New planet system candidates within the solar vicinity

Donka Petkova[1], Petko Nedialkov[2], Vladimir Shkodrov[3]
[1] University of Shumen, 9700 Shumen, Bulgaria
[2] University of Sofia, 1164 Sofia, Bulgaria
[3] Institute of Astronomy, Bulgarian Academy of Sciences, 1784 Sofia, Bulgaria
d.petkova@shu-bg.net, japet@phys.uni-sofia.bg, shkodrov@astro.bas.bg
(Conference talk)

Abstract. We recovered the initial sample of target stars already searched for planet systems by the California & Carnegie group and the team of the Anglo-Australian Telescope via the technique of radial velocity. The parametric space of the Galactic coordinates both spherical and cartesian was thoroughly checked for incompleteness. A list of new planet systems candidates, suitable for detection with echelle spectrograph from Rozhen NAO, is proposed. It contains 140 Solar-type stars targets within a cone, centered on the North galactic pole. Several similar stars in the Solar vicinity at distances between 5 and 10 pc are also discussed.

Key words: extrasolar planetary systems; photometric and interferometric detection; main-sequence and post-main sequence stars (F, G, K, and M)

Нови кандидати за звезди с планетни системи в слънчевата околност

Донка Петкова, Петко Недялков, Владимир Шкодров

Възстановена е първоначална извадка от звезди, около които са търсени извънслънчеви планети чрез анализ на лъчевите скорости от обединения екип на групите Калифония & Карнеги и групата на Англо-австралийския телескоп. Параметричното пространство на галактичните координати на звездите, както сферични, така и декартови, е изследвано щателно за непълноти. Предложена е нова извадка на звезди от слънчев тип – кандидати да притежават планетни системи, подходящи за наблюдения от Рожен НАО с ешеле-спектрограф. Извадката съдържа 140 звезди в конус около Северния галактичен полюс. Няколко подобни обекта за наблюдение в околността на Слънцето на разстояние между 5 и 10 пс са също обсъдени.

1 Introduction

The radial velocity analysis is the most powerful tool for detection of a star bearing planet. The vast majority of exoplanets are discovered by the means of that technique. Most of them are found within the nearby 50 pc. The closer volume within 25 pc of the Sun ($V < 7^m$), with a few exceptions for a Solar-like stars, has been thoroughly searched for short-period giant planets (Robinson et al., 2007). More comprehensive studies, for example - N2K project, are now in progress.

In this paper we explore the potential of Hipparchos (Turon et al., 1993) database to provide new candidates for planet bearing stars within the Solar vicinity.

2 CCA sample restoration

The selection criteria set is the most important issue when observational lists for planet systems searches are being compiled. However, it is not a common practice to publish neither the lists themselves, nor clearly established conditions under which the samples were constructed. It is even impossible to set any conditions when samples are complied from diverse archival sources. Thus, most of the initial observational intentions are heavily obscured.

Until recently two groups contributed substantially to the increasing number of discoveries. The first group (Tinney et al. 2001) joints the efforts of the California & Carnegie team at Keck and Lick observatories and the Anglo-Australian Telescope team (hereafter, CCA group). The second group which exploits the facilities at l'Observatoire de Haute Provence and La Silla Observatory is the Geneva extrasolar planet team (Mayor & Santos 2003). Unfortunately, the target list of the second group is not recoverable (Butler et al., 2006). In contrast, the CCA group made public their observational lists for the northern hemisphere in the paper of Wright et al.(2004) and for the southern sky in electronic form (http://www.phys.unsw.edu.au/ cgt/planet/aapslist.html). Generally, it is announced that the lists contain 1330 mostly dwarf stars of spectral types F, G, K and M, but their spatial distribution has never been studied in details. Since the formal unification of these data sources results

