Las gigantes HE 0107−5240 i HE 0557−4840, i nuevas busquedas de estralles puebres en metales

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Abstract. We report on a new determination of the iron abundance of HE 0107−5240, based on the detection of two Fe II lines in an UV spectrum of the star, which yields $[\mathrm{Fe/H}] = -5.7$. Another interesting metal-poor star recently discovered with Hamburg/ESO Survey (HES) is HE 0557−4840. With $[\mathrm{Fe/H}] = -4.8$, it is the first star located in the “gap” in the metallicity distribution function of the galactic halo, between the two stars known at $[\mathrm{Fe/H}] < -5.0$ and the stars at $[\mathrm{Fe/H}] > -4.0$. HE 0557−4840 is carbon-enhanced (i.e., $[\mathrm{C/Fe}] = +1.7$). The abundance ratios of the heavier elements are similar to those seen in the majority of the metal-poor stars at $[\mathrm{Fe/H}] > -4.0$.

We also describe two upcoming wide-angle surveys which will be utilized for searches for metal-poor stars: The Southern Sky Survey (SSS), and a stellar survey to be conducted with the Chinese LAMOST telescope. These efforts are expected to increase the number of known extremely metal-poor stars, including stars below $[\mathrm{Fe/H}] = -5.0$, by about two orders of magnitude.

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NEWS ON HE 0107−5240

We have detected the Fe II 3227.74 Å line in a VLT/UVES spectrum of HE 0107−5240 covering the ultra-violet wavelength region. Adopting the stellar parameters of [1], and using a 1D hydrostatic MARCS model atmosphere tailored for the chemical composition of the star, the measured equivalent width of the line yields $[\mathrm{Fe/H}] = -5.7$. We have tentatively also detected the Fe II 3213.31 Å line. Its strength is consistent with the aforementioned iron abundance, as are the upper limits derived from the non-detection of further Fe II lines. This newly-derived iron abundance makes HE 0107−5240 again the record holder for the most iron-deficient star currently known, since the runner-up, HE 1327−2326, has $[\mathrm{Fe/H}] = -5.4$ [2, 3].

We note that when applying the 3D corrections of [4] to the abundances derived from Fe I and Fe II lines, the LTE abundances agree very well with each other: $[\mathrm{Fe\,I/H}]_{\mathrm{3D,LTE}} = -5.6$; $[\mathrm{Fe\,II/H}]_{\mathrm{3D,LTE}} = -5.7$. Assuming that the surface gravity of $\log g = 2.2$, which was determined from an isochrone (see [1]), is correct, this constrains the maximum 3D NLTE effect of Fe I that can be accommodated within the ionization equilibrium: given the uncertainties of the iron abundances, it can not be larger than ~ 0.3 dex.

Using the UV spectrum of HE 0107−5240 we were also able to determine the abundances of the odd-Z elements Sc and Co: $[\mathrm{Sc/Fe}]_{\mathrm{3D}} = +0.1 \pm 0.2$; $[\mathrm{Co/Fe}]_{\mathrm{3D}} = +0.5 \pm 0.2$. These abundances suggest that in HE 0107−5240, the odd-even effect of the heavy elements is weak. This is an important constraint for models of the origin of the abundance pattern of the star, for example those discussed by Nomoto et al. in this volume.

Details of the analysis of the UV spectrum of HE 0107−5240, abundances of further elements, and improved upper limits, will be published in a forthcoming paper [5].

Finally, we note that radial velocity monitoring of HE 0107−5240 is being carried out with VLT/UVES. No significant radial velocity variations have been detected during a period of ~ 6 years (see Figure 1).

