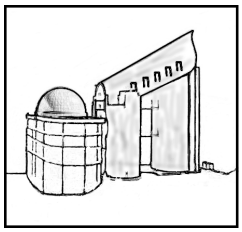

2nd LAMOST–KEPLER WORKSHOP

"LAMOST in the era of large spectroscopic surveys"

ABSTRACTS

INVITED REVIEWS

IR_01 **Current status of the LAMOST Survey Strategy System and the 2D pipeline**

by **Haotong Zhang (China)**, Hailong Yuan, Zhongrui Bai, Guangwei Li, Yajuan Lei, Yiqiao Dong

I will review the current status of the LAMOST Survey Strategy System and the 2D data reduction pipeline.

IR_02 **The LAMOST observations (update)**

by **Jianrong Shi (China)**

I will introduce the observations of the LAMOST survey, the magnitudes and the exposure times of the VB, V, B, M and F plates. I also presents some test observations for the medium resolution spectra and the future medium resolution survey.

IR_03 **The LAMOST data reduction and release (update)**
by **Ali Luo (China)**

In this talk, a review of the current status of the data reduction pipeline of LAMOST and an overview of the updates to the 2D and 1D reduction procedures and the LAMOST stellar parameter pipeline (LASP) will be given. The different versions of the data releases will be compared, the access to the data introduced and the details of the data quality will be presented. Stellar parameters are measured for 5 millions stars during the first phase of the LAMOST survey. Based on this large database, we performed a detailed statistical study regarding the instrumental stability and intrinsic errors. Through machine learning and with the information from multi-wavelength bands, we have discovered some interesting outliers in the large stellar parameter data base.

IR_04 **The LAMOST compared to future large spectroscopic surveys: application to studies of the Milky Way**
by **Sofia Feltzing (Sweden)**

The Milky Way was for a long time regarded as a relatively well-understood and almost static entity with fixed stellar populations. However, starting in around 1990, we have found that the Milky Way stellar structure is very diverse and indeed very dynamic. The European Hipparcos satellite clearly showed how intricately the stars move in the solar neighbourhood. With Gaia's first full data release coming in 2018, we are sitting on the brink of a revolution in Milky Way studies. However, Gaia on its own is not enough for understanding the nature of the stars or their full 3D movements. For that we need stellar spectra to characterize the stars and to obtain the radial velocities. This can be done from ground-based observations. LAMOST is a major spectroscopic survey encompassing most stellar components of the Milky Way. In this talk I will contrast LAMOST with future large spectroscopic surveys and discuss how the data from these surveys can be combined with Gaia data to deepen our understanding of the Milky Way as a galaxy. I will in particular compare with 4MOST, WEAVE and DESI.

IR_05 The LAMOST as ground-based support facility for space missions
by **Jianning Fu (China)**, Peter De Cat & Martin Smith

In the era of space missions such as *Kepler* and K2, which can provide extremely high duty-cycle, high-precision time-series photometric observations for a large number of stars in multiple stellar populations, ground-based spectroscopic observations are needed to characterize hundreds of thousands of stars in a homogeneous way, to support the research of exoplanets, asteroseismology, Galactic archaeology, etc. In 2010, we initiated the LAMOST-*Kepler* project which aimed at collecting low-resolution spectra for as many objects from the KIC10 catalogue as possible with LAMOST. Since the end of 2015, a number of K2 fields have been observed with LAMOST. In the presentation, I shall introduce the updated progress of the observations of the two projects, summarize the existing scientific work based on the data provided by this project, and discuss the prospects of using LAMOST for the stars in the fields of future missions such as TESS and PLATO.

IR_06 The scientific impact of the LAMOST on stellar astronomy
by **Joanna Molenda-Żakowicz (Poland)**

Since several years, the LAMOST instrument keeps providing us with detailed knowledge about various astrophysical objects. The extra-galactic part of the LAMOST survey allows us to get understanding about the large-scale structure of the Universe. The stellar part of the LAMOST survey provides information about stars in the Milky Way and the nearby galaxies, allowing us to study the structure and evolution of our Galaxy. In this talk, I will focus on the influence of LAMOST on our knowledge and understanding of the properties of stars treated as individual objects as well as of stars which are representative for different samples. Among those, I will discuss stars belonging to globular and open clusters, stars located in selected areas of the sky (e.g. the *Kepler* and the K2 fields of view), the metal-poor stars, the hyper-velocity stars, and the stars showing pulsations of different types.

