3rd International Workshop on Spectral Stellar Libraries
ASI Conference Series, 2017, Vol. 14, pp 93–98
Editors: P. Coelho, L. Martins & E. Griffin

Data processing status of the LAMOST

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Received July 1st, 2017 ; accepted Oct 15th, 2017

Abstract. The Large sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) has been carrying out its regular five years survey mission since September 2012, and will finish in June 2017. The novel design of LAMOST is successfully yielding a huge spectroscopic database. The LAMOST Data Release 4 (DR4) was published internally at the end of 2016, and will be internationally accessible from July 2018. The DR4 comprises a total of 3,459 plates including 7,664,073 spectra. Among those, nearly 90% are stellar objects, the others being spectra of galaxies and QSOs. Along with the spectroscopic data in FITS format, DR4 also provides several catalogues which contain general information, stellar parameters, etc. This paper introduces briefly the status and progress of the LAMOST DR4, including its survey strategy, data processing and analysis pipeline, the data products and future developments.

Keywords : techniques: spectroscopic, surveys, methods: data analysis

1. Introduction

LAMOST[1] is a ground-based optical reflective Schmidt telescope located at the Xinglong Observatory in Hebei province of China. The 4000 multi-fibre design in conjunction with a 4-meter aperture and 5° field of view (Cui et al. 2012) enables the observation of tens of thousands of celestial objects in one night. LAMOST can observe spectra covering a large area of the accessible northern celestial sphere, and

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[1] http://www.lamost.org/

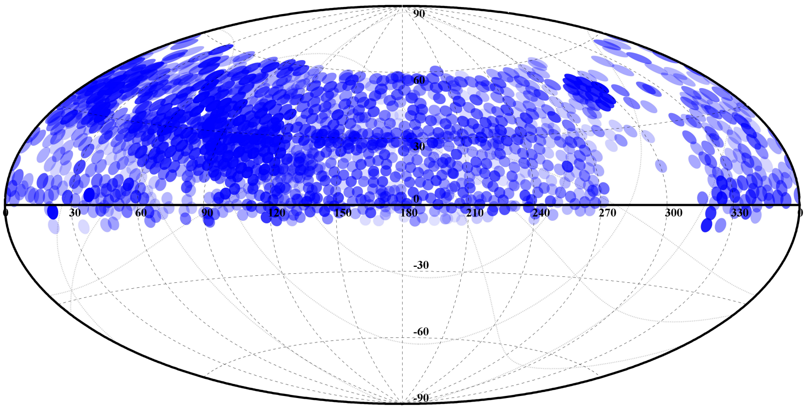

Figure 1: Sky cover of LAMOST DR4. Fields observed in duplicate are in a darker colour.

will acquire about 9 million spectra of various kinds of objects during its regular survey. Both the LAMOST Experiment for Galactic Understanding and Exploration (LEGUE) and the LAMOST ExtraGAlactic Survey (LEGAS) were carried out in survey mode (Zhao et al. 2012, Deng et al. 2012, Liu et al. 2014).

2. Survey strategy

The Survey Strategy System (SSS) that was developed can effectively customise the target plates for each exposure. The designed plates have four magnitude levels: V plates (for magnitude 9 – 14), B plates (magnitude 14 – 16.8), M plates (magnitudes 16.8 – 17.8) and F plates (magnitude 17.8 – 18.5). The plates are classified according to the science backgrounds: Halo and Disc (HD), extra galactic (EG), Galactic Anti Centre (GAC), M31 and Kepler (KP).

The primary aim of the survey in the first five years was to obtain an even sky coverage between -10° $\leq \delta \leq$60°. Within each plate, extra galactic sources (QSOs, galaxies etc.) are given the highest priority, and stellar objects with rare colour also have higher priority than the rest. By considering various allocation restrictions and using optimisation methods (Yuan et al. 2014), each plate can present about 2800~3500 objects. Fig. 1 illustrates the sky coverage of the plates in DR4.

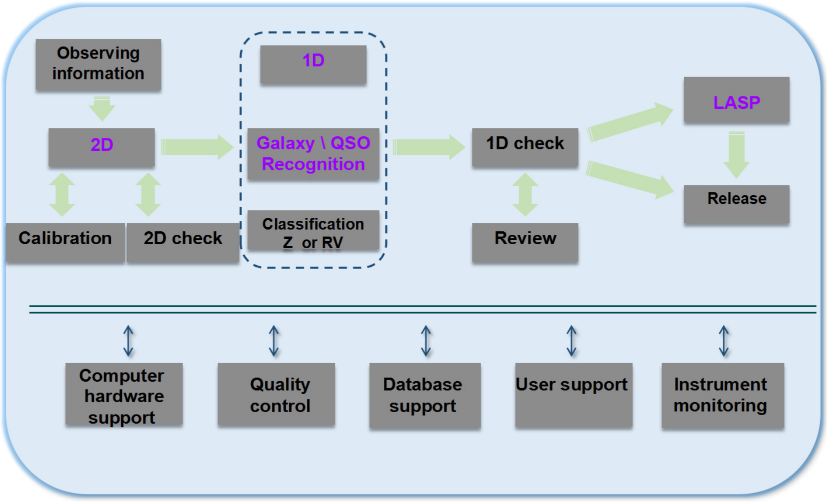

Figure 2: The LAMOST data processing framework.

3. Data processing and analysis pipeline

The LAMOST data processing and analysis pipeline (Luo et al. 2015) is integrated with four main modules: 2D , 1D, Galaxy & QSO Recognition, and LASP. The workflow and framework are demonstrated in Fig. 2.

