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No planet around HD 219542 B⋆

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Abstract. The star HD 219542 B has been reported by us (Desidera et al. 2003) to show low-amplitude radial velocity variations that could be due to the presence of a Saturn-mass planetary companion or to stellar activity phenomena. In this letter we present the results of the continuation of the radial velocity monitoring as well as a discussion of literature determinations of the chromospheric activity of the star (Wright et al. 2004). These new data indicate that the observed radial velocity variations are likely related to stellar activity. In particular, there are indications that HD 219542 B underwent a phase of enhanced stellar activity in 2002 while the activity level has been lower in both 2001 and 2003. Our 2003 radial velocity measurements now deviate from our preliminary orbital solution and the peak in the power spectrum at the proposed planet period is severely reduced by the inclusion of the new data. We therefore dismiss the planet hypothesis as the cause of the radial velocity variations.

Key words. stars: individual: HD 219542 B – stars: planetary systems – stars: binaries: visual – stars: activity – techniques: spectroscopic – techniques: radial velocity

1. Introduction

In Desidera et al. (2003, hereafter Paper I) we presented high precision radial velocity (hereafter *RV*) monitoring of the components of the wide binary system HD 219542. This pair is part of the sample of wide binaries currently under monitoring at TNG using the high resolution spectrograph SARG (Gratton et al. 2001). We have found evidence for the presence of low amplitude *RV* variations on the secondary HD 219542 B with a period of 112 days at a confidence level of 96–97%. These *RV* variations could be due to a Saturn-mass planet orbiting at 0.46 AU or to stellar activity.

The relatively low statistical confidence of the proposed planetary orbit as well as the possible presence of stellar activity indicate that a confirmation is required before we can classify of HD 219542 B as a bona fide planet host star.

It is well known that stellar activity induces distortions of the profile of the spectral lines that could be seen as *RV* variations and then mimic the occurrence of companions orbiting the target (see e.g. Saar et al. 1998). These spurious *RV* variations may have amplitudes and timescales comparable to those induced by giant planets, making challenging the search for planets around active stars. The controversial case of HD 192263 (Henry et al. 2002; Santos et al. 2003) is worth of mention in this context.

Two different components of the magnetic activity phenomena are of concern for planet searches. Star spots alter the profile of spectral lines, as well known from Doppler imaging studies of rapidly rotating spotted stars (see e.g. Rice 2002; Strassmeier 2002). For slowly rotating stars the distortions of line profile are more subtle but nevertheless sufficient to be detected as spurious *RV* variations (Hatzes 2002). The *RV* variations resulting from the presence of surface features typically follow the time scales of the rotational period of the star (a few days for the active stars for which such signal is more easily detectable), but for the long term and sparse sampling typical of planet search surveys no clear periodicities are often present, because of the limited lifetime of such features. *RV* variations caused by star spots are usually correlated to photometric

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variations (Paulson et al. 2004; Queloz et al. 2001). The second contribution is represented by plages, that cause a change of the shape of spectral lines, mostly because of the alteration of the granulation pattern (Saar 2003; Kürster et al. 2003). The variations of the area covered by plages along the magnetic cycle and/or the rotational period then cause *RV*s variations, correlated with chromospheric emission. For some low activity stars, for which the effects of rotational modulations are lower than those of the long term magnetic cycle, a fairly good correlation between *RV*s and chromospheric emission can be found (Saar & Fischer 2000).

In order to disentangle the origin of *RV* variations (keplerian orbital motion vs. activity jitter) basically three approaches can be pursued.

1. To directly search for the presence of distortions of line profiles (ideally on the same spectra on which *RV*s are derived), as done by e.g. Hatzes et al. (1998) for 51 Peg and Queloz et al. (2001) for HD 166435
2. To obtain measurements of stellar activity (chromospheric emission, photometry), possibly simultaneous to *RV*s, to search for correlation between *RV*s and activity. Note that one single activity diagnostics may not be enough since photometry and chromospheric emission are mostly sensitive to different components of magnetic activity.
3. To continue the *RV* monitoring of the object. In fact, stellar activity typically is not stable on yearly timescales, so that an activity signal is not expected to maintain the same phase and amplitude with time (see Queloz et al. 2001)

For our candidate we followed the second and third approaches, collecting new *RV* data and considering literature determinations of the chromospheric emission of the star (Wright et al. 2004), published after Paper I, to study the evolution of its activity level. The line bisector variations corresponding to the observed *RV* variations are below our detectability threshold, as discussed in Paper I.

2. Radial velocities

The new *RV*s have been obtained from SARG spectra in the same way as in Paper I, using the AUSTRAL code (Endl et al. 2000). Six new spectra were acquired from June 2003 to January 2004, hereafter referred as 2003 season. Table 1 and Fig. 1 present the full radial velocity data set for HD 219542 B (nightly averages)[1]. As can be seen in Fig. 1, the data taken during the 2003 season do not follow the tentative orbital solution derived in Paper I.

Figure 2 shows the Lomb-Scargle periodogram (Lomb 1976; Scargle 1982) for the data included in Paper I and for the whole dataset presented here. The power at 112 days sharply decreases with the addition of the data of the last observing season.

