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Precise radial velocities of giant stars*

I. Stable stars

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ABSTRACT

Context. Future astrometric missions such as SIM PlanetQuest need very stable reference stars. K giants have large luminosities, which place them at large distances and thus the jitter of their photocenters by companions is relatively small. Therefore K giants would be best suited as references. To confirm this observationally a radial velocity survey is performed to quantify the level of intrinsic variability in K giants.
Aims. From this radial velocity survey we present 34 K giants with an observed standard deviation of the radial velocity of less than 20 m/s. These stars are considered "stable" and can be used as radial velocity standards.
Methods. The radial velocity survey contains 179 K giants. All K giants have a declination between −30° and +65° and visual magnitude of 3−6 mag. The Coudé Auxiliary Telescope (CAT) at UCO/Lick Observatory is used to obtain radial velocities with an accuracy of 5−8 m/s. The number of epochs for the 34 stable stars ranges from 11 to 28 with a total timespan of the observations between 1800 and a little over 2200 days.
Results. The observational results of the 34 "stable" stars are shown together with a discussion about their position in the M_V vs. $B-V$ diagram and some conclusions concerning the radial velocity variability of K giants. These results are in agreement with the theoretical predictions. K giants in a certain range of the M_V vs. $B-V$ diagram are suitable reference stars.

Key words. techniques: radial velocity observations – stars: late-type

1. Introduction

To perform high precision astrometric observations very stable reference stars are needed. In preparation of the Space Interferometry Mission (SIM PlanetQuest), Frink et al. (2001) investigated which type of stars would be best suited as reference stars. Although known to be photospherically active, K giants appeared to be the best choice, mainly because of their large distances, brightness and sky coverage. To quantify the photospheric activity observationally, a radial velocity survey was started to measure the level of intrinsic radial velocity variability in K giant stars.

For about a decade, well known techniques have been used to perform very accurate radial velocity observations, up to a few m/s (see e.g. Marcy & Butler 2000; Queloz et al. 2001) and with HARPS (High Accuracy Radial velocity Planet Searcher on the 3.6 m telescope, La Silla Observatory, ESO Chile) even to 1 m/s (Pepe et al. 2003). Most extrasolar planets known so far have been discovered around main sequence stars using radial velocity observations. Like main sequence stars, K giant spectra contain a large number of narrow spectral lines and accurate radial velocity variations can also be obtained for these stars.

In this paper we present results for 34 K giants, from the above-mentioned survey, with an observed standard deviation of the radial velocity of less than 20 m/s. These stars are considered stable and can be used as radial-velocity standards.

In general the possibility of accurate radial velocity observations makes it possible and necessary to select radial velocity standards with smaller radial velocity variations. The IAU standard stars (Pearce 1955) and the suggested extensions by Heard (1968) and Evans (1968) for the northern and southern sky respectively do not yet have an accuracy of a few m/s. More recently Kharchenko et al. (2004) selected 3967 stars from their "Catalog of radial velocities of galactic stars with high precision astrometric data (CRVAD)" (based on Barbier-Brossat & Figon 2000) as radial velocity standard candidates. Furthermore Udry et al. (1999a,b) present a list of CORAVEL radial-velocity standard stars, and a list with proposed high-precision radial-velocity standards, respectively. The stars presented in this paper are in addition to the already known radial velocity standard stars.

The paper is organized as follows. In Sect. 2 the observations are described, followed in Sect. 3 by the results for the individual stars. Section 4 contains a discussion and some conclusions concerning the radial velocity variability of K giants.

2. Observations

The sample of 179 K giants has been selected from the Hipparcos catalog (ESA 1997) based on the criteria described in Frink et al. (2001). They are all brighter than 6 mag,

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* Based on observations taken at University of California Observatories/Lick Observatory.

Table 1. Properties of the stable stars: right ascension (RA) in "hh:mm:ss" and declination (Dec) in "dd:mm:ss", both J2000.0, apparent magnitude (m_V) and absolute magnitude (M_V) in the V band, parallax (*plx*) in mas, $B-V$ color, (rather uncertain) mass obtained with the method described by Allende Prieto & Lambert (1999) in $M_{\odot}$, the spectral type (*SP*) and the radial velocity *RV* in km s^{-1} from Famaey et al. (2005) and Barbier-Brossat & Figon (2000), respectively. The latter catalog does not give errors in the radial velocity for each star.