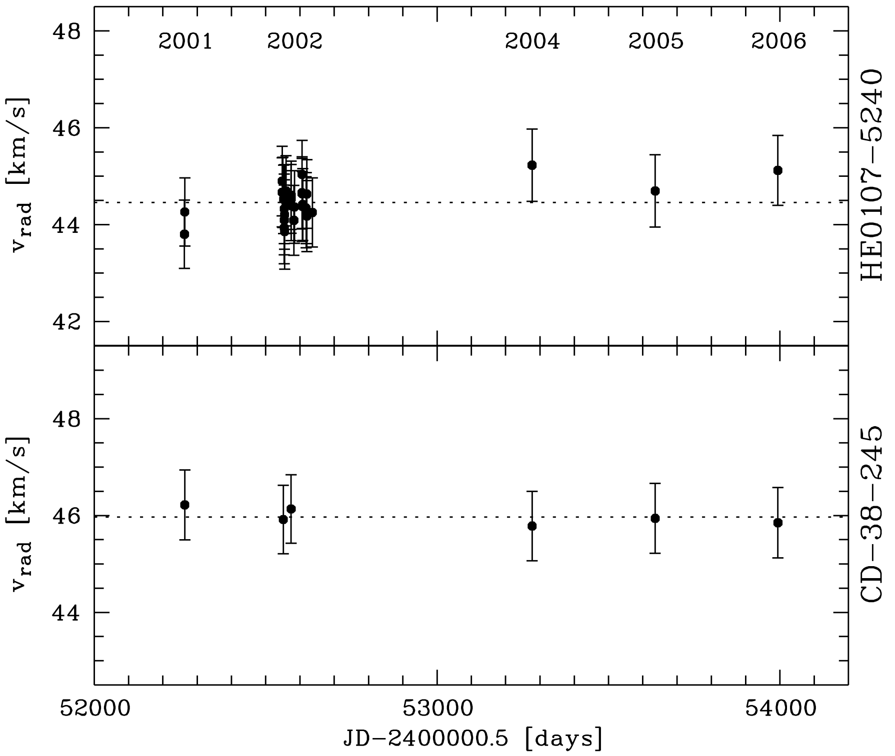

FIGURE 1. Radial velocity measurements of HE 0107−5240 and CD−38° 245. The spectra were obtained with VLT/UVES. The error bars illustrate the total error, consisting of the quadratic sum of the internal and external errors.

DISCOVERY OF THE "GAP STAR" HE 0557−4840

Until recently, no star with an iron abundance in the range $-5.2 < [\mathrm{Fe/H}] < -4.0$ was known. This "metallicity gap" presented a challenge for models of galactic chemical evolution (see e.g. [6]). Norris et al. [7] now report on the discovery of a star in the gap: The giant HE 0557−4840 has $[\mathrm{Fe/H}] = -4.8$. Its abundance pattern suggests that this star is a transition object between the stars with extreme overabundances of carbon, nitrogen and oxygen at $[\mathrm{Fe/H}] < -5.0$, and the more "normal" objects at $[\mathrm{Fe/H}] > -4.0$: While HE 0557−4840 is strongly carbon-enhanced (i.e., $[\mathrm{C/Fe}]_{\rm 1D} = +1.7$), the enhancement is about a factor of 100 lower than seen in HE 0107−5240 and HE 1327−2326. The overabundances of N and O are also considerably lower; however, so far only upper limits for the abundances of these elements in HE 0557−4840 are known. With the possible exception of Co, the abundance ratios of the heavier elements follow the trends seen in the majority of the more metal-rich stars at $[\mathrm{Fe/H}] > -4.0$. No lines of neutron-capture elements have been detected in the high-resolution spectrum of HE 0557−4840 (for abundances, upper limits, and details of the analysis, see [7]).

NEW SURVEYS FOR METAL-POOR STARS

The Southern Sky Survey

The Southern Sky Survey (SSS)[1] will be conducted with the fully automated 1.35 m SkyMapper telescope, which is currently being built at Siding Spring Observatory. The SkyMapper camera has 32 CCDs of 4 k × 2 k each. At a scale of 0.5″ per pixel, the sky coverage of a single exposure will be 2.4° × 2.4°. The short readout time of 12 s will ensure a high shutter-open efficiency.

The SSS will be a multi-colour, multi-epoch survey covering the total southern sky. Accurate, uniformally standardized photometry in the range 8–23 mag will be obtained in the *uvgriz* bands, where the *ugriz* filters are similar to those used in the Sloan Digital Sky Survey (SDSS)[2], and *v* is an additional, intermediate-band filter covering the Ca II H and K lines.

The *v* filter will allow for a much more efficient selection of candidate metal-poor stars than was possible

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[1] `http://www.mso.anu.edu.au/skymapper/`

[2] `http://www.sdss.org/`

in the SDSS. Simulations indicate that for cool giants at [Fe/H] $= -2.0$, [Fe/H] can be estimated with an accuracy of up to ~ 0.2 dex, and even at [Fe/H] $= -4.0$, the accuracy is ~ 0.7 dex for turnoff stars as well as giants (see Figure 12 of [8]). This means that it will likely be possible to reliably distinguish between stars of [Fe/H] $= -4.0$ and [Fe/H] $= -3.0$ based on the photometry alone. A more detailed description of the SSS can be found in [8].

The SkyMapper telescope has already seen First Light in the factory; First Light on the mountain is planned for late 2007.

LAMOST

The Chinese **L**arge sky **A**rea **M**ulti-**O**bject fiber **S**pectroscopic **T**elescope (LAMOST)[3] is a Chinese national key project. It is unique in combining a large aperture (4 m) and wide field of view (diameter 5°) with high multiplexity (4000 fibers, feeding 16 two-arm spectrographs). LAMOST is a reflecting Schmidt telescope. Its spectrographs can be used in two modes: a low-resolution mode, in which a resolving power of up to $R = 2000$ and a broad wavelength coverage (3700–9000 Å) will be achieved, and a medium-resolution mode with up to $R = 10,000$ and a smaller wavelength coverage (i.e., 5100–5500 Å in the blue arms and 8300–8900 Å in the red arms). The performance estimates indicate that spectra with a resolving power of $R = \lambda/\Delta\lambda = 1000$ and a signal-to-noise ratio of $S/N = 10$ can be obtained for objects of $V = 20.5$ mag in an exposure time of 1.5 hours. These capabilities make LAMOST an ideal facility to conduct a new, deeper wide-angle survey for metal-poor stars.

