In this work we present new observational data for hafnium (72). Hf is an important element that is between the lightest rare-earth elements (e.g., La, Z = 57) with elements of the third r-process peak (Os, Ir, Pt, Z = 76-78). Hafnium is the heaviest (Z = 72) stable element represented by low-excitation (<1.5 eV) ionized lines in the spectra of the cool stars (Lawler et al., 2007). This element is important as a stable reference element for nucleocosmochronometry, and also to study of the sources of its production and enrichment with n (neutron)-capture elements of the third r-process peak (Os, Ir, Pt, Z = 76-78). Hafnium is an important element, which is between the lightest rare-earth elements (e.g., La, Z = 57) and the heaviest (Z = 72) stable element, that is between the lightest rare-earth elements (e.g., La, Z = 57) and the heaviest (Z = 72) stable element.

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The metallicity [Fe/H] accepted as the iron abundance log g, the microturbulent velocity $V_t$, and metallicities of the studied stars were determined earlier in our paper (Mishenina et al., 2013). Effective temperatures $T_{\text{eff}}$, the surface gravities log $g$, and metallicities of the studied stars were determined earlier in our paper (Mishenina et al., 2013). Effective temperatures $T_{\text{eff}}$ were estimated by the line depth ratio method (Kovtyukh et al., 2003). Surface gravities log $g$ was determined by two methods: parallaxes and ionization balance of iron. The microturbulent velocity $V_t$ was derived considering that the iron abundance log A(Fe) obtained from the given Fe I line is not correlated with the EW of that line.

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Figure 1(a,b): Comparison of synthetic and observed spectra in the region of Hf II lines. Dotted line: observations; solid black lines marked the spectra calculated for the resulted abundances. The dashed line shows the synthetic spectra without taken into account the contribution from Hf.

Figure 2(a,b): a) Dependences of [Hf/Fe] on [Fe/H] for the stars of the thick disk (filled symbol), of the thin disk (open circle), the Hercules stream (open triangles), and unclassified stars (square), b) comparison with those of other authors.

Figure 3(a,b): Abundance comparisons of log ε(Hf/Eu) vs. [Fe/H] and [Eu/H]. The dotted lines define the range of the solar system r-process only, the dashed line is the total solar system ratio (see in details, Lawler et al. 2007) and the solid line is the mean ratio of the stars in our sample.

Figure 4(a,b): Abundance comparisons of log ε(La/Eu) vs. [Fe/H] and [Eu/H]. The notation is the same as in Fig. 3.
3. Results

We have determined the abundance of hafnium for 126 stars. As can be seen from Fig. 2a, the hafnium abundance decrease with increasing metallicity in both discs. The dependence of our Hf abundances on metallicity and their comparison with those of other authors (Lawler et al., 2007; Roederer et al., 2014) are presented in Fig. 2b. This is the typical behavior of the elements behind the iron peak, the elements formed in the processes of neutron capture.

To estimate the contribution of the s- (slow), and r- (rapid) processes to the Hf abundance, we compare La and Hf, which are predominantly an s-process element in solar system, with the element Eu (Fig. 3,4), having the prevailing contributions of the r- processes. The dotted lines define the range of the solar system r-process only values based on the published deconvolution of the solar system abundances (Simmerer et al., 2004), and the dashed line is the total solar system ratio based on the stellar value for the r-process (see in details Laweler et al., 2007).

4. Conclusions

We obtained the hafnium abundance for 126 FGK dwarfs belonging to different Galactic substructures. The behavior of Hf abundance with metallicity like as other elements of n-capture. The observed stellar abundance ratios of Hf/Eu and La/Eu are coincident with previous estimates of the solar system s-, r-processes. The comparison of Hf abundance with those of La (s-element) and Eu (r-element) support that Hf is s-element.

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