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The Ideal Stars for Exploration of Early-Epoch ^{7}Li Abundances

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Abstract.

We discuss estimates of stellar temperature, and the assemblage of a "critical set" of target low-metallicity stars, from the HK Survey of Beers and collaborators, that can be used in the near future to put additional strong constraints on models for lithium production in the early Galaxy, and for inference of its primordial value.

1. Introduction

Among the light elements produced in the Big Bang lithium plays a unique role, in the sense that its primordial value can be inferred from examination of the surface chemical composition of the most metal-poor stars in the Galaxy. Recent observations (e.g., Ryan, Norris & Beers 1999) have shown that a sample of 22 halo main-sequence stars with [Fe/H] ≤ -2.3 exhibits an extremely small intrinsic dispersion (essentially zero) in their Li abundances, *after* taking into account the presence of a significant slope in the A(Li) vs. [Fe/H] relation on the order of 0.12 ($\pm$ 0.02) dex per dex. The tiny intrinsic dispersion puts tight constraints on allowed surface-depletion mechanisms which may have been in operation, and these authors infer a primordial abundance of A(Li_p)= 2.09 dex, with systematic uncertainties up to 0.1 dex (see also Ryan this volume). Further exploration of this problem requires suitable stellar targets of extremely low metal abundance. We discuss the selection of such a sample.

2. Observational Requirements, the Calibration Sample, and Temperature Estimates

Stellar Li abundance is derived via a model-dependent abundance analysis, which relies in turn on accurate estimates of the physical parameters of the stars under consideration. Ryan et al. (1999) argue that errors in $T_{\rm eff}$ represent the largest contributions to the remaining uncertainties which must be addressed in order to improve estimates of the primordial lithium abundance. Although it has been suggested that stellar temperatures obtained from appli-

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cation of the Infrared Flux Method (IRFM; Alonso, Arribas, & Martinez-Roger 1996) should exhibit a minimum *systematic* error in estimates of stellar temperatures, individual *random* errors remain rather high, on the order of 100-150 K. Alternative approaches, such as the analysis of observed color indices which Ryan et al. employed, suffer from unknown (and potentially large) systematic errors, and leave open the possibility of errors due to reddening corrections in their determination. Thus, we have explored a alternative method for temperature estimation which makes use of an index, $HP2$, obtained from an "band-switched" pseudo-equivalent-width measurement of the Balmer line Hδ from 1-2 Å resolution spectroscopy (see Beers et al. 1999 for more details). This index is reddening free, and for the main-sequence turnoff stars which provide the best Li abundance estimates, it is insensitive to small differences in stellar surface gravity.

The sample of Beers et al. (1999) includes 104 dwarfs with [Fe/H] ≤ -2.0 and with medium-resolution spectra having S/N (at Hδ) $>$ 20/1, and with available estimates of surface temperatures in the range $4500 < T_{\rm eff} < 7000$ K based on the IRFM. We have explored two sets of regression models: (a) a quadratic model, which does not require dependence on stellar metallicity, and (b) a piecewise-linear model, where a small dependence on [Fe/H] is required for those stars with $HP2 < 2$ Å (the cooler ones). Model (b) is superior for the higher temperatures of importance for Li abundance estimation. For the stars in our sample with $T_{\rm eff} \geq 6000$ K, the estimated scatter of the regression results indicates that temperatures on the IRFM scale can be inferred with a random error of 75–100 K, which represents a significant improvement. Beers et al. (2000) discuss these issues in more detail.

Application of Model (b) to the large sample of stars from HK Survey follow-up of Beers and collaborators identifies 80 stars with [Fe/H] ≤ -2.5 (including 10 stars with [Fe/H] < -3.0) and with estimated temperatures in the range considered by Ryan et al. (1999) ($6100 \leq T_{\rm eff} \leq 6300$ K). These stars should prove to be excellent targets for obtaining refined constraints on A(Li$_p$), once high-S/N, high-resolution analyses of their Li abundances are carried out with present-generation 8m telescopes such as VLT, SUBARU, and (soon) GEMINI.

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