IR_07 **The scientific impact of the LAMOST on exoplanet research**
by **Ji-Wei Xie (China)** & Subo Dong

With the discoveries of thousands of planets, the *Kepler* mission has brought revolutions to the exoplanet research field, which is advancing from studying individual exoplanets to characterizing planet populations. However, making any reliable statistical inference with a large *Kepler* planet sample is seriously limited by the lack of accurate stellar parameters for the majority of the targets. With 4000 fibers and 5 degrees of diameter field of view, the LAMOST is uniquely positioned to perform a systematic spectroscopic survey of *Kepler* target stars. The LAMOST-*Kepler* survey provides a complete and unbiased sample to perform statistical inference on planet distribution and correlations with host properties, which provides new insights on planet formation and evolution. This talk will review several such statistical studies, showing the impact of LAMOST on the study of *Kepler* planets. In the future, LAMOST will continue to play such a crucial role in the TESS era.

IR_08 **The scientific impact of the LAMOST regular surveys**
by **Yongheng Zhao (China)**

The regular survey of LAMOST began in September 2012 and will end in June 2017 after the completion of 5 observation seasons. In the first regular survey, the projects of the LAMOST Experiment for Galactic Understanding and Exploration (LEGUE) and the LAMOST Extra-GAlactic Survey (LEGAS) have obtained many scientific achievements. The LEGUE project yields a unique data set of more than 6 million stellar spectra and allows one to study the stellar populations, chemical composition, kinematics and structure of the disk and the halo, the gravitational potential and dark matter distribution, the interstellar dust extinction, rare objects (e.g. extremely metal-poor or hyper-velocity stars), and ultimately advance our understanding of the assemblage of the Milky Way and other galaxies and the origin of the regularity and diversity of their properties.

IR_09 **The future plan of the LAMOST**

by **Chao Liu (China)**, Jianrong Shi, Jianning Fu & Bo Zhang

The LAMOST spectroscopic survey has operated for 5 years and will be end this year. From 2018, the next 5-year plan, the LAMOST-II survey will be started. This talk will be separated into two parts. Firstly, I will highlight some progresses based on the current LAMOST survey data. In particular, I will talk about the current works on the stellar parameter estimations. Two approaches are used for estimation of the stellar parameters: The Cannon and SLAM. The Cannon uses the LAMOST spectra with APOGEE stellar parameters as the training dataset. It can successfully derive alpha-elements, carbon, and nitrogen abundances as well as the effective temperature, surface gravity, and metallicity for the late type giant stars. As an upgrading method, SLAM uses a machine-learning non-linear forward model to replace the oversampled quadratic model in The Cannon. This allows SLAM to be used in a broader parameter space, not only for giant, but also for dwarf stars. The performance of the two methods are quite similar, namely, reach a precision of about 0.04 dex for the alpha, carbon, and nitrogen abundances. I will also show some interesting tests on estimating the primary stellar parameters for binary stars with SLAM. This method will be used to derived elemental abundances from the intermediate resolution spectra in the LAMOST-II survey. In the second part, I will introduce the specific plan of the LAMOST-II survey, which is not simply the extension of the current survey, but it includes some new things, such as the time-domain survey and the intermediate-resolution spectroscopic survey. I will talk about the details of the new intermediate-resolution spectrograph and also some scientific goals.