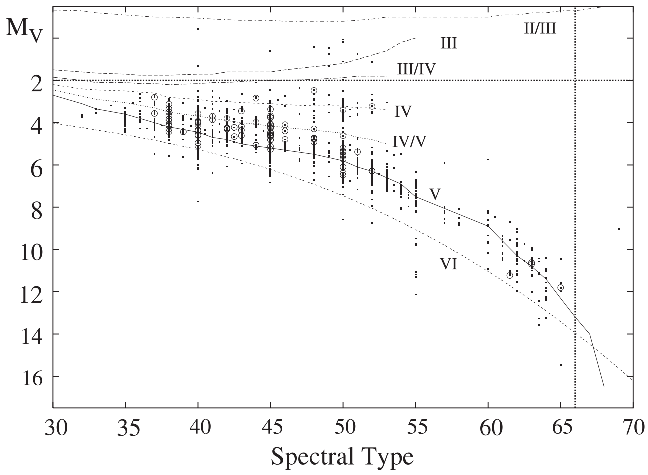


Fig. 1. Absolute magnitude versus spectral type for the initial CCA sample (dots). Along the abscissa 30 stands for F0, 40 - for G0, etc. The stars detected to harbor planets by radial velocity technique are designated with open circles. The adopted luminosity calibrations are from Houk (1978). Within the limits (short-dashed lines) and above the fitting curve for subdwarfs (luminosity class VI) the total number of stars is reduced to 1333.

in a sample consisting of 1410 stars we started with a cross-identification of the samples and found only 11 common objects. Thus, the question how to restrict additionally the initial CCA sample of 1399 stars arose.

Since the luminosity class seems to be a crucial selection factor at least for the Anglo-Australian Telescope search we used Hipparcos output catalog to construct Hertzsprung-Russell diagram (Fig.1) for the initial CCA sample. However, there are 30 stars with missing parallaxes and we used our own calibration to derive distances on the base of their 2MASS photometry. The absolute magnitudes are corrected for extinction assuming modest visual absorption of 1 mag/kpc. Finally, we adopted luminosity calibrations from Houk (1978) in order to determine to which luminosity class a certain star belongs. Thus, a luminosity class, not available in Hipparcos catalog was ascribed to 467 stars. Rejection of luminosity classes other than V or IV and setting of an upper limit for the spectral type not later than M5 lead to a sample in which 1333 stars are left. We find this number satisfactory and will call this reduced CCA sample just "CCA sample" hereafter.

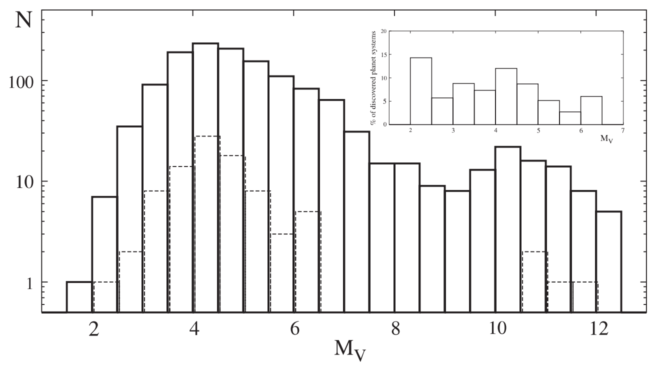


Fig. 2. Luminosity functions of the reduced CCA sample (solid line) and the sample of stars, harboring planets (dashed line). In the upper right corner the percentage of successful detections as a function of the absolute magnitude is shown.

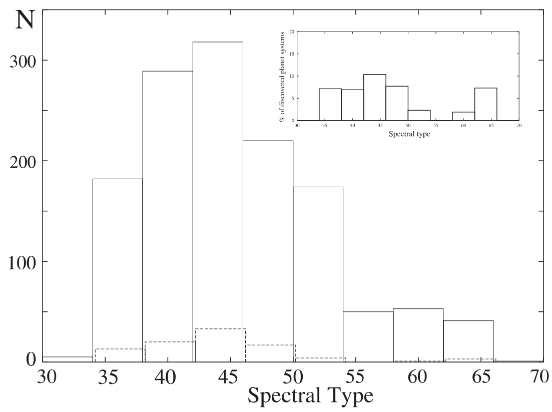


Fig. 3. Spectral type (30 corresponds to F0, 40 - to G0, 50 - to K0 and 60 - to M0) distribution of the CCA sample (solid line) and the sample of stars, harboring planets (dashed line). The percentage of successful detections as a function of the spectral type is depicted in the upper right corner.

