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A Search for Exoplanets around Northern Circumpolar Stars VI. Detection of Planetary Companions Orbiting the Giants HD 60292 and HD 112640

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Abstract: We report the detection of exoplanet candidates in orbits around HD 60292 and HD 112640 from a radial velocity (RV) survey. The stars exhibit RV variations with periods of 495 ± 3 days and 613 ± 6 days, respectively. These detections are part of the Search for Exoplanets around Northern Circumpolar Stars (SENS) survey using the fiber-fed Bohyunsan Observatory Echelle Spectrograph installed at the 1.8-m telescope of the Bohyunsan Optical Astronomy Observatory in Korea. The aim of the survey is to search for planetary or substellar companions. We argue that the periodic RV variations are not related to surface inhomogeneities; rather, Keplerian motions of planetary companions are the most likely interpretation. Assuming stellar masses of $1.7 \pm 0.2 M_\odot$ (HD 60292) and $1.8 \pm 0.2 M_\odot$ (HD 112640), we obtain minimum planetary companion masses of $6.5 \pm 1.0 M_{\rm Jup}$ and $5.0 \pm 1.0 M_{\rm Jup}$, and periods of 495.4 ± 3.0 days and 613.2 ± 5.8 days, respectively.

Key words: planetary systems — stars: individual: HD 60292; HD 112640 — techniques: radial velocities

1. Introduction

Since the discovery of the first exoplanet around a main-sequence (MS) star (Mayor & Queloz 1995) using the radial velocity (RV) method, approximately 300 exoplanets were found in the same way until 2010. During the 15 years of this early stage of the RV method, Sun-like dwarf stars were the major targets because of the benefits of analysis they provide compared with giant stars. Giants may present more complex RV variations because of various surface processes that affect spectral line profiles: stellar pulsations, chromospheric activities, spots, and large convection cells.

In 2010, a new program, the Search for Exoplanet around Northern circumpolar Stars (SENS; Lee et al. 2015), was started. The main goal of SENS is to observe stars that are accessible around the year in order to have better sampling for our targets and thus increase the planet detection efficiency. Almost all of the targets are giant stars (Section 2 in Lee et al. 2015). From the SENS survey, we detected 20 planetary companions (Lee et al. 2015; Lee et al. 2017; Bang et al. 2018; Jeong et al. 2018) and several periodic RV variations probably due to processes other than orbital motions around G-, K-, and M-giant stars. Lack of knowledge about planet formation and evolution makes RV surveys of giant stars an important endeavor.

In this paper, we report the detection of low-amplitude and long-period RV variations in HD 60292 and HD 112640, possibly caused by a planetary companion. In Section 2, we describe the observations and data reduction. In Section 3, the stellar characteristics of the host stars are derived. The measurements of RV variations and their possible origins are presented in Sections 4 and 5. Finally, in Section 6, we discuss our results.

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2. Observations and Data Reduction

The observations were obtained as a part of the exoplanet survey of the SENS program. The fiber-fed, high-resolution ($R = 45\,000$) Bohyunsan Observatory Echelle Spectrograph (BOES; Kim et al. 2007) installed at the 1.8-m telescope of BOAO, Korea, was used. In order to provide precise RV measurements, an iodine absorption (I_2) cell was used with a wavelength region of 4900–6000 Å. The average signal-to-noise (S/N) for the I_2 region was about 150 at typical exposure times ranging from 15 to 20 minutes.

We obtained 30 (HD 60292) and 28 (HD 112640) spectra from 2009 to 2019. The basic reduction of spectral data was done using the IRAF software package and the precise RV measurements related to the I_2 analysis were implemented using the RVI2CELL (Han et al. 2007) code, which is based on the method by Butler et al. (1996) and Valenti et al. (1995).

The long-term stability of the BOES was demonstrated with observations of the RV standard star τ Ceti.

Table 1
RV measurements of HD 60292 from February 2010 to April 2019.

JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)	JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)	JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)
5248.145727	−127.7	15.0	7527.992273	108.5	15.8	8148.066892	−35.7	14.9
5277.085340	−147.6	17.1	7676.359815	−44.0	15.6	8151.161235	−15.1	24.9
5844.338471	26.0	12.2	7705.130424	−75.5	14.8	8277.997266	−119.4	34.3
6288.274108	−90.4	12.1	7758.056809	−99.4	17.3	8290.984081	−19.0	19.3
6620.140717	61.2	13.2	7820.021457	−40.1	13.4	8370.312680	67.1	19.9
6740.035182	−145.2	13.8	7856.096216	4.1	15.9	8422.175121	66.6	17.6
6823.996642	−78.8	16.3	7896.007832	75.7	16.6	8451.303967	87.2	16.2
6972.300781	173.9	14.9	8052.184820	44.9	13.2	8473.010321	82.8	17.0
7066.236207	191.4	17.3	8052.301831	30.4	13.3	8516.003745	6.5	17.6
7302.298077	−109.4	12.4	8092.172561	30.6	16.2	8577.012946	89.0	15.1

Table 2
RV measurements of HD 112640 from December 2009 to May 2019.

JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)	JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)	JD−2450000 (Days)	ΔRV ($\mathrm{m\,s^{-1}}$)	$\pm\sigma$ ($\mathrm{m\,s^{-1}}$)
5171.293230	115.4	14.6	7528.017873	119.0	9.4	8291.035273	16.9	12.3
5225.249646	153.3	16.4	7820.041391	−100.5	10.8	8369.980304	−98.4	13.8
5277.154579	73.6	14.3	7896.074337	−82.8	9.9	8423.327329	−93.2	12.0
6426.057858	98.5	8.9	8052.317284	−23.2	10.7	8451.326479	−141.6	15.4
6740.149723	13.9	12.4	8093.221608	−40.8	10.7	8473.212945	−171.5	12.1
6824.015415	34.6	8.3	8151.265260	25.6	16.3	8531.133694	−42.5	10.5
6972.315804	121.4	10.0	8234.268721	7.0	10.8	8532.142302	−99.5	10.9
7093.246045	−12.2	13.4	8278.016400	36.4	11.8	8627.033024	−11.7	11.0
7093.986619	56.0	14.5	8287.982494	47.0	10.5			
7148.243269	−32.9	11.6	8290.066408	32.2	10.9			

RVs measured by the BOES are constant with an rms scatter of $\sim 7\ \mathrm{m\,s^{-1}}$ (Lee et al. 2013). The RV measurements for HD 60292 and HD 112640 are listed in Tables 1 and 2.

3. STELLAR CHARACTERISTICS

Generally, long-period, low-amplitude RV variations caused by surface activities can occur in evolved stars. Thus, investigation of the stellar characteristics is crucial for identifying the origin of any RV variations. The main photometric parameters for HD 60292 (HIP 37196) and HD 112640 (HIP 63203) were acquired from the *HIPPARCOS* catalog (ESA 1997). The astrometric parallax (π) was taken from the Gaia database (Gaia Collaboration et al. 2018). We determined stellar parameters directly from our spectra by measuring 170 (HD 60292) and 154 (HD 112640) equivalent widths (EW) of Fe I and Fe II lines. We found $T_{\rm eff} = 4348 \pm 28$ K, $[\mathrm{Fe/H}] = -0.17 \pm 0.05$, $\log g = 1.9 \pm 0.1$, and $v_{\rm micro} = 1.7 \pm 0.1\ \mathrm{km\,s^{-1}}$ for HD 60292, and $T_{\rm eff} = 4155 \pm 15$ K, $[\mathrm{Fe/H}] = -0.09 \pm 0.07$, $\log g = 1.7 \pm 0.1$, and $v_{\rm micro} = 1.5 \pm 0.1\ \mathrm{km\,s^{-1}}$ for HD 112640, respectively, using the software program TGVIT (Takeda et al. 2005).

The planet mass is rather uncertain due to differences in masses of the host stars as measured by different methods or authors. Tetzlaff et al. (2011) derived values for age and mass of HD 60292 which are significantly different from ours. They assumed luminosity class V for some stars with unknown luminosity class; thus, the K giant HD 60292 was misidentified as a K dwarf star.

HD 60292 has been known to be of spectral type K0 (ESA 1997) and an apparent magnitude of 6.95. Its absolute magnitude of −0.6 suggests that it is a giant star. The values of the stellar gravity and radius are consistent with those of a giant star. Likewise, the surface gravity of HD 112640 is consistent with that of a giant but inconsistent with a dwarf. Our new estimations of stellar parameters suggest that both HD 60292 and HD 112640 are K giant stars.