HIP	HD	RA hh:mm:ss	Dec dd:mm:ss	m_V[a] mag	M_V mag	*plx*[a] mas	$B-V$[a] mag	Mass $M_{\odot}$	*SP*[a]	*RV*[b] [km s^{-1}]	*RV*[c] [km s^{-1}]
HIP 4906	HD 6186	01 02 56.6	+07 53 25	4.27	0.44	17.14	0.952	2.27	K0III	7.47 ± 0.20	7.50 ± 0.2
HIP 13701	HD 18322	02 56 25.7	−08 53 53	3.89	0.83	24.49	1.088	1.38	K1III-IV		−20.30
HIP 14838	HD 19787	03 11 37.8	+19 43 36	4.35	0.79	19.44	1.033	1.91	K2III	23.05 ± 0.20	23.90 ± 0.4
HIP 19388	HD 26162	04 09 10.0	+19 36 33	5.51	0.76	11.21	1.077	1.39	K2III	24.75 ± 0.02	24.80
HIP 21248	HD 29085	04 33 30.6	−29 45 59	4.49	1.58	26.22	0.972	1.98	K0III		20.60
HIP 22860	HD 31414	04 55 06.8	−16 44 26	5.71	−0.11	6.85	0.953	3.01	K0II		9.80
HIP 33914	HD 52556	07 02 17.5	+15 20 10	5.78	−0.70	5.06	1.140	3.06	K1III	−12.85 ± 0.20	−13.50
HIP 36848	HD 60666	07 34 34.8	−27 00 44	5.78	0.87	10.41	1.045	1.71	K1III		−6.20 ± 0.3
HIP 37447	HD 61935	07 41 14.8	− 09 33 04	3.94	0.71	22.61	1.022	1.94	K0III		10.50
HIP 38375	HD 64152	07 51 43.0	−21 10 25	5.62	1.00	11.90	0.956	2.50	K0III		31.90
HIP 43923	HD 76291	08 56 50.0	+45 37 54	5.72	1.48	14.21	1.125	1.30	K1IV	53.28 ± 0.30	58.40 ± 0.3
HIP 48455	HD 85503	09 52 45.8	+26 00 25	3.88	0.83	24.52	1.222	0.59	K0III	13.63 ± 0.07	14.10 ± 0.3
HIP 53316	HD 94481	10 54 17.8	−13 45 29	5.65	0.16	7.97	0.832	2.89	K0III		5.40
HIP 58181	HD 103605	11 55 58.4	+56 35 55	5.83	0.90	10.34	1.101	1.45	K1III	16.91 ± 0.16	14.70 ± 1.2
HIP 59847	HD 106714	12 16 20.5	+23 56 43	4.93	0.52	13.12	0.957	2.27	K0III	−27.89 ± 0.13	−27.20 ± 0.5
HIP 60742	HD 108381	12 26 56.3	+28 16 06	4.35	0.76	19.18	1.128	1.66	K2III	3.38 ± 0.11	4.70 ± 0.3
HIP 68895	HD 123123	14 06 22.3	−26 40 57	3.25	0.79	32.17	1.091	1.76	K2III		27.20 ± 0.5
HIP 74239	HD 134373	15 10 18.6	−26 19 57	5.75	0.05	7.25	1.045	2.78	K0III		−33.10 ± 0.3
HIP 75944	HD 138137	15 30 40.4	−16 36 34	5.82	−0.37	5.78	1.056	2.94	K0III		−1.70
HIP 78132	HD 142980	15 57 14.6	+14 24 52	5.54	1.33	14.36	1.141	1.19	K1IV	−70.98 ± 0.17	−68.30
HIP 78442	HD 143553	16 00 61.1	+04 25 39	5.82	1.49	13.62	1.003	1.93	K0III	−7.85 ± 0.22	−4.10
HIP 83000	HD 153210	16 57 10.1	+09 22 30	3.19	1.09	37.99	1.160	0.78	K2III	−55.86 ± 0.19	−54.40 ± 1.3
HIP 88684	HD 165438	18 06 15.2	−04 45 05	5.74	3.02	28.61	0.968	1.35	K1IV		−18.90
HIP 89962	HD 168723	18 21 18.6	−02 53 56	3.23	1.84	52.81	0.941	1.96	K0III-IV		8.90 ± 0.7
HIP 90496	HD 169916	18 27 58.2	−25 25 18	2.82	0.95	42.20	1.025	1.88	K1III		−43.20 ± 0.7
HIP 93085	HD 175775	18 57 43.8	−21 06 24	3.52	−1.77	8.76	1.151	4.58	K0II-III		−20.10 ± 0.6
HIP 94779	HD 181276	19 17 06.2	+53 22 06	3.80	0.91	26.48	0.950	2.87	K0III	−29.00 ± 0.30	−29.20 ± 0.6
HIP 96229	HD 184406	19 34 05.4	+07 22 44	4.45	1.80	29.50	1.176	0.92	K3III	−24.73 ± 0.13	−23.90 ± 0.6
HIP 96459	HD 185351	19 36 38.0	+44 41 42	5.17	2.13	24.64	0.928	1.82	K0III	−5.91 ± 0.11	−5.20 ± 1.0
HIP 102422	HD 198149	20 45 17.4	+61 50 20	3.41	2.63	69.73	0.912	1.64	K0IV	−87.55 ± 0.11	−87.90 ± 0.6
HIP 106039	HD 204381	21 28 43.4	−21 48 26	4.50	0.80	18.18	0.889	3.46	K0III		−20.80 ± 0.8
HIP 112724	HD 216228	22 49 40.8	+66 12 01	3.50	0.76	28.27	1.053	1.61	K0III	−12.59 ± 0.20	−14.20 ± 0.7
HIP 115438	HD 220321	23 22 58.2	−20 06 02	3.96	0.48	20.14	1.082	2.06	K0III		−6.10 ± 0.4
HIP 115830	HD 220954	23 27 58.1	+06 22 44	4.27	0.83	20.54	1.062	1.54	K1III	6.05 ± 0.19	6.50 ± 1.8