It is interesting to see how successful was the search in terms of luminosity and given spectral type. For this purpose we constructed the luminosity function (Fig.2) and the distribution by spectral type (Fig.3) for the CCA sample and the sub-sample of stars harboring planet systems. As seen in the figures in the upper right corner the typical percentage of successful detections is $\sim 7\%$. It is worthy to notice the lack of any detected planet bearing star in the magnitude interval $6.5 \div 10.5$ mag and within the spectral type interval $K4 \div K8$. Partially it could be explain with the worse statistics of these bins, although at least several such stars are expected to be detected there.

2.1 Space distribution of the new candidates for planet systems

Once the CCA sample has been clarified we are ready to study the spatial distribution of its content in details. The (l,b)-plane seems to be randomly populated as seen in Fig.4. Though the Anglo-Australian Telescope search has a clear cut off at $\delta = -20°$, the California & Carnegie search is not spatially complementary to it by declination since some of its targets penetrate even at $\delta = -40°$. We calculated the cartesian coordinates (x,y,z) of each star in

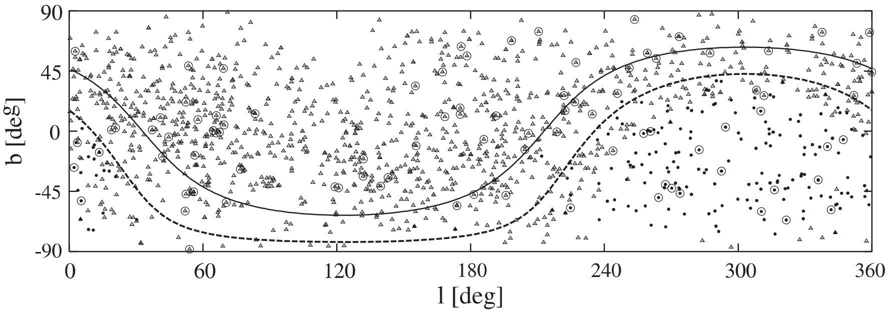


Fig. 4. Space distribution on (l,b)-plane of the CCA sample (triangles - stars from the California & Carnegie search and dots - stars from the Anglo-Australian Telescope search). Open circles designate 91 stars detected to harbor planet systems. Solid line represents the equatorial plane ($\delta = 0°$), and dashed one - $\delta = -20°$.

CCA sample, assuming that $z_\odot = 0$ pc and define R as the distance between the star and Sun projected onto the Galactic midplane. The space distribution on (z,R)-plane, shown in Fig.5, reveals two "cones of avoidance" toward the Galactic poles. There are 328 possible targets from Hipparcos within cones up to $\mid z \mid = 75$ pc. These targets satisfy the following conditions: (i) $2^m < M_V < 6.5^m$ and (ii) luminosity class IV or V. The corresponding spectral type interval is $F2 \div K3$. Thus, some of the K and all M type stars were ruled out of target sample either because the probability to find planet bearing stars among them is low or there is a lack of such stars in Hipparcos catalog. Only 27 targets in cones were searched by the CCA group which succeed to detect 2 planet systems among them. Other groups discovered 3 other planets reducing system the final number of unknown possible targets to 298. There are 140 candidates in northern Galactic hemisphere and 158 in the southern one.

The first 10 entries of the target list for objects around the North Galactic pole are given in Table 1. The rest of the table is available in electronic form upon a request. The distribution along z-coordinate of the stars with detected planets and the stars not bearing planets is illustrated in Fig.6. The mean z-coordinate of the two sub-samples is not statistically different from zero which

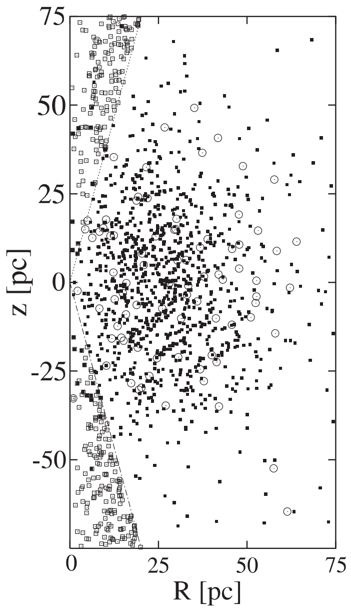


Fig. 5. Space distribution on (z,R)-plane of the CCA sample (filled squares - stars not bearing planets and open circles - stars with detected planet systems). The ordinate R is the distance from the star to the axis of the Solar cylinder. Two "cones of avoidance" toward the Galactic poles are enclosed by dashed lines. The proposed new targets are depicted with open squares.

