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The *Kepler* field of view covered with the LAMOST spectroscopic observations†

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Abstract. The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) at the Xinglong observatory in China is a 4-m telescope equipped with 4,000 optical fibres. In 2010, we initiated the LAMOST-*Kepler* project which aimed at collecting low-resolution spectra of stars from the *Kepler* Input Catalog covering uniformly the *Kepler* field of view. The first round of the LAMOST-*Kepler* project has been completed in September 2014 resulting in more than 100,000 low-resolution spectra. We used those data to derive the effective temperature, the surface gravity, and the mean metallicity of our targets, as well as to detect fast rotators, and to identify emission-line stars. Our results are consistent with those reported in the literature and derived from high-resolution spectroscopy. The second round of the LAMOST-*Kepler* project will allow to improve the coverage of the *Kepler* field and to repeat observations of selected targets.

Keywords. Stars: atmospheric parameters – Surveys: spectroscopic – Space missions: Kepler – Astronomical facilities: LAMOST

1. LAMOST-*Kepler* Project

The LAMOST-*Kepler* project, described in detail by De Cat *et al.* (2015), has been initiated in 2010. It's aim is to cover the field of view of the space mission *Kepler* (Koch *et al.* 2010) with low-resolution spectroscopic observations obtained for as many stars as possible. Those data will then be used to derive the stars' atmospheric parameters, i.e., the effective temperature, the surface gravity, and the metallicity, and to measure their radial and projected rotational velocity. The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST Wang *et al.* 1996) is the most suited instrument to perform this task. It is the largest Schmidt telescope in the world and has a circular field of view with a diameter of 5 deg that is covered with 4 000 optical fibers connected to low-resolution spectrographs.

Our list of targets has been prioritized according to the availability of the atmospheric parameters of the stars in the *Kepler* Input Catalog (KIC; Brown *et al.* 2011) and the importance of those stars for the scientific community involved in the *Kepler* research. From the highest to the lowest priority, our original list of targets included $\sim$ 120 MK secondary standard stars, $\sim$ 6,500 stars selected by the *Kepler* Asteroseismic Science Consortium

† Based on observations collected using the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) located at the Xinglong Observatory, China.

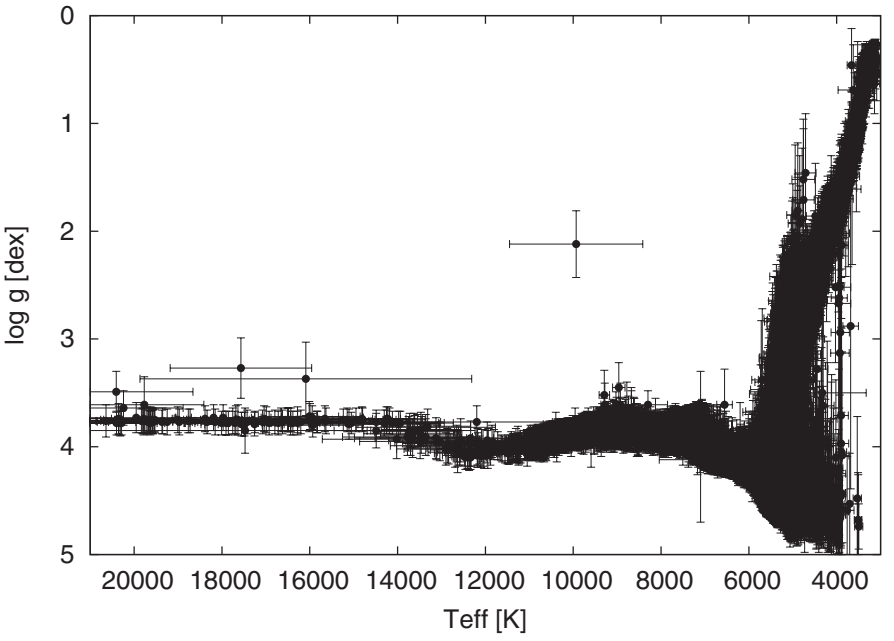

Figure 1. The $T_{\rm eff} - \log g$ diagram obtained by the 'European team' for the stars observed with LAMOST in the framework of the LAMOST-*Kepler* project in the observing seasons 2011-2014.

(KASC)‡ , $\sim$ 150,000 stars selected by the *Kepler* planet search group (Batalha *et al.* 2010), and about 1,000,000 other stars from the KIC. To allow the use of the full capacity of the LAMOST, we consulted the USNO-B catalog (Monet *et al.* 2003) to select additional targets with $V < 20$ to fill as many fibers as possible. Our list of targets included also stars from the open clusters NGC 6791, NGC 6811, NGC 6819, and NGC 6866. We requested observations for 14 LAMOST to fully cover the *Kepler* field of view, as shown in Fig. 2 of De Cat *et al.* (2015).

The first round of the LAMOST-*Kepler* project was completed in 2014. Between 2011 and 2014, we measured 38 LAMOST plates during 27 observing nights and collected 101,086 low-resolution spectra (R = 1000 or 2000 in 2011 and R = 1800 from 2012 onwards) for 80,447 different stars; 17,114 stars were observed more than one time.

2. Methods of Analysis

The spectra collected in the framework of the LAMOST-*Kepler* project are now being analyzed by three teams with independent methods (see De Cat *et al.* 2015 for the details.)

The 'Asian team' (Ren *et al.* in preparation) and the 'European team' (Frasca *et al.* in preparation) both obtain the atmospheric parameters of the stars, their radial velocity, and the spectral classification. Additionally, the 'European team' measures the projected rotational velocity of stars with $v \sin i \geqslant 150$ km s^{-1}. In Fig. 1, we show a preliminary Kiel diagram obtained for the stars observed with LAMOST in the seasons 2011-2014

‡ Relevant information on KASC can be found on the *Kepler* Asteroseismic Science Operations Center (KASOC) webpage http://kasoc.phys.au.dk/ maintained by Rasmus Handberg from the University of Birmingham in the United Kingdom.

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and analyzed by the 'European team' by using the code ROTFIT (Frasca *et al.* 2003, 2006).

The 'Asian' team performs also the statistical analysis of the derived parameters.

The 'American team' provides the MK classification by means of the code MKCLASS described by Gray & Corbally (2014). The code is able to detects stars with peculiar features in the spectra, i.e., e.g., barium stars, Ap and Am stars, λ Bootis stars, etc (Gray & Corbally, in preparation).

3. Future of the Project

At the beginning of the LAMOST-*Kepler* project, the LAMOST instrument experienced some pointing problems and malfunctions of some of the spectrographs and fibers. As a result, a significant fraction of the spectra obtained by that time could not be reduced by the reduction pipeline (see Table 3 of De Cat *et al.* 2015.) Moreover, a good LAMOST spectrum is only available for 17 % of the stars that have been observed by *Kepler* so far. We therefore requested a second round of the LAMOST observations during which we will focus on those targets observed by *Kepler* for which no LAMOST spectrum with a signal-to-noise ratio above 20 in the r band is available yet. The second priority will be given to those stars already observed by *Kepler* for which a good quality LAMOST spectrum was obtained in the first round of the LAMOST-*Kepler* project. That will allow us to detect possible radial velocity variations of our targets.

The second round of the LAMOST-*Kepler* has already started. On 29 and 30 May 2015, two LAMOST-*Kepler* fields were observed (LK14 and LK11, as given in Table 1 of De Cat *et al.* 2015.) These observations will continue during the next observing seasons. Also the possibility of observing fields of view of the K2 mission (Howell *et al.* 2014) is being discussed.

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