Calibration of the SDSS/SEGUE Spectroscopic Pipeline

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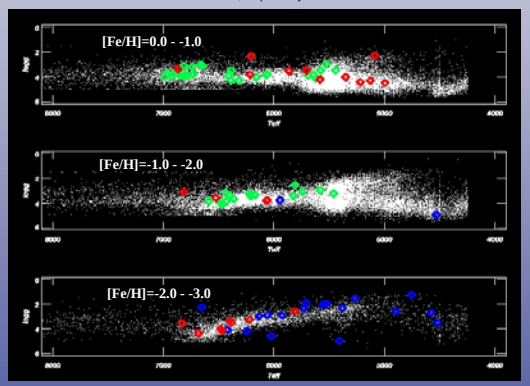
We describe an ongoing effort to validate the estimated atmospheric parameters (Teff, log g, [Fe/H]) obtained from SDSS spectroscopy (R = 2000) and *ugriz* photometry, which are being employed for both the previous SDSS-I and the ongoing SEGUE surveys. The spectroscopic pipeline makes use of a number of methods for the estimation of each parameter, with estimated internal errors on the order of σ (Teff) = 150 K, σ (log g) = 0.4 dex, and σ ([Fe/H]) = 0.2-0.3 dex. However, several of these methods rely on an uncertain transformation of *g-r* colors to *B-V* colors, and there does not presently exist an external validation of the derived parameters based on high-resolution spectroscopy. In order to address these deficiencies, we have generated two new grids of synthetic spectra and *ugriz* colors (based on both Kurucz NEWODF models with no convective overshoot and MARCS OS models) for stellar atmospheric parameters covering the ranges 3500 K ≤ Teff ≤ 10000 K, 0.0 ≤ log g ≤ 5.0, and -5.0 ≤ [Fe/H] ≤ 0.0. These two grids will provide a useful internal check on the dependence of the derived parameters on the adopted stellar models. In addition to these grids, we have also generated a carbon-enriched sub-grid, covering the entire parameter space for various values of carbon enhancement ([C/Fe] = +0.5,+1.0,+1.5,+2.0). This sub-grid makes use of carbon-enhanced MARCS models instead of scaled solar models, since the atmospheric structures themselves can be altered by enhanced carbon, especially at cooler temperatures. The synthetic colors will be calibrated using a selection of standard stars and open and globular cluster stars covering a wide range of stellar atmospheric parameters. We have already obtained a small number of the high-resolution spectra for SDSS stars needed to calibrate the spectroscopic pipeline; much larger samples of high-resolution data are presently being acquired. Preliminary comparisons of the estimated atmospheric parameters based on the SDSS/SEGUE spectroscopic pipeline with those derived from the high-resolution spectra are reported here.

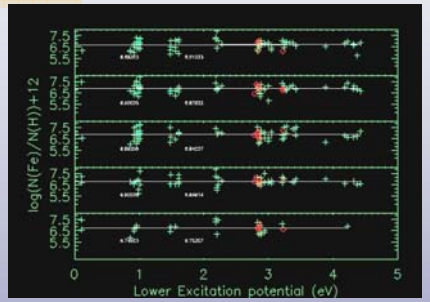
Observations: The high-resolution spectra were obtained with different telescopes and spectrographs, with different spectral resolution. The table below indicates the source of the data, and the instrumental setup and specifications. The sample stars for calibration were chosen to encompass the parameter space covered by SEGUE.

Telescope	Instrument	Resolving Power	λ Coverage (Å)	Stars
Keck-I	HIRES	40000	3800-10000	24
Keck-II	ESI	6000	3800-10000	27
HET	HRS	15000	4400-8000	47
Subaru	HDS	45000	3000-5800	5

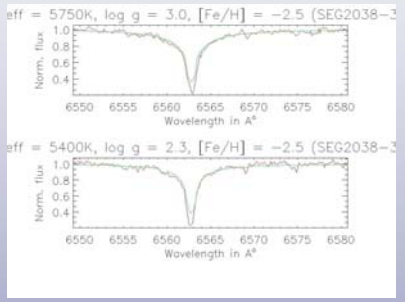
The figure below shows the parameter space of the present high resolution observations. The white dots are the SEGUE observations. The green, red and blues points are HET, KECK-HIRES and KECK-ESI observations, respectively.