Table 1. Target list of new candidate stars bearing planet systems

HIP	RA(J2000.0)	DEC(J2000.0)
57300	11:44:58.39	+27:24:25.7
57835	11:51:37.13	+35:11:25.5
58071	11:54:34.34	+23:48:39.5
58184	11:56:00.23	+35:20:25.9
58189	11:56:01.10	+25:29:21.1
58213	11:56:20.63	+26:40:46.7
58314	11:57:28.93	+19:59:02.0
58405	11:58:31.02	+31:20:14.6
58560	12:00:29.02	+22:32:52.8
58577	12:00:48.03	+29:11:13.9

points to a shift with respect to the Galactic midplane, similar to that of the Sun if any. The both samples are severely concentrated toward $z = 0$ with an exponential scale-height of ~ 40 pc which is certainly a selection effect rather than real fact since the late type dwarfs are known to have much larger (~ 350 pc) scale-height.

The last mining for targets in Hipparcos domain came from the finding of a shell where CCA group did not detect any planet system. It becomes clear from Fig.7 where the distribution of the volume density $D(r)$ is plotted. There are 21 possible targets from Hipparcos in the empty $5 \div 10$ pc shell

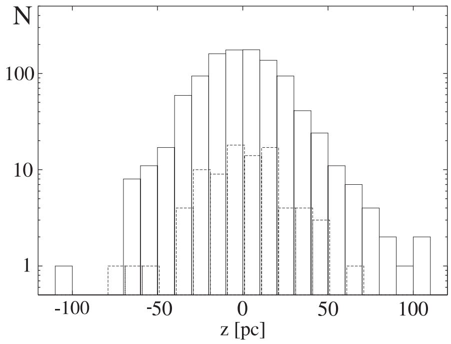


Fig. 6. Z-coordinate distribution of the CCA sample. Note, that the histogram of the stars with detected planets (dashed line) has the same slope as the histogram of the stars not bearing planets (solid line).

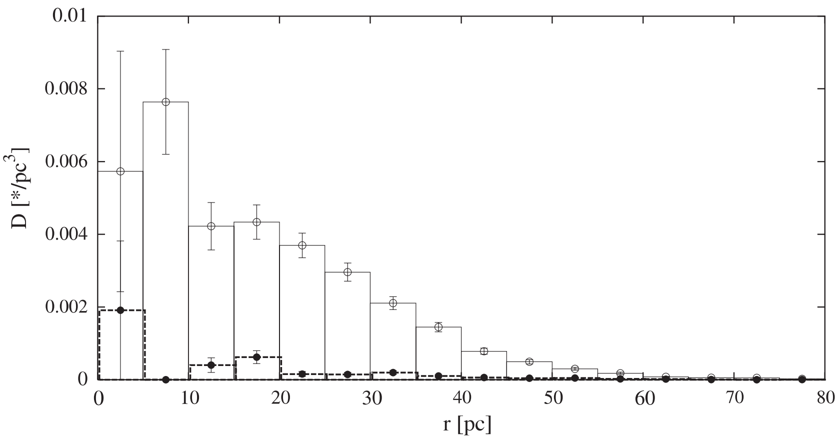


Fig. 7. Volume density within Solar vicinity versus the mean distance to the stars. The solid line represents the distribution of stars not bearing planets, the dashed line - the stars with detected planet systems. Interestingly, no stars with a planet system has been detected in the *5 ÷ 10* pc shell.

and 14 of them has been involved in the CCA search. No other planet systems were discovered by other groups, but 3 among the rest 7 are included in SPOC catalog (Valenti & Fisher, 2005) indicating that they surely have been searched for planets. Accounting for the spectral binarity or variability of 2 other stars we remain with only 2 uninspected possible targets, namely, HIP84405 and HIP27072 positioned at quite low declination ($\delta < -20°$). Since they fulfill the selection criteria of the Geneva group at La Silla Observatory it is quite possible that they also have been searched. One have to conclude that the lack of short-period giant planets orbiting 35 solar-like neighboring stars within $5 \div 10$ shell can be real.