[1] For the 2000–2002 velocities, there are minor differences with respect to those published in Paper I. These are due to the fact that some trends in the radial velocity of the ~100 pixel long chunks along a spectral order, due to errors in the wavelength calibration of the stellar template (without iodine lines), are removed considering the average velocity of each chunk for the whole dataset. This correction then slightly changes with the addition of the new data. The differences are much smaller than internal errors. The inclusion of the new data also changes the normalization.

Table 1. Differential radial velocities for HD 219542 B.

JD-2 450 000	*RV* $m\,s^{-1}$	Err. $m\,s^{-1}$	JD-2 450 000	*RV* $m\,s^{-1}$	Err. $m\,s^{-1}$
1825.51	−5.0	7.4	2424.71	12.4	5.3
1826.49	−10.7	6.0	2445.71	13.3	4.7
2070.71	1.0	4.0	2472.70	−6.7	5.6
2071.71	7.2	4.2	2538.51	25.0	8.1
2072.69	9.6	6.0	2570.42	−2.9	3.4
2113.71	−0.7	4.6	2585.45	−16.0	4.9
2115.69	6.7	3.9	2597.33	2.9	3.3
2116.68	−5.0	6.0	2605.36	−3.0	3.6
2117.71	−1.4	5.2	2810.69	−2.2	4.9
2120.72	0.9	5.1	2818.66	2.2	8.6
2145.66	0.1	4.7	2891.55	−2.4	5.8
2190.54	3.2	3.8	2953.35	−11.8	6.0
2216.47	10.6	7.0	2982.39	−12.8	8.2
2245.43	−7.7	4.2	3018.35	−5.8	6.3

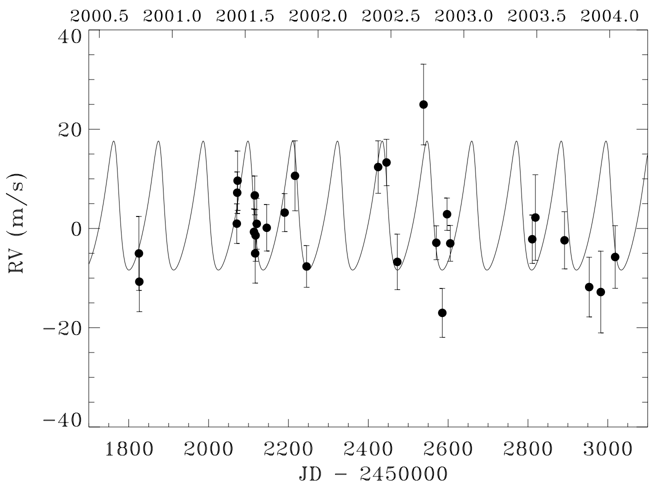

Fig. 1. Radial velocity curve for HD 219542 B. The data taken in the 2003 season do not follow the tentative orbital solution derived in Paper I (overplotted as a solid line).

3. Chromospheric activity

Wright et al. (2004) recently published the measurement of Ca II H and K emission for the whole samples of the Keck and Lick planets searches. HD 219542 A and B were recently added to the Keck planet search sample. Overall, 11 and 15 measurements from June 2002 to July 2003 are presented for the two stars respectively. The mean *S* index for HD 219542 A and B result of 0.158 and 0.204 respectively. The calibration of Noyes et al. (1994) coupled with the colors of the stars as given by Simbad, i.e. $(B - V) = 0.64$ and 0.69 for HD 219542A and B

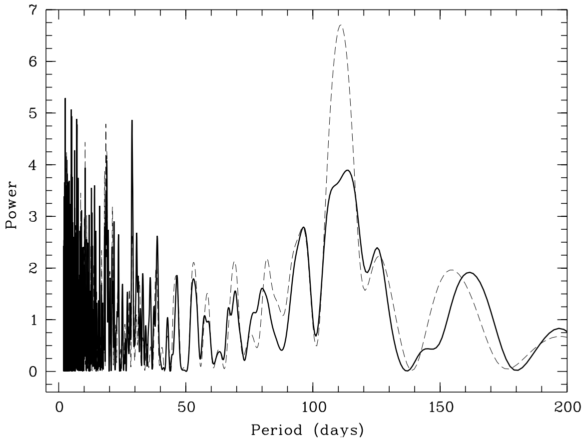

Fig. 2. Lomb-Scargle periodogram of radial velocities for HD 219542 B. The solid line refers to the full data set while dashed line is the periodogram of the data included in Paper I. The inclusion of 2003 data causes a strong decrease of the 112 days peak. Note that for display purposes only the period range 2 to 200 days is shown.