INVITED TALKS

IT_01 Analysis of the stellar parameters measured with the LASP code based on low-resolution data

by **Anbing Ren (China)**, Jianning Fu, Peter De Cat, Yue Wu, Xiaohu Yang, Jianrong Shi, Ali Luo, Haotong Zhang, Subo Dong, Ruyuan Zhang, Yong Zhang, Yonghui Hou, Yuefei Wang, Zihuang Cao & Bing Du

All of the 14 subfields of the *Kepler* field have been observed at least once with the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST, Xinglong Observatory, China) during the 2012-2014 observation seasons. There are 88,628 reduced spectra with a signal-to-noise ratio in *g* band SNR$g \geq 6$ in the database of the LAMOST-*Kepler* project (LK-project). By adopting the upgraded version of the LAMOST Stellar Parameter pipeline (LASP), we have determined the atmospheric parameters (Teff, log*g*, and [Fe/H]) and the heliocentric radial velocity for 51,406 stars with 61,226 spectra. Compared with atmospheric parameters derived from both high-resolution spectroscopy and the asteroseismology method for stars in common with Huber et al. (2014), an external calibration of LASP atmospheric parameters was made, leading to the determination of external errors for the giants and dwarfs, respectively. Multiple spectroscopic observations for the same objects were used to estimate the internal uncertainties of the atmospheric parameters as a function of SNR*g* with the unbiased estimation method. The LASP atmospheric parameters were calibrated based on both the external and internal uncertainties for the giants and dwarfs, respectively. A general statistical analysis of the stellar parameters leads to the discovery of 106 candidate metal-poor stars, 9 candidate very metal-poor stars, and 18 candidate high-velocity stars. Fitting formulae were obtained segmentally for both the calibrated atmospheric parameters of the LK-project and the KIC parameters with the common stars. The calibrated atmospheric parameters and radial velocities of the LK-project will be useful for studying stars in the *Kepler* field.

IT_02 Activity indicators and stellar parameters of LAMOST-*Kepler* targets

by **Antonio Frasca (Italy)**

We present the results of the analysis of LAMOST spectra in the *Kepler* field with the ROTFIT pipeline. The application of our code to these spectra has allowed us to perform an MK spectral classification and to derive the atmospheric stellar parameters (Teff, log*g*, and [Fe/H]). Moreover, we have also measured the radial velocity of the targets and provide an estimate of the projected rotational velocity for the very rapid rotators in the analyzed sample. The use of low-activity real-star spectra with a negligible rotational broadening as templates has allowed us to detect H-alpha emission also when it is only filling the line core. This emission arises from chromospheres or circumstellar environments, depending on the targeted sources. We have also used the CaII infrared triplet lines as diagnostics of chromospheres or accretion with the same analysis technique. The atmospheric parameters and activity diagnostics for such a large star sample are of fundamental importance for several lines of research. The main results of our work, focusing on the advantages and drawbacks of our technique applied to the LAMOST low-resolution spectra, and our future perspectives will be discussed.

IT_03 **Science with the LAMOST-*Kepler* spectra based on an analysis with the MKCLASS code**

by **Richard O. Gray** & **Chris Corbally (USA)**

We have reported the accurate two-dimensional spectral classifications obtained with the expert code, MKCLASS, for the first set of *Kepler* region spectra from LAMOST (Gray et al. 2016). Here we update how these classifications have been used since for science. In particular, we note how they have led to four confirmed lambda Bootis-type stars with pulsation in both p- and g-modes. These have excellent potential in helping solve the lambda-Bootis star enigma. We also give preliminary analysis of the additional 97,641 LAMOST-Kepler spectra observed in 2015.

IT_04 **LAMOST stellar parameters from the LSSPP - A sample of K Giants in the Halo**

by **Timothy Beers (USA)** & Young Sun Lee

I report on the derivation of stellar parameters for stars in LAMOST DR3, based on application of a custom version of the pipeline software used for analysis of medium-resolution spectra from the Sloan Digital Sky Survey, the LSSPP. A comparison is made with parameters obtained by the default LAMOST pipeline approach. Our techniques are used to refine estimates of parameters for a sample of some 5000 LAMOST K giants, which are employed to search for evidence of a metallicity gradient in the outer-halo population of the Galaxy.