[a] The Hipparcos and Tycho Catalogues (ESA 1997). [b] Radial velocities for 6691 K and M giants (Famaey et al. 2005). [c] General Catalog of mean radial velocities (Barbier-Brossat & Figon 2000).

presumably single, and have masses ranging from about 1 to 3 solar masses. In Table 1 properties of the 34 stable stars are listed.

Our ongoing K giant radial velocity survey started in June 1999, with the Coudé Auxiliary Telescope (CAT) in conjunction with the Hamilton high resolution ($R = 60\,000$) echelle spectrograph. An iodine cell is placed in the light path. With integration times of up to thirty minutes for the faintest stars we reach a signal to noise ratio of about 80−100, yielding a radial velocity precision of 5−8 m/s. This is adequate for our survey and hence no attempt has been made to reach the 3 m/s accuracy which is in principle possible with this setup (Butler et al. 1996). The pipeline described by Butler et al. (1996) is used. A template iodine spectrum and a template spectrum of the target star obtained without an iodine cell in the lightpath are used to model the stellar observations obtained with an iodine cell in the lightpath. The Doppler shift is a free parameter in this model and determined as the shift of the template stellar spectrum to obtain the best model for the observed spectra. With this method the radial velocity itself is not measured. Only the change in the radial velocity with respect to the stellar template is obtained with a precision of a few m/s. The mean radial velocities of the stars are known with an accuracy of the order of a few tenths of km s^{-1} from for instance Famaey et al. (2005) and Barbier-Brossat & Figon (2000). The radial velocities from Famaey et al. (2005) were obtained with the CORAVEL spectrovelocimeter mounted on the swiss 1 m-telescope at the Observatoire Haute Provence, France. These are more accurate than the ones from Barbier-Brossat & Figon (2000), but not available for all stars in our sample. The latter is an extension of the WEB Catalog of Radial Velocities (Duflot et al. 1995).

3. Results

34 stars out of the sample of 179 stars have an observed standard deviation of the radial velocity of less than 20 m/s. The exact value of this threshold is somewhat arbitrary. It is set by a visual inspection of the radial velocity variations observed in our sample. Stars without systematic radial velocity variations or trends all happen to have an observed standard deviation of the radial velocity of less than 20 m/s. Furthermore, selecting reference stars for SIM PlanetQuest with radial velocity variations smaller than 20 m/s would result in an acceptable 3.6% contamination of the reference star grid with binary stars