In evolved stars, estimating rotational periods is important for distinguishing RV variations from rotational modulation because long-period RV variations with low amplitude may stem from stellar rotation modulation (Lee et al. 2008; Lee et al. 2012a). In order to calculate the stellar rotational velocity, a line-broadening model (Takeda et al. 2008) was used. For the determination of line broadening, we used the automatic spectrum-fitting technique (Takeda 1995). We estimated rotational velocities $v_{\rm rot}\sin(i) = 3.4\ \mathrm{km\,s^{-1}}$ for HD 60292 and $v_{\rm rot}\sin(i) = 3.6\ \mathrm{km\,s^{-1}}$ for HD 112640. Using the rotational velocities and the stellar radii, we derived upper limits for the rotational periods $P_{\rm rot} = 2\pi R_\star/[v_{\rm rot}\sin(i)]$ of 400 days for HD 60292 and 545 days for HD 112640. Table 3 summarizes the basic stellar parameters.

Table 3
Stellar parameters for HD 60292 and HD 112640 assumed in this work.

Parameter	Unit	HD 60292	HD 112640	Reference
Spectral type		K0	K0	*HIPPARCOS* ESA (1997)
		K0 III	K0 III	This work
m_v	mag	6.95	6.54	*HIPPARCOS* ESA (1997)
M_v	mag	−0.6	−0.8	This work
B-V	mag	1.315 ± 0.010	1.408 ± 0.007	*HIPPARCOS* ESA (1997)
age	Gyr	0.63 ± 0.24	—	Tetzlaff et al. (2011)
	Gyr	1.8 ± 0.5	1.6 ± 0.3	This work
d	pc	328.9	296.7	McDonald et al. (2017)
RV	km s^{-1}	−12.7 ± 0.1	−12.36 ± 0.15	Gaia Collaboration et al. (2018)
π	mas	3.14 ± 0.03	3.06 ± 0.02	Gaia Collaboration et al. (2018)
$T_{\rm eff}$	K	4348 ± 28	4155 ± 15	This work
[Fe/H]	dex	−0.17 ± 0.05	−0.09 ± 0.07	This work
log g	cgs	1.9 ± 0.1	1.7 ± 0.1	This work
$v_{\rm micro}$	km s^{-1}	1.7 ± 0.1	1.5 ± 0.1	This work
$R_\star$	$R_\odot$	27.0 ± 1.5	39.0 ± 5.0	Gaia Collaboration et al. (2018)
$M_\star$	$M_\odot$	1.7 ± 0.2	1.8 ± 0.2	This work
	$M_\odot$	6.3 ± 0.5	—	Tetzlaff et al. (2011)
$L_\star$	$L_\odot$	247.8	283.5	McDonald et al. (2017)
$v_{\rm rot}$ sin(i)	km s^{-1}	3.4 ± 0.3	3.6 ± 0.2	This work
$P_{\rm rot}$ / sin(i)	days	400	545	This work

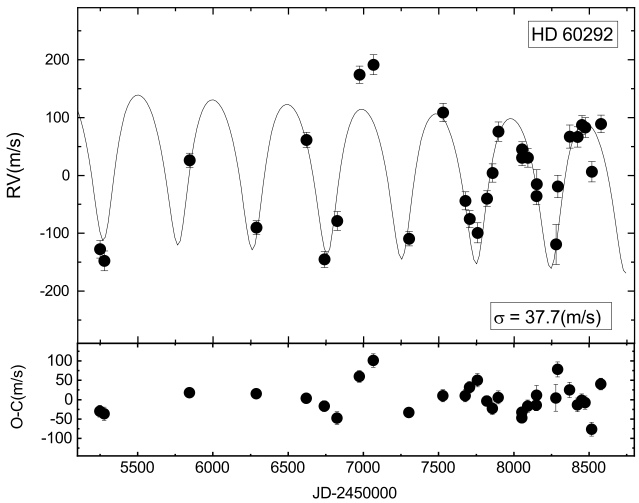

Figure 1. RV measurements (top) and the residuals (bottom) of HD 60292 from 2010 to 2019. The solid line is the orbital solution with a period of 495.4 days.

