Publications of the Korean Astronomical Society
30: 279 ∼ 281, 2015 September

pISSN: 1225-1534
eISSN: 2287-6936
http://dx.doi.org/10.5303/PKAS.2015.30.2.279

ACCURACY OF LAMOST DR1 STELLAR PARAMETERS

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(Received November 30, 2014; Reviced May 31, 2015; Aaccepted June 30, 2015)

ABSTRACT

We adopt the PASTEL catalog combined with SIMBAD radial velocities as a testing standard to validate the stellar parameters (effective temperature $T_{\rm eff}$, surface gravity $\log g$, metallicity [Fe/H] and radial velocity $V_{\rm r}$) from the first data release (DR1) of The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) survey. After applying data reduction and temperature constraints to the sample obtained by cross-identification, we compare the stellar parameters from DR1 and PASTEL. The results show that the DR1 results are reliable under certain conditions. We derive a dispersion of 110 K, 0.19 dex, 0.11 dex and 4.91 $\rm km\,s^{-1}$ in specified effective temperature ranges, for $T_{\rm eff}$, $\log g$, [Fe/H] and $V_{\rm r}$ respectively. Systematic errors are negligible except for those of $V_{\rm r}$. In addition, for stars with PASTEL [Fe/H] < -1.5, the metallicities in DR1 are systematically higher than those in PASTEL.

Key words: stars: fundamental parameters — astronomical data bases: catalogs — astronomical data bases: surveys

1. INTRODUCTION

LAMOST, also called the Guoshoujing Telescope, is a special quasi-meridian reflecting Schmidt telescope located in the Xinglong Station of National Astronomical Observatories, Chinese Academy of Sciences (Cui et al., 2012). The Milky Way provides us a unique example to study formation and evolution of a galaxy in detail. LAMOST has both a large aperture and a wide field of view, benefiting from its special design, which makes it a powerful tool for this subject (Zhao et al., 2012; Deng et al., 2012).

The DR1 of the LAMOST survey consists of 2,204,860 spectra of stars, quasars, galaxies and some other unknown objects. To extract stellar parameters from such a large number of spectra, an automated stellar parameter pipeline — ULySS was developed (Wu et al., 2011). There are 1,944,406 spectra of stars in DR1 catalogs; 1,085,404 of them yield a full set of stellar atmospheric parameters and radial velocities due to quality control.

Before the stellar parameters are used in research work, their reliablity should be investigated. The PASTEL catalog is a catalog of high quality stellar atmospheric parameters with original bibliographies (Soubiran et al., 2010). We cross-identify the PASTEL catalog and the DR1 catalogs to provide a sample for comparison. During the comparison, we take the PASTEL parameters and SIMBAD radial velocities as "ground truth".

2. CROSS-IDENTIFICATION AND THE SAMPLE FOR VALIDATION

The PASTEL catalog is regularly updated. The version of which we make use is 17-May-2013, consisting of 52,045 entries for 26,657 individual stars. We expand the search radius to 10 arcsec to avoid missing bright stars with positional offsets in the DR1 catalogs. Then we exclude false results according to photometric data and images from the SIMBAD database and obtain a sample of 422 individual stars.

With this sample we perform a test comparison and select some potential outliers for inspection. We remove results from spectra (eg. low S/N, weird continuum shape), risky cross-identifications and a few errors in the PASTEL catalog. That enables us to investigate how hot stars affect our comparison results. We group multiple measurements from DR1 into different effective temperature bins: $T_{\rm eff} < 8000\,{\rm K}$, $8000\,{\rm K} \le T_{\rm eff} < 10000\,{\rm K}$ and $T_{\rm eff} \ge 10000\,{\rm K}$. We find that DR1 stellar atmospheric parameters for stars hotter than 8000 K show a great deviation from PASTEL results (see Figure 1). But $V_{\rm r}$ measurements in the $8000\,{\rm K} \le T_{\rm eff} < 10000\,{\rm K}$ bin still show moderate accuracy compared with the

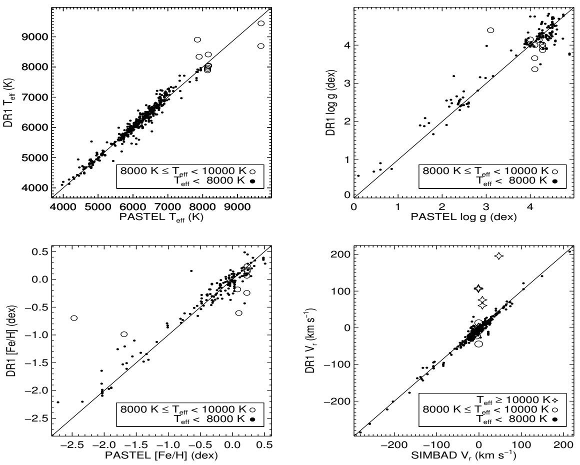

Figure 1. Comparison of stellar parameters from DR1 and PASTEL in different temperature bins. Filled circles indicate measurements in the $T_{\rm eff} < 8000\,$K bin, open circles represent measurements in the $8000\,{\rm K} \leq T_{\rm eff} < 10000\,$K bin and open stars are measurements in the $T_{\rm eff} \geq 10000\,$K bin.