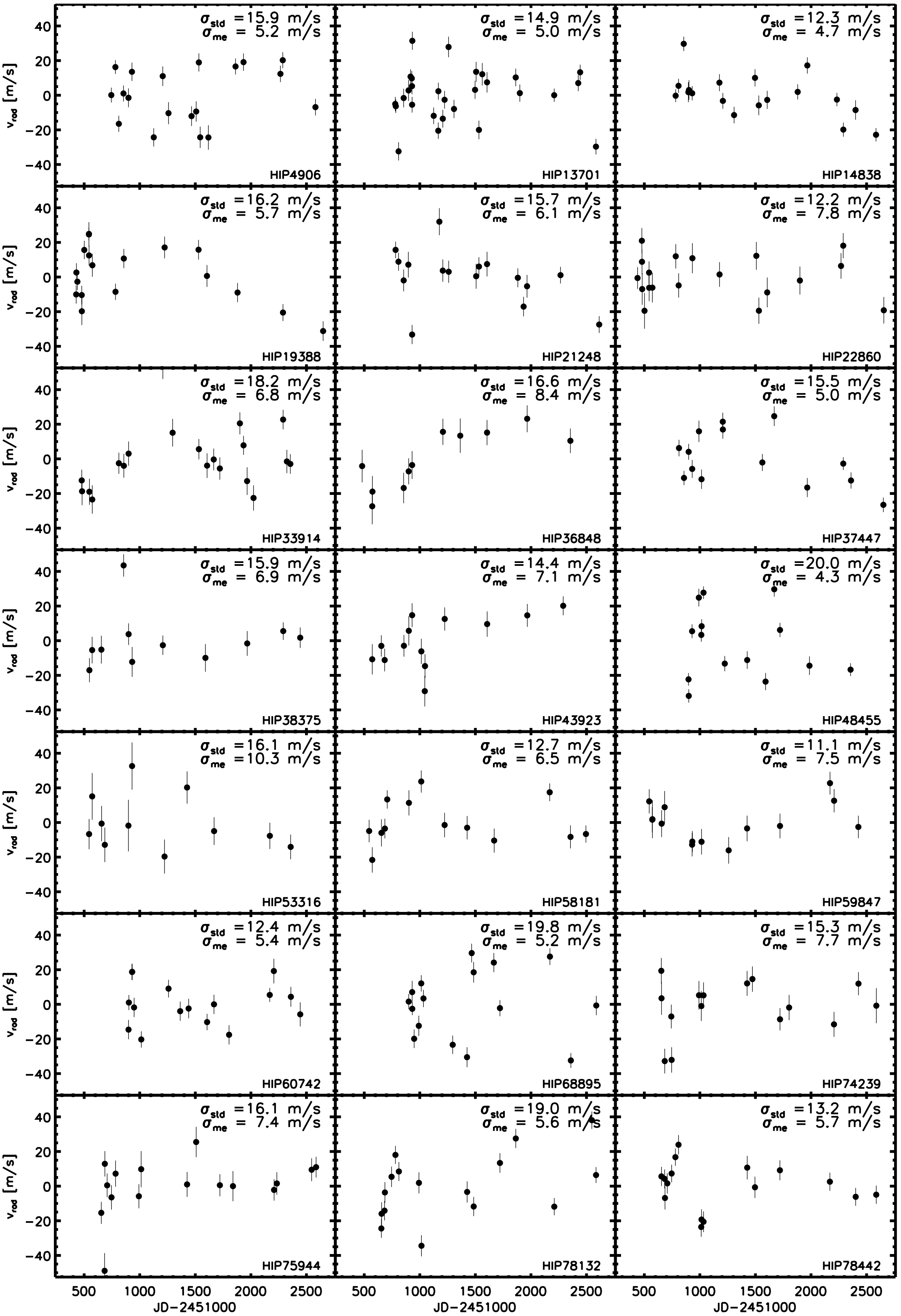

Fig. 1. Radial velocity variations with an arbitrary zero point as a function of Julian date for the first 21 stars. The numbers in the upper right corner of each frame are the observed standard deviation ($\sigma_{\rm std}$, upper number) and the mean error ($\sigma_{\rm me}$, lower number) of the radial velocity observations. The Hipparcos catalog number is plotted in the lower right corner of each frame.

(Frink et al. 2001). Plots of the radial velocity variation are shown in Fig. 1. The numbers in the upper right corner of each frame denote the observed standard deviation ($\sigma_{\rm std}$, upper number) and the mean error ($\sigma_{\rm me}$, lower number) of the radial velocity observations. The latter is derived from the rms scatter of hundreds of individual "chunks" of the spectrum, typically