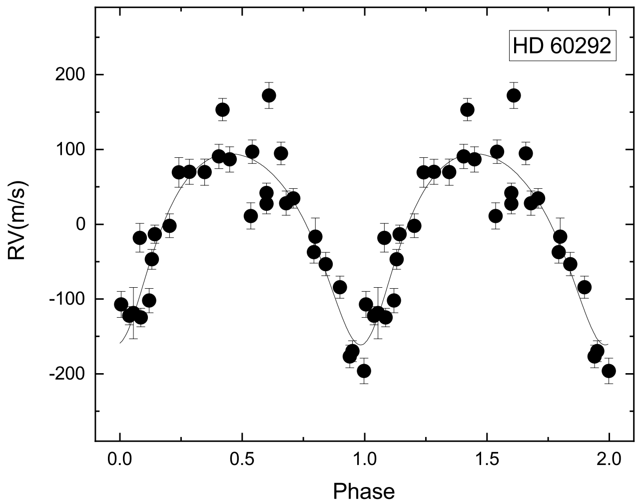

Figure 2. Phase diagram for HD 60292. The solid line indicates the best Keplerian fit.

4. Orbital Solutions from Radial Velocities

In order to find periodicities in the RV time series, we used the Lomb-Scargle (L-S) periodogram (Lomb 1976; Scargle 1982), which is appropriate for analyzing long-term variability in unequally spaced data. We determined the orbital elements by fitting the RV with Keplerian orbit models in the Systemic Console 2 software (Meschiari et al. 2009). We estimated the parameter uncertainties using the bootstrap routine within Systemic Console 2 with 10 000 synthetic data set realisations. The RV measurements and the RV phase diagrams for the orbit are shown in Figures 1–4. The best-fit Keplerian orbits have periods of 495.4 ± 3.0 days for HD 60292 and 613.2 ± 5.8 days for HD 112640. The corresponding semi-amplitudes K are 120.0 ± 15.3 m s^{-1} for HD 60292 and 83.0 ± 8.5 m s^{-1} for HD 112640. There are no significant periodic residuals left in the data after subtracting the main period (top panels in Figures 5 and 6). Assuming stellar masses of 1.7 ± 0.2 $M_\odot$ (HD 60292) and 1.8 ± 0.2 $M_\odot$ (HD 112640), we find minimum masses of a planetary companions of 6.5 ± 1.0 $M_{\rm Jup}$ at a distance from the host star $a = 1.5$ au for HD 60292, and 5.0 ± 1.0 $M_{\rm Jup}$ at $a = 1.7$ au for HD 112640. All orbital elements are listed in Table 4.

5. Origin of Radial Velocity Variations

Evolved stars often exhibit pulsations as well as surface activity, which result in low-amplitude periodic RV

Table 4
Orbital parameters for HD 60292b and HD 112640b.

Parameter	Unit	HD 60292	HD 112640
Period	days	495.4 ± 3.0	613.2 ± 5.8
$T_{\rm periastron}$	JD	2455773.7 ± 19.4	2455300.4 ± 38.8
K	m s^{-1}	120.0 ± 15.3	83.0 ± 8.5
e	—	0.27 ± 0.1	0.24 ± 0.18
ω	deg	83.5 ± 14.2	114.4 ± 22.8
slope	m s^{-1} day^{-1}	-1.6×10^{-6}	2.9×10^{-3}
$N_{\rm obs}$	—	30	28
σ (O-C)	m s^{-1}	37.7	29.3
$M_\star$	$M_\odot$	1.7 ± 0.2	1.8 ± 0.2
$m \sin(i)$	$M_{\rm Jup}$	6.5 ± 1.0	5.0 ± 1.0
a	au	1.5 ± 0.1	1.7 ± 0.1

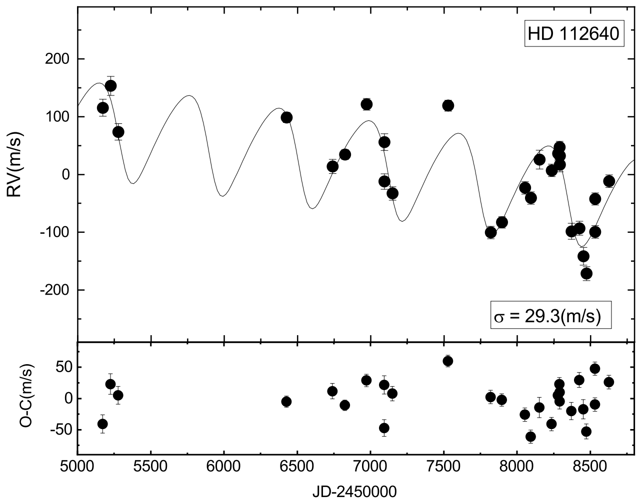

Figure 3. RV measurements (top) and the residuals (bottom) of HD 112640 from 2010 to 2019. The solid line is the orbital solution with a period of 613.2 days.