Due to the limited quality of the spectra obtained, previous spectroscopic wide-angle surveys for metal-poor stars, like the HK survey [9, 10] or the Hamburg/ESO Survey (HES; [11]), yielded only *candidates* for metal-poor stars, which needed to be verified by follow-up spectroscopy at a resolution of $\Delta\lambda \sim 2$ Å (for a review of metal-poor star surveys, see [12]). This observational step is the bottleneck in these surveys, since the majority of the spectra had to be obtained in single-slit mode.

Since the quality of the spectra to be acquired with LAMOST will be comparable to that of the follow-up spectra used in the HK and HE surveys, no follow-up observations will be necessary in the LAMOST survey, and the selection efficiency for stars with [Fe/H] < -3.0 is expected to be close to 100 %, while it is on the order of 5 % in the HES, and only 1 % in the HK survey. The false positives are mostly stars of higher metallicity than desired.

LAMOST has seen First Light on 29 May 2007 with one spectrograph and about a quarter of the mirror segments. The remaining mirror segments and spectrographs will be installed by the end of 2008.

Outlook on expected achievements of the new surveys

In Table 1, we list estimates of the number of stars at [Fe/H] < -3.0 and [Fe/H] < -5.0 expected to be found in the future surveys for metal-poor stars discussed in the previous sections, and SEGUE (Beers et al., this volume). The estimates are based on an extrapolation of the number of such stars found in the HES.

The extrapolations are at best accurate to within a factor of two, since the performance of the involved telescopes is not yet known precisely, and for the LAMOST survey it is unclear how much time will be allocated to the metal-poor star project, so that the sky coverage might be considerably lower. Furthermore, it has not been taken into account that the space density of halo stars decreases with increasing galactocentric distance, so that an extrapolation of the space density of extremely metal-poor stars found in the HES to deeper surveys, reaching larger galactocentric distances, yields systematically too high numbers. Another issue that has been neglected in the estimates is crowding at low galactic latitudes, which might reduce the effective sky coverage. However, the purpose here is just to give order-of-magnitude estimates of the number of stars to be found, and it is expected that the number of known extremely metal-poor stars, including stars at $[\mathrm{Fe}/\mathrm{H}] < -5.0$, will be increased by about a factor of ~ 100 within the next few years.

The considerable increase in survey volume will also yield strong constraints on the existence of stars at even lower metallicities; i.e., at $[\mathrm{Fe}/\mathrm{H}] < -6.0$. If the metallicity distribution function of the galactic halo has a tail which continues to $[\mathrm{Fe}/\mathrm{H}] < -6.0$, or even has a peak at $[\mathrm{Fe}/\mathrm{H}] < -7.0$, as indicated by the stochastic chemical enrichment models of Karlsson [14], chances are good that such stars will be found in the SSS and LAMOST, and perhaps even with SEGUE.

While the brighter stars can be studied in detail with 8 m-class telescopes and currently-available instruments, high-resolution spectroscopy of the faintest stars to be identified in the new survey might have to await more efficient instruments and/or 30 m-class telescopes.

The input catalog for the LAMOST survey will be compiled from the SDSS photometric catalogues by just selecting stars in the effective temperature range appro-

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[3] `http://www.lamost.org/`

TABLE 1. Numbers of stars at [Fe/H] < -3.0 and [Fe/H] < -5.0 identified in the HES so far, and estimates of numbers of such stars to be found in new surveys for metal-poor stars. These estimates were obtained by multiplying the HES numbers by the increase in effective survey volume with respect to the HES. The number of stars to be found in SEGUE will mainly be limited by number of fibers allocated for metal-poor star follow-up. Only about 10 % of all candidates down to $B = 19$ can be observed. For the SSS, it has been assumed that the spectroscopic follow-up observations, which will be done with the SSO 2.3 m telescope and the WiFes spectrograph [13], will reach $B = 18.5$ mag. Note that in the SSS we will specifically target the most metal-poor stars, while no metallicity selection will be done in the LAMOST survey. Therefore, the LAMOST survey will yield more stars at $[\mathrm{Fe/H}] > -5.0$ than the SSS effort.

Survey	**Eff. sky coverage**	**Eff. mag. limit**	$N < -3.0$	$N < -5.0$
HES	6400 deg^2	$B < 16.5$ mag	200	2
SEGUE	1000 deg^2	$B < 19.0$ mag	1000	10
SSS	20,000 deg^2	$B < 18.5$ mag	3000	100
LAMOST	10,000 deg^2	$B < 19.0$ mag	10,000	100

priate for metal-poor stars (i.e., $4000\,\mathrm{K} < T_{\mathrm{eff}} < 6800\,\mathrm{K}$); i.e., no metallicity selection will be applied. This will make it possible to use the survey data for statistical studies, like determination of the metallicity distribution function of the galactic halo, or characterization of the populations of the Galaxy, i.e., thick disk, inner halo, and outer halo (see paper of Beers et al. in this volume for the properties of the inner and outer halo; see also [15]).

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