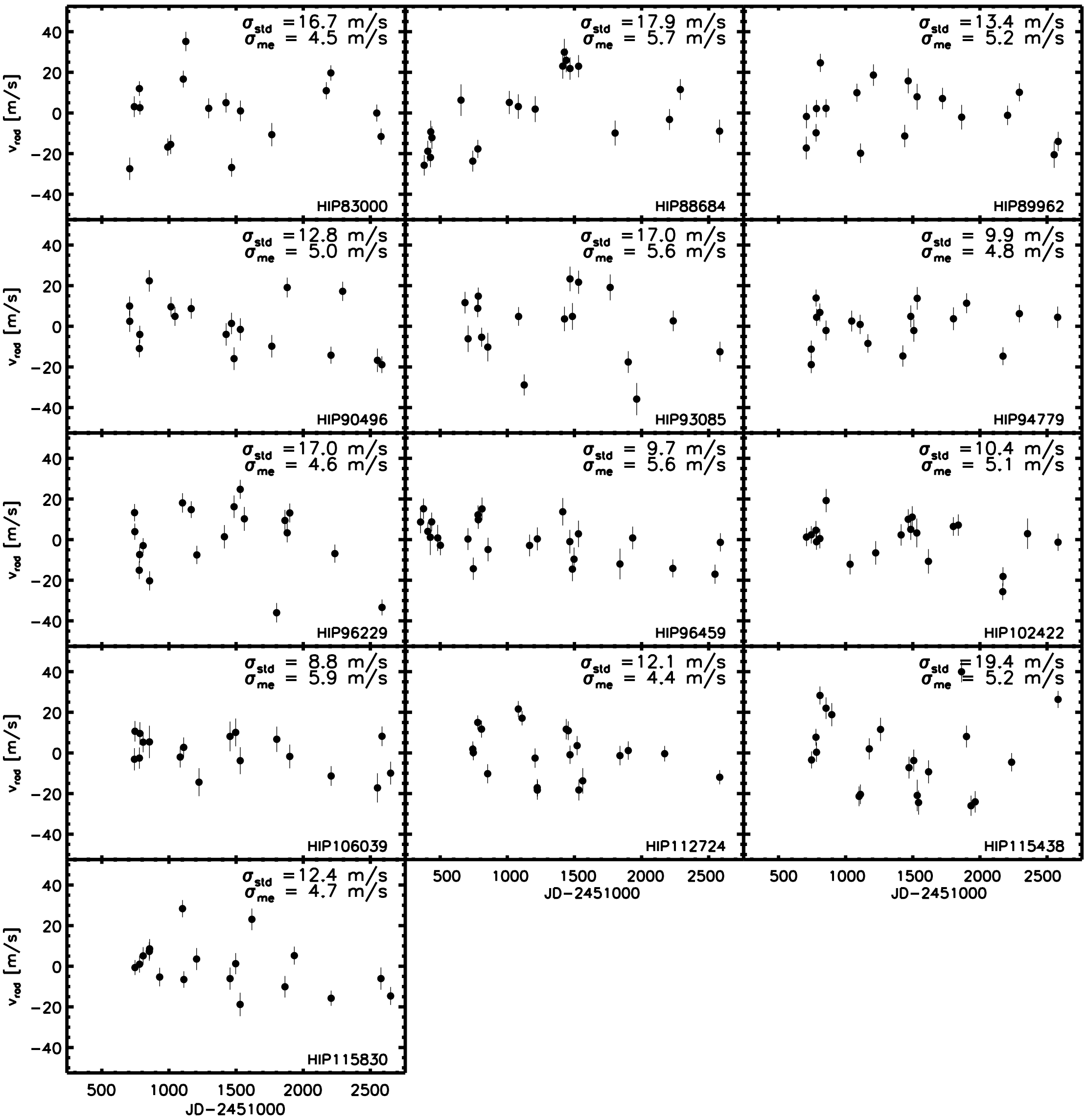

Fig. 1. continued for stars 22–34.

2 Å. In Table 2, for each of the 34 stable stars the mean error, number of observations, and timespan of the observations in this survey are listed together with the observed standard deviation, intrinsic standard deviation (which is obtained by quadratically subtracting the mean error from the total observed radial velocity scatter), and the reduced χ^2. Furthermore a flag is set to K for stars also present among the 3967 candidate standards presented by Kharchenko et al. (2004). In case the flag is set to N, there are not enough observations in Kharchenko et al. (2004) to make it a radial velocity standard candidate, but all other parameters do match their stability criteria.

All other stars in the sample show radial velocity variations larger than 20 m/s. Around one star a substellar companion has been discovered (ι Draconis, Frink et al. 2002). The highly non-sinusoidal radial velocity variation observed for this star can only be induced by a companion with high eccentricity and not by stellar activity. This star also shows a long-term trend indicating a third component in the system. About 23 spectroscopic binaries are present. Some are already known in the literature, but some were not observed before and will be presented in a forthcoming paper (Reffert et al. 2006). Furthermore, about 35 stars with sinusoidal periodic variations are present (Hekker et al. 2006), among which four show an additional long trend indicating a binary in a wide orbit. The nature of these sinusoidal periodic variations is under investigation. For at least four stars there are strong arguments that the presence of nearly sinusoidal variations of the radial velocity are most likely caused by substellar companions (Mitchell et al. 2006). Two of the stars with very large radial velocity variations of several km s^{-1} appear to be supergiants. A summary of the whole program is presented in Mitchell et al. (2006).

4. Discussion and conclusions

To obtain more information on the type of stars that appear to be stable, all 179 stars from this survey are plotted in an M_V vs. $B-V$ diagram, see Fig. 2. A box is drawn around the stable stars. The box contains 11 binaries, three variable stars with long trends indicating that they are binaries, and 73 other stars among which the 34 stable stars. The binaries and variable stars with a long trend are excluded in the further discussion.