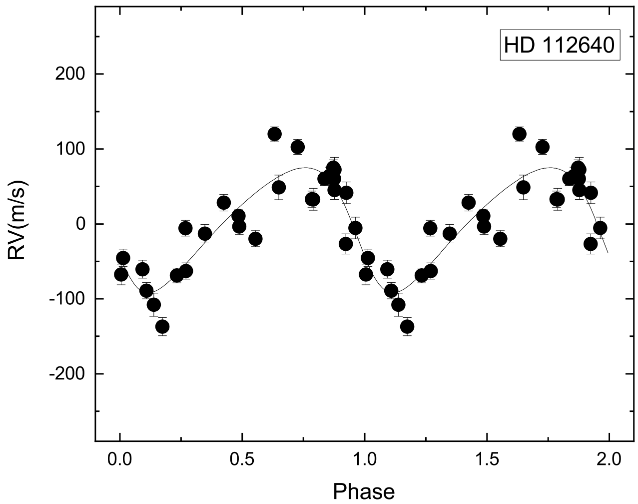

Figure 4. Phase diagram for HD 112640. The solid line indicates the best Keplerian fit.

variations. Generally, short-term RV variations with low amplitudes have been known to be the result of stellar pulsations (Hatzes & Cochran 1998), while long-term RV variations may be caused by three kinds of phenomena: stellar pulsation, rotational modulation of inhomogeneous surface features, or planetary (substellar) companions. In order to establish the origin of the RV variations for HD 60292 and HD 112640, we analyzed *HIPPARCOS* light curves, spectral line bisectors, and stellar chromospheric activity.

5.1. Light Curves

In order to search for brightness variations caused by rotational modulation of cool stellar spots or pulsations, we analyzed the *HIPPARCOS* photometry data. The available photometry database comprises 106 (HD 60292) and 140 (HD 112640) *HIPPARCOS* measurements from 1990 to 1993. The rms photometric errors were 0.013 mag for HD 60292 and 0.011 mag for HD 112640, corresponding to relative flux variations of 0.18% and 0.16% over the time span of the observations, respectively. The "*HIPPARCHOS*" panels of Figures 5 and 6 show the L-S periodograms of the light curves, showing no significant periodic variations.

5.2. Line Bisectors

RV variations due to planetary companions are not supposed to affect the shape of spectral lines. This distinguishes them from rotational modulations of stellar surface inhomogeneities which can cause variable asymmetries in spectral line profiles Queloz et al. (2001).

To investigate spectral line profile variations, we calculated (a) the RV difference of the central values at high and low flux levels of the line profiles (BVS; bisector velocity span), and (b) the difference of the velocity span of the upper half and lower half of the bisectors (BVC; velocity curvature)(Hatzes et al. 2005; Lee et al. 2013). For calculating bisectors, we selected two unblended strong lines, Fe I 6358.7 Å and Ni I 6767.8 Å, in the spectrum of HD 60292, and three unblended strong lines, Fe I 6065.5 Å, Fe I 6421.3 Å, and Ni I 6767.8 Å, in the spectrum of HD 112640 that are located beyond the I_2 absorption region. To avoid the line core and wings, the BVS of a given line was measured using the line profiles at flux levels of 0.4 and 0.8 times the central

Table 5
Bisector measurements of HD 60292 and HD 112640.