IT_05 Analysis of the stellar parameters based on the LAMOST-K2 project data

by **Ruyuan Zhang (China)** & Jianning Fu

Massive photometric data of different parts of the galaxy were obtained by covering 16 campaigns around the eclipse through K2, the second phase of the *Kepler* mission. Unlike the *Kepler* space telescope, K2 mainly focuses on the data of more bright stars. Applying the ground based survey, it is way more competent to observe those bright stars. LAMOST, a very influential ground based facility, initiated the "LAMOST-K2" project at the end of 2015. Due to the fact that LAMOST is located at the northern hemisphere, only 8 K2 fields can be observed by it. By analyzing the statistics of the LAMOST stellar parameters, some special targets in the LAMOST-K2 field are found: around 65 samples of those have high radial velocity (vrad > 300 km/s), 2061 stars were identified as metal poor candidates ([Fe/H]<-1 dex) and 138 stars were recognized as very metal poor candidates ([Fe/H]<-2 dex). Among more than 10 K2 fields, campaign one, which lies in the northern galactic cap, never observed high precision photometric data and spectra before. Calibration of the input catalog of K2 has been done by combining the large surface data obtained from the asterseimic method with data of the LAMOST atmospheric parameters. Finally, by using the stellar parameters and the location in the Hertzsprung-Russel diagram, classification of the red giants in the field of the first campaign of K2 is also done in this work.

IT_06 Active stars in the *Kepler* field of view

by **Yuta Notsu (Japan)**, Christoffer Karoff, Hiroyuki Maehara, Satoshi Honda, Shota Notsu, Kosuke Namekata, Kai Ikuta, Daisaku Nagami & Kazunari Shibata

Superflares are flares that release a total energy 10-10^4 times larger than that of the biggest solar flares with energies of ~10^{32} erg. Recent *Kepler* observations found more than 1000 superflares on a few hundred solar-type stars (e.g., Maehara+2012 Nature). Such superflare stars show quasi-periodic brightness variations with periods from one to a few tens of days. Rotation period and starspot coverage can be estimated from these brightness variations (Notsu+2013 ApJ). These values are used for discussing detailed properties such as the relation between spot size and flare frequency (Maehara+2017 PASJ), but spectroscopic observations are needed in order to know to what extent estimated values of rotation period and spot sizes are right. Using LAMOST-*Kepler* Survey spectra, Karoff et al. (2016, Nature Communications) measured the intensity of CaII H&K lines of 5,648 solar-type stars, including 48 superflare stars. The results suggest that there is a good correlation between starspot coverage (from *Kepler*) and CaII intensities, and, in particular, superflare stars (including slowly-rotating stars) are generally characterized by larger chromospheric emissions than other stars. We are now comparing activity measurements using Ca II H&K lines with measurements using other chromospheric lines in LAMOST spectra (especially the CaII 8542 line). We have also conducted high-dispersion spectroscopic observations of more than 50 superflare stars by using grand-based telescopes like Subaru 8.2m (Notsu+2015a&b PASJ). Similar correlations between starspot coverage and chromosheric emissions can be seen, and we can say that the results from LAMOST (lower resolution but large number of samples) are consistent with those from high-dispersion spectroscopic observations. In this talk, we first briefly summarize statistical study results of superflares from *Kepler* data, and then overview our spectroscopic studies mentioned above.

IT_07 Exploring the early evolution of the Milky Way with LAMOST
by **Haining Li (China)**

Surveys of very metal-poor (VMP) stars and follow-up spectroscopic studies for them in the past decade have provided abundant information on the nature of the first stars and the early chemical evolution of the Milky Way. LAMOST will soon accomplish its first 5-year spectroscopic survey and has already observed over 6 million Galactic stars. Such a huge database will provide an unprecedented chance to enlarge the currently limited VMP star sample. In 2013, we started to obtain follow-up high-resolution spectroscopy for candidate VMP stars selected from the LAMOST database. So far, the project has obtained a success rate of >90% in searching for VMP stars, resulting in chemical abundances for about 230 VMP stars including more than 70 EMP stars and a number of chemically interesting objects such as: (1) Three UMP (ultra metal-poor) stars with [Fe/H] ~ -4.0. One of them is the second UMP turnoff star with Li detection. (2) A dozen Li-rich VMP/EMP stars, including six super Li-rich (A(Li) > +3) stars. They distribute in a wide range of evolutionary stages and metallicities (-3.1 < [Fe/H] < -1.7). (3) Other peculiar VMP/EMP stars including r-process enhanced stars, etc. The follow-up project has also observed a number of member stars of halo moving groups and low-alpha abundance halo stars, which would shed light on the merging history of our Galaxy. Statistics of the large sample of VMP stars, together with abundance patterns of these peculiar objects, will be of great interest and importance to probe the early Galaxy and low-mass star evolution with very low metallicities.