The stable stars are not homogeneously distributed in the M_V vs. $B-V$ diagram but they all have a $B-V$ color less than 1.2. This is shown in Fig. 3, where the standard deviation of the

Table 2. Observational results of the 34 stable stars: the mean error of the individual observations for each star in m/s, the number of observations (N), the time span of the observations in days, the standard deviation of the radial velocity (σ) in m/s, the intrinsic scatter ($\sigma_{\rm int}$) obtained by quadratically subtracting the mean error from the total observed radial velocity scatter, the reduced χ^2 and a flag. This flag is set to K for all stars also present among the 3967 candidate standards presented by Kharchenko et al. (2004). The flag is set to N for the stars with less than 4 observations in Kharchenko et al. (2004) which do otherwise match their criteria. If the flag is blank a photometric variability flag is present in the Tycho 1 catalog (ESA 1997) and these stars are therefore not included in the Kharchenko et al. (2004) candidate standard star catalog. More details about the selection method used by Kharchenko et al. (2004) are described in the text.

HIP	HD	Mean error [m/s]	N	Timespan [days]	σ [m/s]	$\sigma_{\rm int}$ [m/s]	$\chi^2_{\rm r}$	Flag
HIP 4906	HD 6186	5.2	19	1837	15.9	15.0	9.2	
HIP 13701	HD 18322	5.0	28	1806	14.9	14.0	8.6	
HIP 14838	HD 19787	4.7	18	1803	12.3	11.4	8.3	
HIP 19388	HD 26162	5.7	18	2222	16.2	15.2	7.6	K
HIP 21248	HD 29085	6.1	16	1832	15.7	14.5	7.5	
HIP 22860	HD 31414	7.8	19	2216	12.2	9.4	2.4	N
HIP 33914	HD 52556	6.8	20	1877	18.2	16.9	6.6	K
HIP 36848	HD 60666	8.4	11	1874	16.6	14.3	3.8	K
HIP 37447	HD 61935	5.0	14	1839	15.5	14.7	9.6	
HIP 38375	HD 64152	6.9	11	1897	15.9	14.3	5.8	N
HIP 43923	HD 76291	7.1	13	1718	14.4	12.5	4.1	K
HIP 48455	HD 85503	4.3	14	1458	20.0	19.5	23.6	
HIP 53316	HD 94481	10.3	11	1814	16.1	12.4	2.3	N
HIP 58181	HD 103605	6.5	13	1951	12.7	10.9	4.2	K
HIP 59847	HD 106714	7.5	14	1882	11.1	8.2	2.6	K
HIP 60742	HD 108381	5.4	16	1545	12.4	11.2	5.8	
HIP 68895	HD 123123	5.2	16	1688	19.8	19.1	14.9	
HIP 74239	HD 134373	7.7	15	1935	15.3	13.2	4.5	K
HIP 75944	HD 138137	7.4	16	1933	16.1	14.3	3.3	N
HIP 78132	HD 142980	5.6	16	1932	19.0	18.2	12.0	K
HIP 78442	HD 143553	5.7	16	1933	13.2	11.9	5.4	N
HIP 83000	HD 153210	4.5	17	1872	16.7	16.1	13.4	
HIP 88684	HD 165438	5.7	20	2200	17.9	17.0	10.8	N
HIP 89962	HD 168723	5.2	18	1876	13.4	12.4	7.0	
HIP 90496	HD 169916	5.0	18	1879	12.8	11.8	7.0	
HIP 93085	HD 175775	5.6	17	1899	17.0	16.1	8.4	
HIP 94779	HD 181276	4.8	18	1835	9.9	8.7	4.7	
HIP 96229	HD 184406	4.6	19	1843	17.0	16.4	14.3	
HIP 96459	HD 185351	5.6	25	2233	9.7	7.9	3.4	K
HIP 102422	HD 198149	5.1	20	1874	10.4	9.1	4.8	
HIP 106039	HD 204381	5.9	18	1908	8.8	6.5	2.1	
HIP 112724	HD 216228	4.4	20	1839	12.1	11.3	8.2	K
HIP 115438	HD 220321	5.2	21	1836	19.4	18.7	14.7	K
HIP 115830	HD 220954	4.7	18	1904	12.4	11.5	7.2	K

radial velocity is plotted as a function of $B-V$ color. The majority of the bluer stars show smaller variations in the radial velocity than the redder ones. This increase of the radial velocity variability with $B-V$ color, first described by Frink et al. (2001), is consistent with similar trends of photometry and radial velocity variability with spectral type (Hatzes & Cochran 1998; Larson et al. 1999; Nidever et al. 2002). These results are also in good agreement with the results by Henry et al. (2000). They obtained photometric observations of 187 G, K and M 0 field giants and show that "stable" giants with a short-term standard deviation less than 0.0020 mag have a $B-V$ less than 1.35. They note that nearly all stable giants are on the left side of the coronal dividing line (CDL). The CDL separates the giants with hot coronae on the left from giants with cool, massive winds on the right (Linsky & Haisch 1979; Haisch 1999).