HD 60292			HD 112640		
JD−2450000 (Days)	BVS ($m\,s^{-1}$)	BVC ($m\,s^{-1}$)	JD−2450000 (Days)	BVS ($m\,s^{-1}$)	BVC ($m\,s^{-1}$)
5248.146	15.61	−37.97	5171.293	7.56	−37.52
5277.085	−34.50	84.45	5225.250	−44.37	−34.74
5844.338	−5.92	−21.57	5277.155	−52.7	24.88
6288.274	−86.76	49.27	6426.058	−58.6	−21.59
6620.141	−62.70	23.54	6740.150	5.89	−5.25
6740.035	−63.47	−24.52	6824.015	−26.0	38.66
6823.997	13.57	−36.48	6972.316	−8.42	−0.32
6972.301	33.22	56.91	7093.246	−7.84	−40.51
7066.236	204.64	−59.72	7093.987	49.15	19.06
7302.298	−51.39	−11.03	7148.243	0.713	46.35
7527.992	−45.75	22.03	7528.018	−7.97	−6.74
7676.360	−47.42	−44.45	7820.041	6.43	40.94
7705.130	−34.88	−28.5	7896.074	−30.7	20.68
7758.057	−11.75	43.1	8052.317	−17.1	21.91
7820.021	28.37	−16.78	8093.222	3.656	−72.59
7856.096	−49.62	39.375	8151.265	27.80	−14.31
7896.008	83.29	−11.53	8234.269	11.04	12.98
8052.185	−51.7	12.74	8278.016	16.58	−16.17
8052.302	−23.4	−12.64	8287.982	15.96	36.64
8092.173	−8.98	11.85	8290.066	54.76	14.26
8148.067	137.08	1.81	8291.035	−14.6	23.17
8151.161	115.91	87.43	8369.980	−20.05	−23.38
8277.997	17.58	−61.81	8423.327	5.163	18.41
8290.984	−66.05	35.125	8451.326	−13.2	11.81
8370.313	−30.22	−20.53	8473.213	−1.83	−5.841
8422.175	−74.02	−49.55	8531.134	58.27	25.81
8451.304	−84.29	9.71	8532.142	40.8	−76.49
8473.010	40.018	−49.49			
8516.004	143.62	9.42			

depth as span points. The average BVS and BVC were computed using the bisector measurements of several spectral lines after subtracting the mean value for each spectral line. Table 5 shows the averaged BVS and BVC values for each star. Figures 5 and 6 (third panels from top) show the LS periodograms of the BVS and BVC time series. None of the parameters shows significant periodic variability.

5.3. Chromospheric Activity

The EW variations of Ca II H&K, H_α, H_β, and the Ca II triplet lines (Larson et al. 1993) are usually used as indicators of chromospheric activity. Such activity could have a significant effect on the RV variations. Ca II H&K is emitted in the chromosphere; the core of the spectral line often exhibits central reversal in the presence of chromospheric activity (Saar & Donahue 1997). Unfortunately, the signal-to-noise ratio of our data is insufficient to resolve the emission features in the Ca II H&K line cores for both stars. The Ca II triplets are not suitable either because of fringing and saturation of our CCD spectra at wavelengths above 8000 Å.

Thus, we use the H_α and H_β lines in this study. We measured the H line EWs using a band pass of ±1.0 Å centered on the line core to avoid nearby blending lines and weak telluric lines. We find mean H_α EWs of 1179.03 ± 1.76 mÅ for HD 60292 and 1213.15 ± 1.75 mÅ for HD 112640. The mean EWs of the H_β lines are 892.07 ± 1.16 mÅ for HD 60292 and 981.55 ± 0.99 mÅ for HD 112640. The H_α and the H_β EWs show rms variations with time of less than 0.2% for both stars. L-S periodograms of the H line EW time series are shown in the bottom panels of Figures 5 and 6. There are no significant excesses in spectral power around 495.4 days (HD 60292) and 613.2 (HD112640) days. Table 6 lists our H line EW measurements.

6. Discussion

The analysis of the RV measurements for HD 60292 and HD 112640 revealed low-amplitude variations with periods of 495.4 days and 613.2 days, respectively, that persisted over six cycles between 2009 and 2019 in both cases. Low-amplitude and long-term – referring to periods longer than a few hundred days – RV variations in evolved stars, may be caused by stellar pulsations, rotational modulations of inhomogeneous surface features, or planetary (substellar) companions.

Of these, variations by pulsations are unlikely because the period of the fundamental radial mode is of the order of days. We calculated the expected pulsation

Table 6
H line EW measurements of HD 60292 and HD 112640.