The 2D pipeline extracts spectra from raw CCD images, considering dark and bias subtraction, flat-field correction, spectral extraction, sky subtraction, wavelength calibration, combining repeated exposures, and the stitching of two bands (Bai et al. in preparation).

The 1D pipeline, which is based on a cross-correlation method, includes object classification (STAR, GALAXY, QSO or Unknown), redshift estimations for galaxies and QSOs, initial radial-velocity (RV) measurements for stars, plus a spectral visualisation interface, database management, a data release system and a data quality controlling package.

The LAMOST galaxy and QSO spectral recognition and redshift measurement module (Zhang et al. 2017) was created by using a method based on the detection and measurement of spectral lines. If the 1D pipeline's identification and measurement results have low confidence, the corresponding observed spectra will be assigned to this module. The final results are only released after manual checks.

The LAMOST Stellar Parameter Pipeline - LASP (Wu et al. 2011a, 2014, Sec. 4.4 of Luo et al. 2015) was developed for deriving stellar atmospheric parameters automatically: effective temperature ($T_{\rm eff}$), surface gravity ($\log g$), metallicity ([Fe/H]),

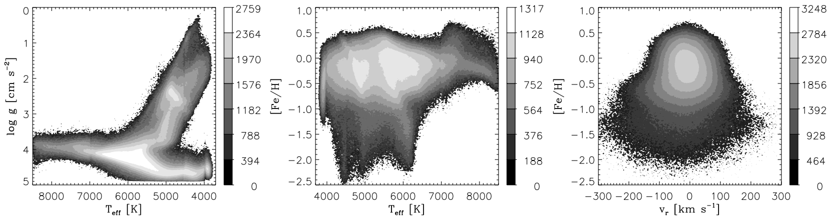

Figure 3: The contour distributions of the stellar parameters determined by LASP. The plots include parameters deduced from 4,339,831 stellar spectra in DR4.

and radial velocity (RV). LASP employs two methods consecutively. The Initial Correlation Function (CFI) method (Du et al. 2012) first gives a set of coarse estimations. Then, taking the CFI results as starting guesses and combining the 1D pipeline 'final subclass' information, we use ULySS (Universite de Lyon Spectroscopic analysis Software, Koleva et al. 2009, Wu et al. 2011b) to determine the parameters simultaneously by minimising the χ^2 between the observed and the model spectra by full spectral fitting. The model spectrum is computed by an interpolator (Wu et al, 2011b) based on the empirical ELODIE stellar library (Prugniel & Soubiran 2001, 2007). Fig. 3 shows the distribution of stellar parameters in LAMOST DR4. The accuracies achieved for RV, $T_{\rm eff}$, log g and [Fe/H] are 5 km/s, 140 K, 0.22 dex, 0.12 dex respectively.

4. Data products

LAMOST DR4 contains observations obtained between October 24, 2011 and June 2, 2016, totalling 7,664,073 spectra of different objects. Among those data 6,856,896 are stars, and 6,082,059 of them have SNR ≥10. The number of Galaxy, QSO and Unknown are 118,657, 36,374 and 652,146, respectively. The spectra cover 3800–9200 Å with a resolving power of R∼1800. Starting from DR4, we will also release the background sky data for users.

Besides the spectral data, DR4 supplies 5 catalogues of spectroscopic parameters: a general catalogue (7,664,073 entries), one of A-type stars, giving several Balmer line indices and spectral line widths (365,119 entries), one listing stellar parameters from LASP for late-A and FGK stars (4,339,831 entries, and the largest of its kind in the world), an M-type star catalogue, listing spectral indices and magnetic activity flags (436,782 entries), and one giving the exposure information (3,459 entries). LAMOST DR4 can be accessed at `http://dr4.lamost.org`.

5. Conclusion and prospect

The first 5 years of the regular LAMOST survey was completed in June 2017, and will produce about 9 million spectra with large sky coverage and depth. It therefore opens up a possibility to survey a significant volume of the Milky Way spectroscopically, in particular the disk. Together with GAIA[2] data, the huge, unique LAMOST dataset will especially broaden the scientific study of stellar astrophysics and the characterisations of the Galaxy such as stellar populations, chemical composition, kinematics and structure of the thin/thick disk and the halo, probing the gravitational potential and the distribution of the dark matter, and will support the search for rare objects, etc.

After the first 5 years of its regular survey, LAMOST committee plans to start the second 5 years of regular survey, starting in September 2018. Besides the low resolution (R$\sim$1800) mode, during the bright moon nights the mode will be switched to R$\sim$8000, covering 4960–5350Å in blue and 6300-6800 Å in the red. LAMOST will effectively improve our understanding of the assembling and evolutionary history of the Milky Way with more various evolutionary stages from the stars it observes.

Acknowledgements

The authors acknowledge grants (Nos. 11403056, 11403046, 11403059, 11503054) from NSFC, the joint astronomical fund from NSFC and CAS (No.U1531242). Y. WU also acknowledges assistance from the fund supported by the Guangdong Provincial Engineering Technology Research Centre for Data Science and the Young Researcher Grant of National Astronomical Observatories, Chinese Academy of Sciences. The Guoshoujing Telescope (the Large Sky Area Multi-Object Fibre Spectroscopic Telescope LAMOST) is a National Major Scientific Project built by the Chinese Academy of Sciences; funding for it was provided by the National Development and Reform Commission. LAMOST is operated and managed by the National Astronomical Observatories, Chinese Academy of Sciences. Participation of the first author in this conference was made possible with FAPESP project 2016/13479-0.

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[2] `http://sci.esa.int/gaia/`

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