4.1. *Statistics*

In Fig. 4, a histogram of the standard deviation of the radial velocity from the stars in the box (Fig. 2) is shown. Nearly half of the stars have a radial velocity with a standard deviation less than 20 m/s, 90% less than 50 m/s and 96% less than 100 m/s. By selecting stars from the region in the color–magnitude diagram outlined by this box, it is thus possible to construct samples of K giants with small radial velocity variations.

4.2. *Variability*

For each star the standard deviation of the observed radial velocities, although small, is significantly larger than the measurement errors, which implies that the stars show low-level radial velocity variations. To quantify this a χ^2 test is performed to obtain the probability of the reality of this variability. The reduced χ^2 values are listed in Table 2. 31 of the 34 stars have a >99.9% probability of variability, for the other 3 the probability is >99%. The presence of variability is consistent with the findings of Barban et al. (2004) who detected solar-like oscillations in two red giant stars. One of these stars, HIP 89962/HD 168723, is also present in our sample. They observed short time scale variations and interpreted these as p-mode pulsations. The radial velocity observations by Barban et al. (2004) have approximately the same amplitude as observed in the present survey. This indicates that

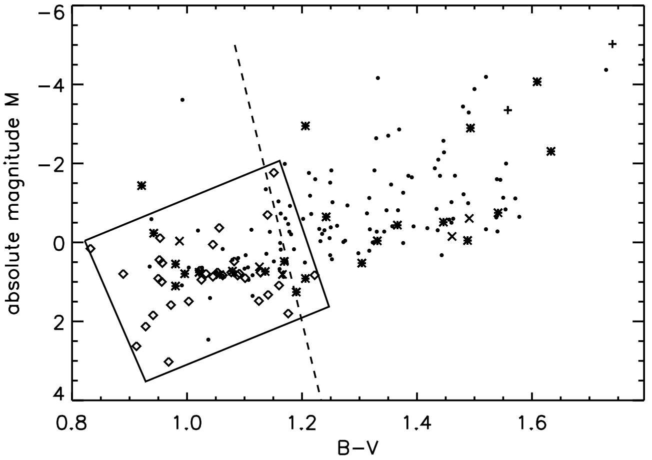

Fig. 2. M_V vs. $B-V$ diagram with all 179 stars in the survey. The diamonds represent the stable stars, the asterisks represent the binaries, the crosses the variable stars with a long trend, the plus-signs are two supergiants with large, random radial velocity variations, and the dots are all other stars. The box is drawn around the stable stars and contains 11 binaries, 3 variable stars with a long trend, and 73 stars among which the 34 "stable" stars. The dashed line indicates the coronal dividing line (CDL) (Haisch 1999).

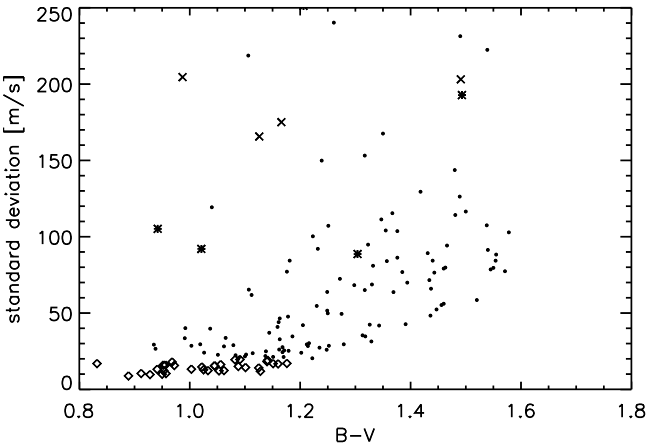

Fig. 3. Standard deviation of the radial velocity of the stars from the survey plotted as a function of $B-V$. Most stars with $B-V < 1.2$ show smaller variations in the radial velocity than the ones with $B-V > 1.2$. The symbols are the same as in Fig. 2. The stars with a standard deviation larger than 250 m/s, are not shown.

the small radial velocity variations in the "stable" K giants are likely p-mode pulsations in the atmospheres of these stars. These pulsations are much more rapid than the typical time sampling of our observations, and thus appear as scatter in our data.