IT_08 Exoplanet populations as a function of stellar properties
by **Gijs D. Mulders (USA)**, Antonio Frasca & Joanna Molenda-Żakowicz

Exoplanets around different type of stars provide a window into the diverse environments in which planets form. The mass and metallicity of exoplanet host stars reflect the conditions in the protoplanetary disks where these planets once formed. The relation between exoplanet populations and their host stars provide strong constraints on the planet formation process. Giant planets occur more frequent around more massive and more metal-rich stars, as predicted by the core-accretion scenario for giant planet formation. Sub-Neptunes, those found in abundance with *Kepler*, occur around stars with a wide range of metallicities and, curiously, occur more frequently around low-mass M dwarfs than around solar-mass stars, challenging current paradigms in planet formation theory. I will indicate areas where the LAMOST-*Kepler* project can continue to contribute to characterizing trends between exoplanets and their host stars, in particular in understanding how the population of the smallest exoplanets depends on stellar metallicity.

IT_09 The merging history of the Milky Way as seen by LAMOST
by **Jeffrey L. Carlin (USA)**

Although the majority of stars observed by LAMOST are brighter than 17th magnitude, the spectroscopic stellar parameters can be used to select more than 10,000 red giant stars in the Milky Way halo from among the more numerous foreground dwarfs. In this talk, I will discuss some efforts to use LAMOST-selected distant RGB stars to probe the merging history of the Galaxy via tidal debris in the halo. I will detail results from our method to statistically detect stellar excess structures (which we call “SHARDS”, or Stellar Halo Accretion-Related Debris Structures). This technique uses correlations in velocity-distance phase space, accounting for the LAMOST selection function, to statistically identify stellar excesses relative to a smooth underlying model of Galactic populations. We find that at least 10% of the Milky Way halo stars from LAMOST are part of SHARDS, and that the LAMOST data contain excess substructure over all Galactocentric radii less than 40 kpc, beyond what is expected due to statistical fluctuations and incomplete sampling of a smooth halo. The level of substructure is consistent with the fraction of stars in SHARDS from model halos created entirely from accreted satellites. I will also discuss insights into the nature of the Sagittarius tidal stream gleaned from late-type giants observed by LAMOST, as well as perturbations in the Galactic disk that may be signatures of the effects of dwarf galaxies merging with the Milky Way. Finally, I will speculate about future avenues toward characterizing known tidal substructures via their LAMOST detections, and extending the statistical characterization of SHARDS in the Galactic stellar halo to include velocities and stellar metallicities (and possibly alpha abundances) as additional signatures of the merging history of our Galaxy.

IT_10 Workshop summary with some thoughts on the future expectations
by **Marc Pinsonneault (USA)**

CONTRIBUTED TALKS

CT_01 Ages and distances for LAMOST stars with Gaia parallaxes

by **Alexey Mints (Germany)** & Saskia Hekker

In an effort to unify the spectroscopic data of different surveys for Galactic archaeology purposes we developed and made public our Unified tool for Distance, Age and Mass estimation (UniDAM). This tool is based on a Bayesian method to compute probability density functions of distance modulus, log(age) and mass using spectroscopic parameters (effective temperature, surface gravity and metallicity), infrared photometry (2MASS and AllWISE) and PARSEC isochrones. Here we present the result from UniDAM with Gaia parallaxes incorporated consistently. For over 100,000 LAMOST stars we have Gaia-TGAS parallaxes that we can use to improve distance modulus and log(age) estimates. The use of parallaxes allows us to improve our age and distance estimates substantially - by about 30% in log(age) and about 50% in distance modulus. We also show that further improvements can be expected from further Gaia data releases, bringing log(age) uncertainties to about 0.1 dex and distance modulus uncertainties down to 0.01 mag. We show that for the most distant stars in LAMOST, spectrophotometric estimates of distance modulus will have higher precision even than those from end-of-mission Gaia parallaxes.