In the near future we plan to apply Kolmogorov-Smirnov test for CCA sub-samples of the planet bearing stars and stars without discovered planet systems. The parametric space of mass, radius, age, rotational period, metallicity and velocity components from will be thoroughly search in order to find significant differences. These efforts may improve the probability for detection of a planet around a specific star.

3 Acknowledgements

This work was partially supported by the following grants: VU-NZ-01/06, VU-F-201/06 & VU-F-205/06 of the Bulgarian Science Foundation.

References

Robinson, S. E., Ammons, S. M., Kretke, K. A., Strader, J., Wertheimer, J. G., Fischer, D. A., & Laughlin, G. 2007, ApJS, 169, 430

Turon, C., Hilditch, R., & Hilditch, R., 1993, The Observatory, 113, 223;

Tinney, C. G., McCarthy, C., Jones, H. R. A., Butler, R. P., Carter, B. D., Marcy, G. W., & Penny, A. J. 2002, MNRAS, 332, 759

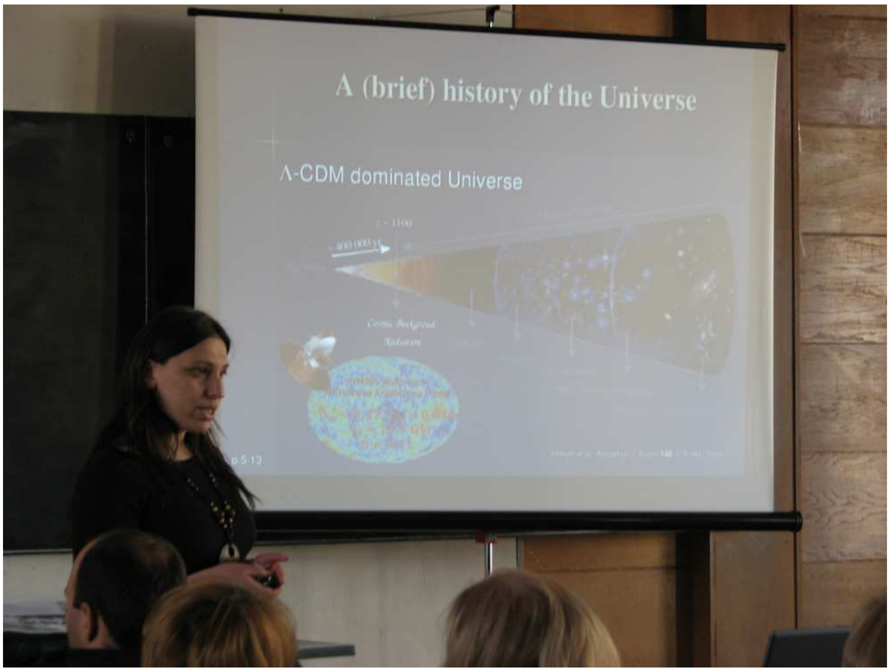
Mayor, M., & Santos, N. C. 2003, In Astronomy, Cosmology and Fundamental Physics, p. 359;

Butler R., Wright J., Marcy W., Fischer D., Vogt S., Tinney C., Jones H., Carter B., Johnson A, McCarthy C., Penny A., 2006, ApJ, 646, 505;

Wright J.T., Marcy G.W., Butler R.P., Vogt S.S., 2004, ApJS, 152, 261;

Houk, N. 1978, Michigan Catalogue of two-dimensional spectral types for the HD stars, Vol. 2, Ann Arbor: Dept. of Astronomy, Univ. Michigan;

Valenti J.A. & Fischer D.A., 2005, ApJS, 159, 141.


A (brief) history of the Universe
Λ-CDM dominated Universe