SIMBAD $V_{\rm r}$. Finally, we confine our sample to an effective temperature range $T_{\rm eff} < 8000\,$K for stellar atmospheric parameters, and another effective temperature range $T_{\rm eff} < 10000\,$K for $V_{\rm r}$.

3. COMPARISON OF STELLAR PARAMETERS

After applying problematic data reduction and reasonable constraints to the sample, we derive a clean and well-established sample of 306 stars for $T_{\rm eff}$ comparison, 121 stars for $\log g$, 121 stars for [Fe/H] and 277 stars for $V_{\rm r}$. Figure 2 shows the comparison results with systematic errors and dispersions derived from Gaussian fits.

Obvious systematic errors of stellar parameters are negligible except for those of $V_{\rm r}$. Since $V_{\rm r}$ values in the SIMBAD database are collected from different literature sources, biases in the different measurements should have canceled out; a systematic error of $-3.78\,{\rm km\,s^{-1}}$ should be taken into account when $V_{\rm r}$ is being used. We noticed that DR1 metallicities of metal-poor stars are systematically higher than metallicities obtained by high resolution spectral analysis. Results from DR7 of the Sloan Digital Sky Survey (SDSS) also show similar behavior due to lack of corresponding calibrators (Xu et al., 2013). Lee et al. (2008) showed that in the effective temperature range $4500\,{\rm K} \leq T_{\rm eff} \leq 7500\,$K, the precisions of stellar atmospheric parameters derived by the Sloan Extension for Galactic Exploration and Understanding Stellar Parameter Pipeline are comparable with DR1 dispersion, based on comparison with results from high resolution spectra. These similarities are not surprising as both SDSS and LAMOST are medium-resolution spectroscopy surveys, and in addition the technique used to derive the stellar parameters share some similarities.

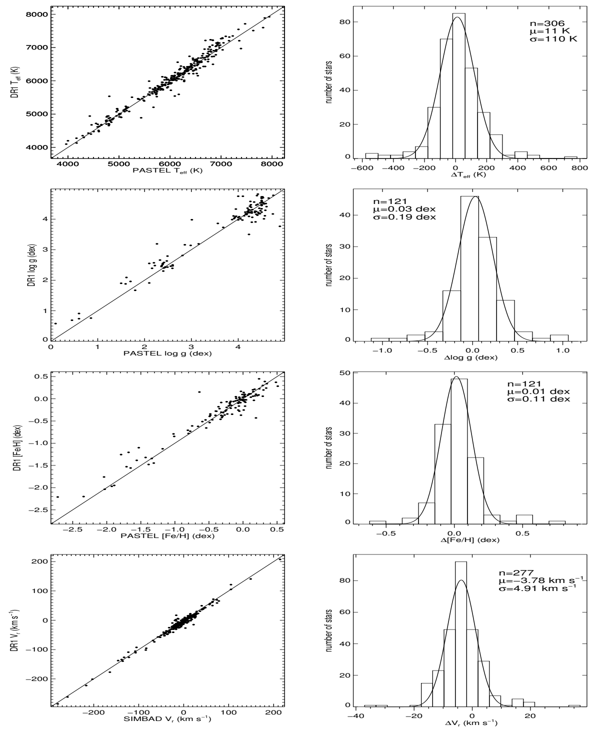

Figure 2. Comparison of stellar parameters from DR1 and PASTEL combined with SIMBAD database for individual stars in the clean sample. Offset of stellar parameters is defined by $\triangle P = P_{\rm DR1} - P_{\rm PASTEL}$, where P is one of the four stellar parameters. In the four panels of the right column, n is number of stars, μ and σ is mean and standard deviation of the Gaussian fit, respectively.

ACKNOWLEDGMENTS

This work was supported by the National Key Basic Research Program of China (NKBRP) 2014CB845700. This work was also supported by National Natural Science Foundation of China (Grant No. 11473001 and 11233004). Guoshoujing Telescope (the Large Sky Area Multi-Object Fiber Spectroscopic Telescope LAMOST) is a National Major Scientific Project built by the Chinese Academy of Sciences. Funding for the project has been provided by the National Development and Reform Commission. LAMOST is operated and managed by the National Astronomical Observatories, Chinese Academy of Sciences. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

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