CT_02 Low-metallicity pulsating stars in the LAMOST DR1

by **Filiz Kahraman Alicavus (Turkey)**

In this study, the results of low-metallicity pulsating stars' research are presented. The stars were selected from the LAMOST DR1 catalogue considering the ranges of [6500:8600] K, [3.6:4.8] dex, and [-2.4:-0.5] dex of effective temperature Teff, surface gravity log*g*, and metallicity [Fe/H], respectively. Photometric data of the selected stars were taken from WASP. The stars showing light variation were determined and the frequency analysis was performed. The spectral types, Teff, and projected rotational velocities *v*sin*i* of the stars were derived. Additionally, the proper motions of the stars were obtained to check whether the stars belong to the thick disc or halo. As a result of the research, five confirmed, two candidate RR Lyrae stars, and three candidate SX Phe stars were found.

CT_03 **OAN-SPM spectroscopic observations of a number of stars in the *Kepler* field: Comparison with LAMOST database**

by **Lester Fox-Machado (Mexico)**

We present low and medium resolution spectroscopy of a number of stars in the *Kepler* field of view obtained in the past few years during several runs at the Observatorio Astronomico Nacional-San Pedro Martir (OAN-SPM) in Baja California, Mexico. The Boller & Chivens spectrograph installed in the Cassegrain focus of the 2.12-m telescope has been used. The atmospheric parameters of the stars have been computed using the iSpec tool for the analysis of stellar spectra (Blanco-Cuaresma et al. 2014). A comparison between derived physical parameters and those listed in the LAMOST public database will be presented.

CT_04 **Asteroseismic analysis of selected high amplitude δ Scuti candidates in the *Kepler* field**

by **Ceren Ulusoy (Turkey)** & Burak Ulaş

We present preliminary results on the analysis of the *Kepler* light curve of selected high amplitude δ Scuti (HADS) candidates. Initially, Kepler data are used to derive frequency content of the variability of the stars. Then, the frequency analysis has been performed for each star using the software package SigSpeC (Reegen, 2007). The period ratios for the modes of highest amplitude are therefore discussed in the Petersen Diagram (Petersen, 1973).

CT_05 Studies of close binary systems triggered by the LAMOST-*Kepler* survey
by **Giovanni Catanzaro (Italy)**

The *Kepler* four-years space mission and its K2 extension provide photometric time series with unprecedented accuracy. Given the relevance of these data, the introduction of large databases, as homogeneous as possible, collecting important astrophysical parameters such as temperature, gravity and metallicity became necessary. The LAMOST-*Kepler* project, based on LAMOST spectroscopy of *Kepler* targets, aims at providing the atmospheric parameters and other basic data for thousands of stars, which fall in the field of view of the *Kepler* telescope. In the framework of LAMOST-*Kepler* project, a recent paper by Frasca et al. (2016) focused on the determination of activity indicators, atmospheric parameters, radial and rotational velocities with the code ROTFIT for a sample of about 60000 stars in the *Kepler* field that were observed with LAMOST from 2011 to 2014. In that paper, a comparison with data from the literature for a few hundred targets allowed the authors to assess the accuracy of the parameters and to identify objects with discrepant values. We know the importance of binary systems as benchmark for a lot of studies in astrophysics, for the determination of masses or as laboratory for evolutionary studies, just to quote some. From the sample of radial velocities by Frasca et al. (2016), two stars (KIC5219533 =HD226766; KIC7599132 = HD180757) have been extracted and observed more carefully with the CAOS spectrograph attached to the 0.91-m telescope at Serra La Nave (Sicily, Italy). The preliminary results of these studies are the subject of this talk.

CT_06 Compact pulsators and δ Scuti stars with the LAMOST data
by **Weikai Zong (China)**, Jianning Fu & Jie Su

The LAMOST survey provides more than seven million spectra of stars which brings key information of basic parameters for those targets, building the largest stellar spectra library now and onward. Precise constraints on a great number of pulsating stars can be given by combining the LAMOST data with the photometric data from ground and space. In this talk, we first present the result of the discovery of four new DA pulsating white dwarf stars from the LAMOST survey. The follow-up observations from ground suggest that the detected pulsations in all these four stars are above the typical signal-to-noise ratio of ~4. We then show the result of a δ Scuti star, observed by *Kepler* and LAMOST together, which is possibly a long period binary system as revealed by the time pulsation technique. We finally propose some related projects aiming at mode behaviours (amplitude and frequency modulations) in the compact (white dwarf and hot subdwarf) stars observed by *Kepler* and LAMOST.

