well-defined trend as that for [Ba/Fe]. Our re-

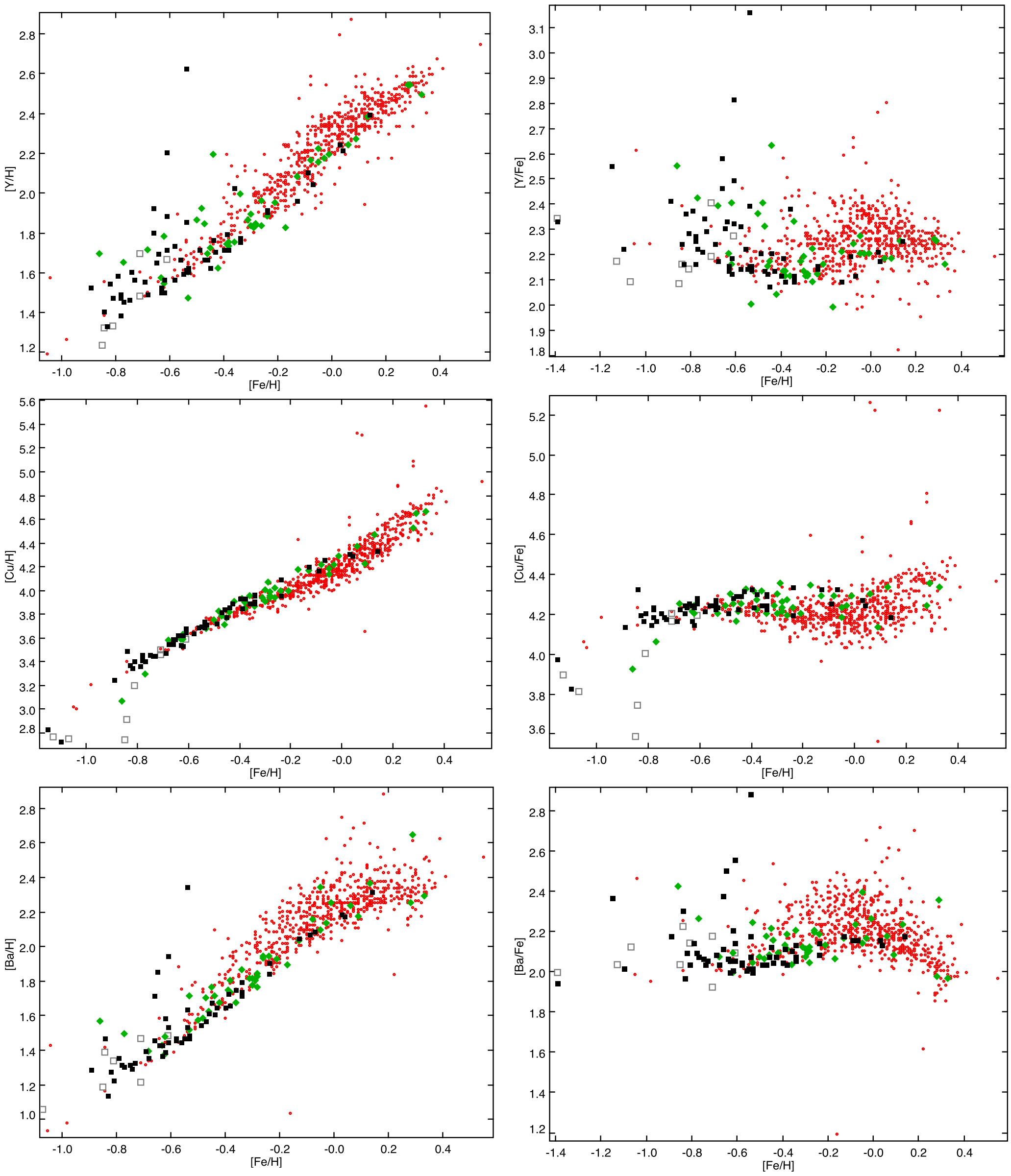

Fig. 1. [Ba/H], [Ba/Fe], [Cu/H], [Cu/Fe], [Y/H] and [Y/Fe] versus [Fe/H]. Stars belonging to the thick disk population, are marked with black filled squares, red circles are the thin disk, green filled diamonds are transient objects while gray empty squares refer to the halo stars.

sults for Ba are not very different from those obtained by Bensby et al. (2014). Our results suggest that low and intermediate mass stars were also playing an important role in building thick/thin disk kinematics. This is a work in progress and our immediate goal is not only to varify the results prsented here, but also obtain reliable abundances for S and Zn.

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[1] http://www.starlink.ac.uk/topcat/