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The new space telescope Kepler and its asteroseismological targets

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Abstract.
We present primary and secondary asteroseismological targets for *Kepler*, the new NASA space mission. We derive $\log T_{\rm eff}$ and $\log L/L_{\odot}$ values for the selected stars and we put the stars in the $\log L/L_{\odot}$ – $\log T_{\rm eff}$ diagram. Then, we present our program of ground–based spectroscopic and photometric observations of the selected targets and we show first results obtained from these observations.

Key words. Stars: oscillations – Space missions: Kepler

1. Introduction

Kepler is a special purpose space mission in the NASA Headquarters Discovery Program. It is designed for detecting terrestrial planets with the method of photometric transits. The *Kepler* instrument is a Schmidt telescope having 1.4 m primary mirror and a 0.95 m Schmidt corrector. The photometer is composed of an array of 42 CCDs, 50×25 mm and 2200×1024 pixels each.

Kepler will be launched in 2008. The planned duration of the mission is 4–6 years. The satellite will perform continuous and simultaneous observations of 100 000 A–K main sequence stars of V=9–15 mag. The temporal resolution of the observations will be set to 15 minutes. *Kepler* field of view will be centered at a Cygnus–Lyra region at the galactic coordinates $l = 76.5^{\rm o}$, $b = +13.3^{\rm o}$ equivalent to $\alpha = 19^{\rm h}22^{\rm m}40^{\rm s}$, $\delta = +44^{\rm o}30'$. The observations will be done in one spectral bandpass, namely, 400–850 nm. All stars brighter than about V=11.5 will be monitored for 1–3 months at a cadence of 1 minute and analyzed for p–mode oscillations. These data will be used for derivation of astrophysical parameters of the stars.

Only data for stars that are on the *Kepler* target list will be telemetred to the ground.

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2. Guest observer program

Parallel with the main program of the mission, *Kepler* will realize the "*Guest observer*" program for targets proposed by guest observers. These targets can be of any kind and can be slightly brighter than 9 mag, i.e., the *Kepler* nominal limit magnitude, or as faint as 18 mag. The only requirement for the targets is that they have to fall into the *Kepler* field of view.

In the *Guest observer* program, up to 3 025 targets may be selected for simultaneous observations. For 3000 of them, the time resolution may be set to 15 minutes, for 25, to one.

Table 1. The HIP numbers, spectral types, V magnitudes, $\log T_{\mathrm{eff}}$ and $\log L/L_{\odot}$ for the *Kepler* primary asteroseismological targets.

HIP	SpT	V	$\log T_{\mathrm{eff}}$	$\log L/L_{\odot}$	HIP	SpT	V	$\log T_{\mathrm{eff}}$	$\log L/L_{\odot}$
91128	M2 V	9.84	3.589	-1.127	95638	G5	10.57	3.775	-0.002
92922	G5	9.12	3.784	0.326	95733		11.02	3.768	-0.226
93011	F2	9.62	3.843	0.869	95843	F2	9.24	3.851	0.570
94145	F0 III	9.00	3.897	1.074	96146	F0	9.06	3.823	0.702
94335 A	F8 V	9.56	3.786	0.373	96634	K0	9.15	3.750	-0.396
94335 B	G8 V	11.02	3.720	-0.139	96735	K0	9.18	3.749	-0.581
94497	K2	9.86	3.720	-0.498	97168		10.35	3.789	-0.140
94565	G0	9.34	3.811	0.783	97219	G5	9.00	3.744	-0.299
94704	K2	11.09	3.774	-0.493	97657	K5	9.46	3.702	-0.634
94734		9.50	3.799	0.448	97974	G0	10.00	3.855	0.001
94743	F5	9.15	3.871	0.644	98381	K2	9.91	3.741	-0.768
95098	F8	9.47	3.823	0.718	98655	K0	10.43	3.904	-0.007
95631	G5	9.10	3.753	0.008	99267	F3	10.11	3.776	-0.224
95637	F0	9.16	3.873	1.066					

3. Asteroseismological targets

Preparing the list of asteroseismological targets for *Kepler*, we focused on stars that are likely to show solar–like oscillations. We searched for stars that are bright enough to have the frequencies measured with high precision and stars for which it is possible to derive fundamental stellar parameters, i.e., $\log T_{\mathrm{eff}}$ and $\log L/L_{\odot}$.

We selected 26 *Hipparcos* stars having precise parallaxes, hereafter *primary targets*, and around 60 stars from NGC 6811 or NGC 6866 open clusters, hereafter *secondary targets*. We discuss the selected stars below.

3.1. Hipparcos stars

For the 26 *Hipparcos* stars that have parallaxes with the ratio σ_{π}/π less than 0.175, we computed luminosities corrected for the Lutz–Kelker bias (Lutz & Kelker 1973). Then, we derived photometric $\log T_{\mathrm{eff}}$ of these stars using 2 MASS photometry (Cutri et al. 2003) or Strömgren indices. In our computations, we applied the Alonso et al. (1996) or Alonso et al. (1999) calibrations for JHK photometry for dwarfs or for giants, respectively, or the calibration of Napiwotzki et al. (1993) for Strömgren photometry. In case of HIP 94335 A and B, we adopted the $\log T_{\mathrm{eff}}$ values listed by Ribas et al. (1998).

We list the selected *Hipparcos* stars, their spectral types, V magnitudes, $\log T_{\mathrm{eff}}$ and $\log L/L_{\odot}$ in Table 1. Most of these stars have F–K spectral type. One, namely, HIP 91128, is an M2 V star, three, namely, HIP 94734, 95733 and 97168, have no spectral classification.

