The Hobby-Eberly Telescope Chemical Abundances of Stars in the Halo CASH Project I. Observations of the First Year

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Abstract. We present preliminary results obtained from the first year of observations of a new, long-term project of the University of Texas, the Hobby-Eberly Telescope Chemical Abundances of Stars in the Halo (CASH) Project.

1. Scientific Goals

The story of early Galactic nucleosynthesis is written in the chemical compositions of metal-poor halo stars. The abundances in these stars reflect only a few chemical enrichment events and hence, this fossil record can be used to trace the chemical and dynamical evolution of the early Galaxy. While the individual abundances of most metals in these stars will remain unchanged throughout the stellar lifetime, close examination is necessary to discern exceptions to this rule.

We have recently started the Chemical Abundance of Stars in the Halo (CASH) Project with the Hobby-Eberly-Telescope (HET) located at McDonald Observatory. The project aims to characterize the chemical composition of the Galactic halo through abundance analyses of large numbers of metal-poor stars. Our goal is to build up the largest high-resolution database available for these objects over several years. The CASH Project has among its primary goals the identification of large numbers of metal-poor stars that are 1. α-element rich (and -poor), 2. carbon-rich, with and without accompanying s-process overabundances, or 3. highly r-process-enhanced. For the first time, the absolute frequencies of abundance anomalies based on statistically significant samples of metal-poor stars will be obtained. Such information is required for an improvement in our understanding of the nature and interplay of the nucleosynthetic processes, and to help in identifying their astrophysical sites in the early Galaxy.

The second major scientific question we seek to investigate is the recent the claim by Carollo et al. (2007) that there is a chemical difference between the so-

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called “inner” and “outer” halo populations. By means of chemical analyses of large numbers of stars associated with both populations we are able to trace the chemical evolution of the Galactic halo. This, in turn, will lead to an improved understanding of Galaxy formation.

2. Target Selection

We have access to several sources of yet unstudied northern-hemisphere targets that have (or will be acquired during the course of this project) preliminary low resolution \((R \sim 2,000)\) spectroscopic data: Re-processed HK-I survey (Beers et al. in prep.) and HK-II survey (Rhee 2001) Bright Hamburg/ESO survey (Frebel et al. 2006) SDSS and SEGUE surveys

An effort has been made over the course of the past few years to obtain low-resolution spectroscopic confirmation of their metal-poor status using 2-4 m telescopes at the McDonald Observatory and elsewhere. The HK-II candidates and northern bright targets from the Hamburg/ESO survey are of particular interest for our proposed work, as they range in brightness from \(B = 12 – 15\).

3. Observing and Data Analysis Strategy

Our new comprehensive, multi-year, survey aims at obtaining moderately high-resolution spectroscopic data of \(\sim 1000\) very metal-poor stars \([\text{Fe/H}] < -2.0\) discovered during the course of previous low-resolution spectroscopic searches, but not yet observed at high spectral resolution. We can meet our intended S/N for HK-II stars with total integration times from 10 to 30 minutes. Over 100 such candidates are immediately available that are observable from the HET. Further targets will be identified in winter 2007 using the 2.1m telescope at McDonald Observatory (West Texas) and the 2.3 m at Siding Spring Observatory (Australia). In total, we plan to target a sample of \(\sim 1000\) such stars with \([\text{Fe/H}] < -2.0\) and \(4500 < T_{\text{eff}} < 7000\) K, over a period of several years, in order to obtain “snapshot” \((R \sim 15,000, S/N \sim 30 – 50)\) spectra with the HRS on HET. This will be the largest high-resolution database for halo objects.

The REDUCE (Piskunov & Valenti 2002) pipeline has been tailored to our HRS setup. The data obtained in the first year (as of Sep. 2007) are reduced, and stellar parameters were obtained. The reduction was validated with an independent IRAF reduction. We are in the process of obtaining abundances other than Fe for our detailed chemical abundance analyses.

4. Results from the First Year

During the first year (as of Sep 2007), we have obtained data for the anticipated \(\sim 200\) objects per year. We have found \(\sim 60\) stars with \([\text{Fe/H}] < -2.5\) of which 6 have \([\text{Fe/H}] < -3\). Among the data taken in UT07-01, we have found a very particular object - a Li self-enriched red giant with s+us process enhancement (Frebel et al. 2008). An abundance analysis based on newly obtained HET/CASH data was carried out for three bright stars from the Hamburg/ESO survey with \([\text{Fe/H}] \sim -2.9\) (Davies et al. 2008).
5. Outlook

The CASH project will represent the largest high-resolution survey of metal-poor halo stars ever conducted, and thus will be one of the “legacy results” of the Hobby-Eberly Telescope. We expect that this survey will provide the fundamental spectroscopic database capable of resolving numerous fundamental questions concerning the origin of elements in the first generations of stars.

More details and further results will be posted on our new project website http://www.as.utexas.edu/cash.html

Acknowledgments. Based on observations that were obtained with the Hobby-Eberly Telescope. The HET is named in honor of its principal benefactors, William P. Hobby and Robert E. Eberly. A. F. acknowledges support through the W. J. McDonald Fellowship of the McDonald Observatory. Funding for this project has also been generously provided by the US NSF (grants AST 06-07708 to C. S. and AST 07-07447 to JJC). T. C. B. acknowledges funding
Figure 2. Preliminary stellar parameters for \( \sim 180 \) stars out of the \( \sim 220 \) observed objects. These stars have been observed in one or several nights, and the stellar parameters determined for the observations of several nights agree well (small or no error bars indicate agreement between different nights of observations). For the remaining stars, we are in the process of combining the data before the stellar parameters are determined, to achieve the minimum \( S/N \) necessary for the parameter determination. Right panel: Hertzsprung-Russell-Diagram of our first year sample. As can be seen we cover a large parameter space with our targets.

from grants AST 04-06784, AST 07-07776 as well as PHY 02-15783; Physics Frontiers Centers/ JINA: Joint Institute for Nuclear Astrophysics, awarded by the US NSF.

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