HD 60292			HD 112640		
JD−2450000 (Days)	H_α EW (mÅ)	H_β (mÅ)	JD−2450000 (Days)	H_α (mÅ)	H_β (mÅ)
5248.146	1180.643	891.644	5171.293	1213.408	981.966
5277.085	1180.219	891.079	5225.250	1214.216	980.599
5844.338	1177.168	890.480	5277.155	1212.625	979.010
6288.274	1178.035	892.022	6426.058	1212.366	981.315
6620.141	1182.011	891.137	6740.150	1212.085	980.095
6740.035	1179.050	891.154	6824.015	1212.856	983.598
6823.997	1177.988	891.509	6972.316	1215.788	981.938
6972.301	1178.517	892.528	7093.246	1210.452	981.799
7066.236	1179.244	892.555	7093.987	1211.815	981.412
7302.298	1178.289	893.303	7148.243	1211.685	981.387
7527.992	1179.254	892.373	7528.018	1211.749	982.022
7676.360	1180.701	892.309	7820.041	1210.488	980.663
7705.130	1179.052	892.762	7896.074	1225.799	981.743
7758.057	1179.875	892.459	8052.317	1214.724	981.876
7820.021	1178.439	893.887	8093.222	1216.208	980.331
7856.096	1179.457	893.789	8151.265	1214.098	983.308
7896.008	1180.357	892.282	8234.269	1214.034	982.046
8052.185	1182.030	892.287	8278.016	1212.544	980.416
8052.302	1181.797	891.903	8287.982	1211.535	981.394
8092.173	1180.817	891.955	8290.066	1212.784	981.886
8148.067	1178.317	892.154	8291.035	1212.168	980.424
8151.161	1178.387	891.091	8369.980	1216.661	981.619
8277.997	1173.709	888.710	8423.327	1216.678	982.092
8290.984	1176.458	889.870	8451.326	1214.280	981.575
8370.313	1177.928	893.459	8473.213	1212.782	982.343
8422.175	1178.610	893.003	8531.134	1212.340	982.213
8451.304	1179.266	892.823	8532.142	1211.557	982.777
8473.010	1179.204	891.900			
8516.004	1176.921	893.549			

periods and RV amplitudes using the relationships of Kjeldsen, & Bedding (1995). The periods are far too short: 1.2 days for HD 60292 and 2.5 days for HD 112640. Furthermore, we expect the semi-amplitudes of pulsations to be 34 $\mathrm{m\,s^{-1}}$ and 56 $\mathrm{m\,s^{-1}}$, respectively, well below the dispersions of 120 $\mathrm{m\,s^{-1}}$ and 83 $\mathrm{m\,s^{-1}}$ measured for HD 60292 and HD 112640.

The H lines were used to monitor chromospheric activities, however do not reveal any significant variation. The *HIPPARCOS* light curves do not show any variability, the BVSs do not display any relation with the RV measurements. Eventually, we can exclude rotational modulation or stellar surface activity as the causes for the observed RV observations, leaving us with the planetary companion hypothesis. Both stars show rotation periods (upper limits) of 400 days (HD 60292) and 545 days (HD 112640) that are too short to explain the observed RV modulations.

The residuals left after subtracting the principal periodic signals from the RV time series show rms scatters of 37.7 $\mathrm{m\,s^{-1}}$ for HD 60292 and 29.3 $\mathrm{m\,s^{-1}}$ for HD 112640. These values are significantly higher than the typical RV precisions obtained from measurements of the RV standard star τ Ceti (7 $\mathrm{m\,s^{-1}}$) and the typical internal errors of individual RV measurements of K giants in our survey, expected to be $\sim$ 15 $\mathrm{m\,s^{-1}}$ for HD 60292 and $\sim$ 11 $\mathrm{m\,s^{-1}}$ for HD 112640. The variations appear to be caused by systematics in the RV measurements and are typical for giant stars (Setiawan et al. 2003; Hatzes et al. 2005; Döllinger et al. 2007; de Medeiros et al. 2009; Han et al. 2010; Lee et al. 2012b) and might also be due to pulsation/convection activity.

Eventually, we conclude that K giants HD 60292 and HD 112640 host planetary companions with minimum masses of 6.5 M_{Jup} and 5.0 M_{Jup}, respectively. These parameters are similar to those of companions around other K giant stars.