In Fig. 1, we show these stars plotted in the $\log T_{\mathrm{eff}} - \log L/L_{\odot}$ diagram. We use arrows to indicate HIP 91128 (M2 V), the coolest star in our sample, and two other stars, namely, HIP 97974 (G0), and 98655 (K0), that fall below the Main Sequence. In the literature, there is little information about these two stars. Therefore, additional observations are needed to derive more information about these stars and confirm their position in the $\log T_{\mathrm{eff}}$ – $\log L/L_{\odot}$ diagram.

3.2. Open clusters

Selecting the secondary targets, we examined four open clusters that fall into the *Kepler* field of view, namely, NGC 6791, 6811, 6819 and 6866. We searched for stars that are the clusters' members and that are bright enough to be observed by *Kepler*. Finally, we selected around 60 stars from the NGC 6811 or

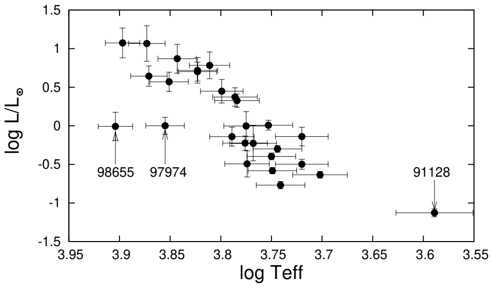

Fig. 1. $\log T_{\rm eff}$ – $\log L/L_{\odot}$ diagram for 26 *Hipparcos* stars. Stars indicated with arrows and labeled with *Hipparcos* numbers are discussed in the text.

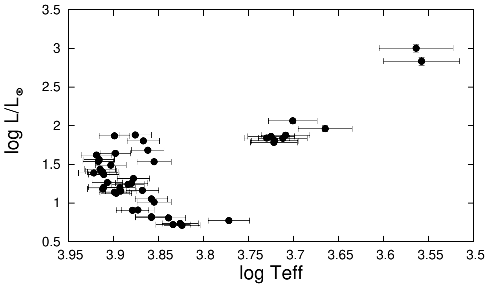

Fig. 2. $\log T_{\rm eff}$ – $\log L/L_{\odot}$ diagram for the stars from NGC 6811 open cluster for which the probability of membership of a star to the cluster is higher than 80%.

NGC 6866 open clusters for which the probability of membership of a star to the cluster is not lower than 70%.

Computing luminosities of these stars, we used V magnitudes and distances listed in WEBDA database. The $\log T_{\rm eff}$ values for these stars we computed in the way described in Sect. 3.1.

In Figs. 2 and 3, we plot the stars from the NGC 6811 and NGC 6866 open clusters in the respective $\log T_{\rm eff} - \log L/L_{\odot}$ diagrams. We use dots for stars for which the probability of membership of a star to the cluster is higher than 80%. In case of NGC 6866, only few stars of which have the membership probability higher than 80%, we use circles for stars for which this probability falls into the range of 70–80%.

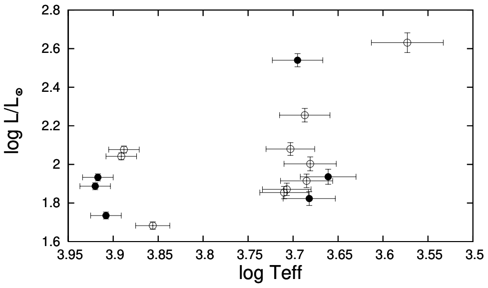

Fig. 3. $\log T_{\rm eff}$ – $\log L/L_{\odot}$ diagram for the stars from NGC 6866 open cluster for which the probability of membership of the star to the cluster is higher than 80% (dots) or falls into the range of 70–80% (circles).

4. Ground–based observations

All of the stars discussed above are on our target list for ground–based observations. We are going to derive the rotational velocity and metallicity of these stars, check the possible binarity and study the variability. We will use that information for computation of pulsational and evolutionary models of these stars.

We have already obtained spectra of the 26 *Hipparcos* stars and we started collecting spectra for the open clusters' members. The observations were kindly performed by Dr. Latham with the use of CfA Digital Speedometer on the 1.5 m Tillinghast Reflector at the Wipple Observatory on Mount Hopkins, Arizona and by myself on the 0.91 m Cassegrain telescope at the M.G. Fracastoro Mountain Station of the Catania Astrophysical Observatory.

The first results of the analysis show that most of the *Hipparcos* stars are slow rotators and that there are at least three spectroscopic binaries on the list, namely, HIP 94335 and 94743, two known eclipsing binaries, and HIP 94734, a new SB star.

We plan to collect standard Strömgren photometry of all the targets. The stars will be observed photoelectrically on the 0.60 m Cassegrain telescope in the Stara Lesna Observatory of the Slovak Academy of Science and on the 0.91 m Cassegrain telescope at the Fracastoro Mountain Station.

5. Summary

We presented a list of asteroseismological targets for the new space telescope, *Kepler*. With the use of all available data, we derived effective temperatures and luminosities of these stars.

All the primary and selected secondary targets are on our list of stars for ground–based spectroscopic and photometric observations. The first results of the observations are the derivation of rotational velocities of the primary and a discovery of a new SB star.

In a collaboration with Dr. Bazot we started computations of evolutionary and pulsational models of the primary targets. The results of our study will be shown in a separate paper.

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We made use of the *Kepler* official webpage, *http://www. kepler. nasa. gov*, the WEBDA database, *http://obswww. unige. ch/webda*, and the NASA Astrophysics Data System.

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