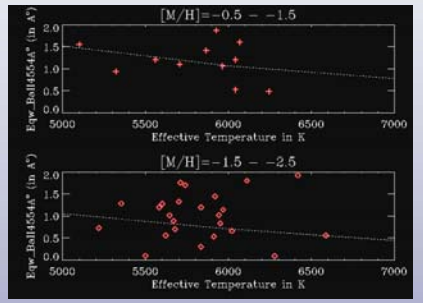
Analysis: For the high-resolution analysis we used Kurucz NEWODF models (Castelli and Kurucz) and MARCS models (Plez). We used both Fe lines and the fitting of hydrogen-line wings for estimation of stellar temperatures. We used the turbospectrum code for the spectrum synthesis and line analysis. The code takes into account line scattering also, as this opacity is important for the bluer regions. Hydrogen-line profiles used the prescription given by Barklem. The atomic data is mostly from the VALD database, while molecular data for CH, CN,CaH, TiO, and ZrO are as compiled by Plez. Other molecules, such as CN, C_2, and MgH are taken from the Kurucz database.



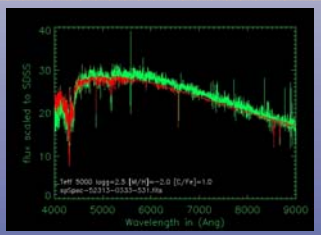
The figure above shows an example of Teff estimation based on the excitation equilibrium of FeI Lines and ionisation equilibrium of FeI and FeII lines for log g determination.



The figure above shows spectra taken with the Hobby- Eberly Telescope (HET) with the HRS instrument, shown in red. The best-fitting model is shown as green.

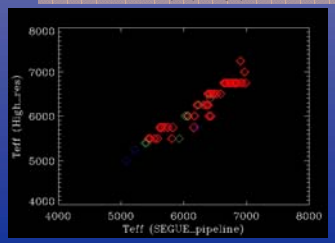


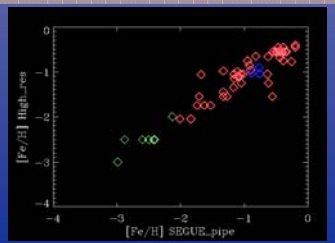
Above is a plot of the BaII 4554 line equivalent width measured from the line index derived by the SEGUE pipeline. The lines indicate the equivalent widths expected for solar-scaled Ba abundance from the models.

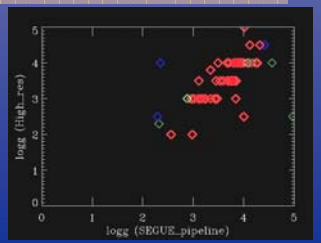


An example of spectrum synthesis. The green line is an SDSS spectrum and the red line is the synthetic spectrum. The CH G band allow us to also estimate the carbon abundance.

Comparison of stellar parameters estimated from the SEGUE spectroscopic pipeline with those from high-resolution analysis . The different colors indicate high-resolution observations from the different telescope/spectrograph combinations.







Summary and future work:

This is ongoing work – more high-resolution data is coming soon, covering a wider range of stellar parameters. This will be one of the largest homogeneously-analyzed datasets of "standard stars", which will form a library of use for future spectroscopic surveys due to its faint limiting magnitude (g ~ 16). Approximate external errors in the present SEGUE pipeline parameters, obtained from comparison with the high-resolution analysis, are:

σ (Teff) ~ 100-150 K, σ (log g) ~ 0.4 dex , σ ([Fe/H]) ~ 0.2-0.3 dex.

Apart from stellar parameters, the SEGUE value added catalog that we will produce also provides abundances (or limits) for a number of additional elements (e.g., C, N, Na, Mg, Ca, Sr, Ba) .

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