CT_07 Oscillations of Li-rich giant stars in LAMOST-*Kepler* fields

by **Mengqi Jin (China)** & Jianning Fu

About 1% of giant stars have been found to have large surface Li abundances, which is unexpected according to the standard stellar evolution models. The knowledge of the exact stage of evolution of Li-rich giant stars is useful to help us to understand the existance of these stars. Based on the 53 candidates of Li-rich giants found in LAMOST-*Kepler* fields, we found that several stars are oscillating. We use asteroseismic analysis to derive more information about these stars and constrain their evolution states.

CT_08 Investigating oscillations in 16,000 red giants using *Kepler* and LAMOST

by **Jie Yu (Australia)**, Timothy Bedding, Daniel Huber, Dennis Stello & Marc Hon

The Kepler mission has provided exquisite data to perform ensemble asteroseismic analysis on evolved stars. In this work, we systematically characterized the solar-like oscillation power excesses for 16,136 oscillating red giants, using full-length long-cadence data. We produced a homogeneous catalog of seismically-derived stellar mass, radius, and surface gravity, and made a systematical characterisation of oscillation power excess, using effective temperatures and metallicities from APOGEE, LAMOST, and the (revised) *Kepler* Input Catalog. We found that low mass helium-core burning (HeB) stars show the same oscillation amplitude while the higher mass HeB stars show lower amplitudes compared to RGB stars. We also discovered that the power excess width is an increasing function of stellar mass. The influence of metallicity on oscillation amplitude, power excess width, and granulation amplitude is found to be significant. Metal-rich red giants have both a higher oscillation and background-granulation amplitude and a narrower excess width. Our asteroseismic stellar properties can be used as reliable distance indicators and age proxies for dating and mapping the Galactic disk observed by *Kepler*. It will also provides an excellent opportunity to test asteroseismology using Gaia parallaxes, and lift degeneracies in deriving atmospheric parameters in large spectroscopic surveys such as APOGEE and LAMOST.

CT_09 **Follow-up observations of extremely metal-poor stars identified from SDSS and LAMOST**

by **David S. Aguado (Spain)**, Carlos Allende Prieto, Jonay I. González Hernández, Rafael Rebolo & Matthew Shetrone

The most metal-poor stars in the Milky Way witnessed the early phases of the formation of the Galaxy, and have chemical compositions close to the pristine mixture from the Big Bang nucleosynthesis, polluted by one or very few supernovae. Here we present a program to search for and characterize new ultra metal-poor stars in the Galactic halo. These stars are extremely rare: despite significant efforts, only a handful of stars have been identified with a metallicity [Fe/H]< -5 dex. We select candidates from SDSS and LAMOST. Dozens of them have already been observed with the ISIS spectrograph on the 4.2-m William Herschel Telescope. The most interesting objects have been confirmed with the Optical System for Imaging and low-Intermediate-Resolution Integrated Spectroscopy (OSIRIS) on the 10.4-m Gran Telescopio Canarias (GTC) and the High Resolution Spectrograph (HRS) on the 9.2-m Hobby-Eberly Telescope (HET). Our analysis is highly automated, and based on the FERRE code (Allende Prieto et al. 2006, ApJ, 636, 804).

CT_10 **Physical properties and flare activities of the G-type eclipsing binaries from the *Kepler* observations**

by **Li-Ching Huang (Taiwan)**, Wing-huen Ip, Han-yuan Chang, Yihan Song & Ali Luo