As the standard deviation is larger for all other stars in the sample (not considered in this paper), we can infer that essentially all K giants show radial velocity variations on the level of a few m/s. Furthermore since all stars with a standard deviation less than 20 m/s are found in the box in Fig. 2 (by definition), which ranges roughly to $B-V = 1.2$, all stars redder than that show intrinsic variations larger than our threshold of 20 m/s.

4.3. Standard star sample

The stars presented in this paper can serve as an addition to the standard star sample presented by Udry et al. (1999a,b). Only one star (HIP 19388/HD 26162) from the present survey is present in their sample. They obtained 252 observations for this star with a timespan of 6993 days and found a velocity dispersion of 0.3 km s^{-1}. This is the precision level of their observations and thus consistent with stability. The 12 stars from the present survey with a flag set to K in Table 2 are also present among the 3967 candidate standards listed in Table 2 of Kharchenko et al. (2004). These candidate standards are selected based on the following criteria: no multiplicity or variability flag, standard errors of equatorial coordinates $\sigma < 40$ mas, standard errors of proper motions $\sigma_{\rm pm} < 4$ mas/yr, standard errors of V magnitude $\sigma_{m_V} < 0.05$ mag and $B-V$ color $\sigma_{B-V} < 0.07$ mag, standard errors of radial velocity $\sigma_{\rm RV} < 2$ km s^{-1}, and at least 4 radial velocity observations. The present observations could serve as a confirmation of their stability.

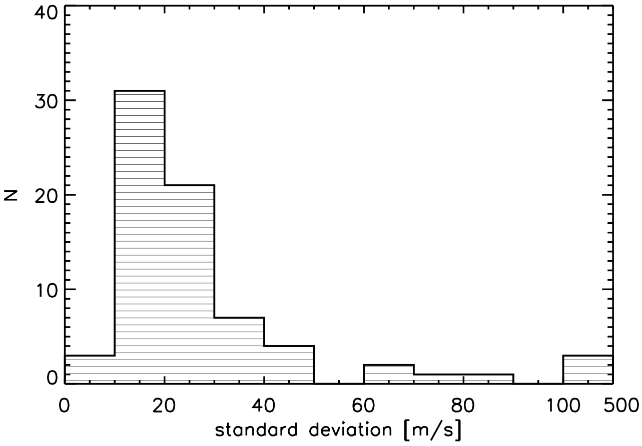

Fig. 4. Histogram of the observed standard deviations (including the contribution of the radial velocity errors) for the stars in the box in the M_V vs. $B-V$ diagram from Fig. 2. Binaries and the variable stars with a long trend are excluded. The stars in the highest bin have a standard deviation between 100 m/s and 500 m/s.

The stars for which the flag in Table 2 is set to N are stars which do not have enough radial velocity observations in Kharchenko et al. (2004) but do match all other criteria. The stars without a flag in Table 2 all have a photometric variability flag in the Tycho 1 catalog (ESA 1997), and are therefore not included in the Kharchenko et al. (2004) candidate standard star catalog. For details see the main catalog, Table 1 of the same publication. However, from the present observations no evidence for variability in the radial velocity larger than 20 m/s is found.

4.4. Reference stars

The results presented in this paper provide a refined answer to the question that originally motivated our radial velocity survey, namely whether K giants are suited as reference stars for the Space Interferometry Mission and other astrometric projects (see Frink et al. 2001, for details). K giants are in principle good reference stars because they are intrinsically bright. Therefore sub-stellar companions do not disturb their photocenters much, neither by contributing light to the system, nor through their gravitational influence. (Note that for a desired apparent magnitude intrinsically brighter stars can be selected at a large distance, so that the angular displacement due to companions remains small.) However, any sample of "anonymous" rather distant K giants will contain a large fraction of binaries with stellar secondaries, which may lead to problems for astrometry. Our data demonstrate that binaries with a radial velocity amplitude of a few tens of m/s can be identified readily with only a small number of high precision spectroscopic observations, provided that the giants chosen are not too red or too luminous. This reinforces the conclusion already drawn by Frink et al. (2001) that K giants are indeed good astrometric reference stars, and validates the grid star strategy adopted by the SIM PlanetQuest project.

4.5. Substellar companions and pulsations

The radial velocity variations on the level of a few m/s are interesting for oscillation studies. With the present observations we show that they are observable in data with a precision of a few m/s. The time sampling of our observations is not suitable to obtain periods, but with campaigns taking multiple observations during each night this should be possible. Due to the fact that the oscillations appear on a level of a few m/s and with short periods it is also possible to search for (substellar) companions around these stars which can have larger radial velocity variations on longer timescales.

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