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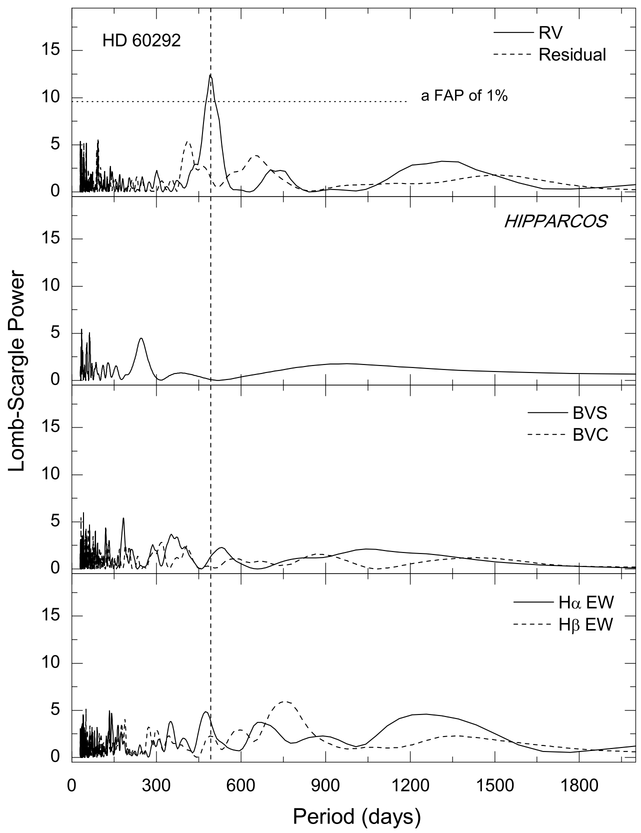

Figure 5. L-S periodograms of the RV time series, the *HIPPARCOS* light curves, the bisector time series, and the hydrogen line EW time series (from top to bottom) for HD 60292. The vertical dashed line indicates the location of a period of 495 days. The periodogram of the RV measurements (top panel) shows significant power at a period of 495.4 days. The dashed line marks the periodogram of the residual. The horizontal dotted line indicates a false alarm probability threshold of 1%.

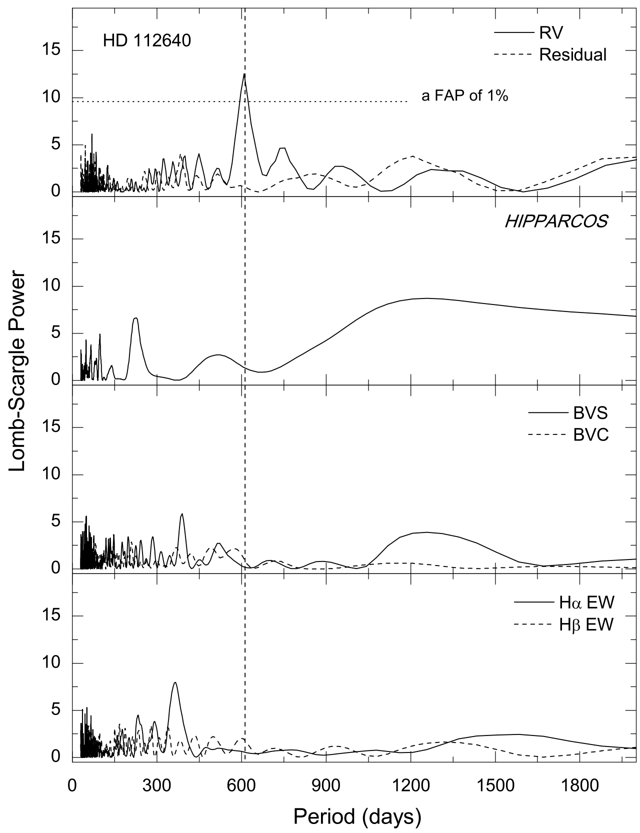

Figure 6. L-S periodograms of the RV time series, the *HIPPARCOS* light curves, the bisector time series, and the hydrogen line EW time series (from top to bottom) for HD 112640. The vertical dashed line indicates the location of a period of 613 days. The periodogram of the RV measurements (top panel) shows significant power at a period of 613.2 days. The dashed line marks the periodogram of the residual. The horizontal dotted line indicates a false alarm probability threshold of 1%.

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