The *Kepler* space telescope has observed more than 2000 eclipsing binary (EB) systems during its primary mission between 2009 and 2013. According to the effective temperatures measured by Huber et al. (2014), we have selected about 131 systems with G-type primary stars characterized with Teff ~ 5000K-6000K for a statistical study. These classifications are compared to the spectral measurements of LAMOST. Many of the binaries are characterized by the EA (Algol)-type light curves of detached systems. To calculate their spectral types, mass ratio, radius, system incline angles, and orbital distance between the two components in individual EBs, we measured their primary and secondary eclipsing transit depths and effective temperature ratios according to the *Kepler* data. In some test cases, we can find a best fit of two spectral components from LAMOST spectra. A fraction of the EBs in this sample displayed flare activities. We found 11 systems showing flare events in their *Kepler* light curves. Then we compare the S-indices of EB systems with and without flare activities. Similar with the single stars with and without flares, systems with flare events usually have a higher S-index than those without. The S-index differences between binary systems are lager than those of single stars, although there are no big S-index differences between EB and single stars.

CT_11 **Revealing the assemblage and evolution history of the Galactic disk with LAMOST**
by **Maosheng Xiang (China)**

The talk will introduce our efforts on studying the assemblage and evolution history of the Galactic disk with LAMOST. This includes a brief introduction to the LAMOST value-added catalogues, which contain robust estimates of stellar atmospheric parameters (Teff, logg, [Fe/H]), absolute magnitudes Mv, alpha-element to iron abundance ratio [a/Fe], carbon [C/H] and nitrogen abundance [N/H] yielded by LSP3, as well as interstellar extinction, distance, and kinematic parameters inferred based on the LSP3 parameters. I will then present robust stellar age estimates for millions of LAMOST stars. Finally, I will introduce scientific explorations on the stellar mass distribution, spatial structure and metallicity distribution of the Galactic disk using mono-age stellar populations from LAMOST.

CT_12 **Galactic kinematics and dynamics from the LAMOST Galactic Spectroscopic Surveys**
by **Yang Huang (China)** & Xiaowei Liu

As a milestone of ‘near-field cosmology’ to fulfill the quest for understanding galaxy formation and evolution, the LAMOST Galactic Spectroscopic Surveys have hitherto collected quality spectra of over 7.5 million stars, and this number is still increasing at a rate of 1 million per annum. Benefitted from this single largest spectroscopic dataset as well as data from other photometric and spectroscopic surveys, significant progresses have been made on the studies of the kinematics and dynamics of the Milky Way, including: (1) Accurate estimates the peculiar velocities of the Sun that define the Local Standard of Rest, the starting point of all Galactic kinematic and dynamic studies; (2) A detailed investigation of the bulk motion of nearby disk stars, in 3 dimensions for the first time; (3) Accurate determinations of the Galactic rotation curve out from 8 to 100 kpc and the escape velocity curve from 5 to 14 kpc, as well as of the mass surface density in the solar neighborhood. The above newly obtained accurate measurements allow us to derive the mass distribution of the Milky Way with an unprecedented precision, and thus to map out the potential and (dark) matter distribution of our Galaxy. The accurate local dark matter density delivered by these studies bears on the interpretation of any signals that the ongoing dark matter search experiments are expected to detect; (4) Finally, by combining the LAMOST measurements and the first Gaia data release, a sample of nearly ten thousand local main-sequence turn-off stars has been selected, with very accurate 3-dimensional positions and velocities, as well as chemical composition and age information. The sample allows us to study the local disc(s) in multi-dimensional phase space, yielding pivotal information that help constraint the formation and evolution of the Galactic disc(s).

CT_13 **The [α/Fe] distributions of the Galactic disk stars from the spectroscopic survey of LAMOST**

by **Ji Li (China)**, Xuan Ci, Shuhua Jia, Maosheng Xiang, Jianrong Shi & Xiaowei Liu

The Galactic disk is the main structural component of the Milky Way, but whether there is a sub-structure of the so-called thin- and thick- disks has always been a controversial issue. Using the stellar spectra from the LAMOST Spectroscopic Survey of the Galactic Anti-center (LSS-GAC), we obtained the distributions of [a/Fe] ratios in the R-z space for about 1 800 000 disk stars from the DR4 of LAMOST, connecting with the star kinematics characteristics. The results indicate that the Galactic disk truly consist of two substructures with different [α/Fe] abundances, but there is no a distinct separation between the thin and thick disk (not in metallicity or the [α/Fe] ratios, nor in the space position). Moreover, there is an apparent “warp” in the edge of the Galactic disk.