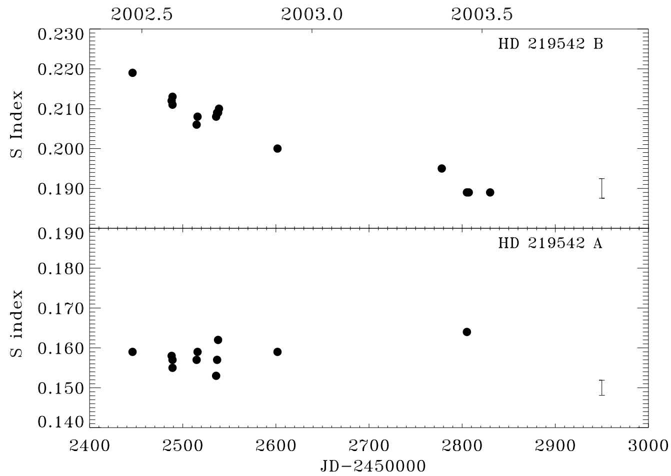

Fig. 3. Ca II H&K emission measurements of HD 219542 A (*lower panel*) and HD 219542 B (*upper panel*) from Keck (Wright et al. 2004). Typical error bars on differential values of S index measured at Keck are shown in the right part of each panel. These results show an enhanced activity in 2002 and a sharp decline over the following year for HD 219542 B. The activity level of component A is fairly constant and lower than component B.

respectively[2] gives $\log R'_{HK} = -5.01$ and -4.80. Our measurement of Paper I was based on a single FEROS spectrum and has a fairly large error because of the low signal and the paucity of available calibrators with low activity level.

Single epoch measurements are also included in Wright et al. (2004) (available at `astro.berkeley.edu/~jtwright/CaIIdata/tab1.tex`). These were obtained using the differential technique described in their paper, reaching errros of 1.2%. They are plotted in Fig. 3.

4. Discussion

The differential Ca II H&K measurements by Wright et al. (2004) indicate a much higher activity level for HD 219542 B during the 2002 season with respect to 2003. The activity level of HD 219542 A is instead lower and nearly constant, with a possible small increase in the 2003 season. When considering the radial velocity curve, it should be noticed that the dispersion of *RV*s of HD 219542 B is larger during the 2002 season. Table 2 shows the seasonal mean and dispersion of *RV*s and Ca II H&K emission, the measured *RV* dispersion excess (calculated as the quadratic difference between the observed dispersion and the mean internal errors) as well as the radial velocity jitter expected on the basis of the calibration by Marcy (2002, private communication).

These results strongly suggest that HD 219542 B underwent a phase of enhanced activity during 2002, while the activity decreased significantly in 2003. On the basis of the low *RV* scatter, the activity level could have been low also in June–July 2001.

We note that the seasonal variations of rms *RV* dispersion are much larger than those predicted by the jitter calibration. The global scatter on longer timescale (4 years) is instead much better predicted by such relation. This indicates that the estimates on *RV* jitter based on the activity level of the star should be more reliable when considering a fairly long time coverage, while on short time scales the calibration might severely underestimate or overestimate the actual jitter. This fact may be explained considering that during the phases of higher activity the appearance of spots and plages causes short term *RV* (and photometric) variations according to the rotational phases (see e.g. Paulson et al. 2004), while the absolute value of the chromospheric emission might be only moderately affected.

It appears that the high activity phase of HD 219542 B during 2002 was relatively short lived when compared to that of the Sun. The star might have a fairly short and/or irregular activity cycle. Alternatively, its activity behaviour might be similar to that of 15 Sge, that has a cycle with activity enhancements lasting about 1 year every 17 years (Baliunas et al. 1995; Wright et al. 2004) and low activity level at other epochs.

HD 219542 A instead shows no sign of enhanced or variable activity. The age of the two components derived using the relation by Donahue (1993) is 5.7 and 2.7 Gyr for HD 219542 A and B respectively. This age difference is larger than typically obtained in coeval systems (Henry et al. 1996) but similar to that derived for the Sun when using the maximum and minimum *S* values along its magnetic cycle.

In Paper I we noted that the 2002 *RV* data could be fitted quite well by sinusoidal variations with a period of 18.5 days. Both the *RV* and Ca H&K emission data are not sufficient to firmly establish the rotational period of the star[3]. However, a

[2] The colors and absolute magnitudes adopted by Wright et al. ($\Delta(B-V) = 0.014$ mag; HD 219542 B brighter by 0.59 mag), indicate that they probably took the magnitude and colors of HD 219542 A from the Simbad object HD 219542 and those of HD 219542 B from the Simbad object CCDM J23166-0135AB, which is actually the composite HD 219542 A+B, instead that for BD -02 5917B.

[3] The power at 18.5 days decreased with the inclusion of 2003 data, see Fig. 2.

Table 2. Seasonal mean and dispersion of radial velocities and Ca H&K emission for HD 219542 B.

Season	$N_{\rm data}$	Mean *RV* m s^{-1}	rms *RV*s m s^{-1}	Err. m s^{-1}	$\log R'_{\rm HK}$	Obs. jitter m s^{-1}	Exp. jitter m s^{-1}
2001	12	2.0 ± 1.6	5.6	5.0	–	2.6	–
2002	8	3.0 ± 4.7	13.3	5.1	−4.78	10.1	7.1
2003	6	−5.4 ± 2.6	6.5	6.8	−4.86	0.0	6.1
all	28	0.0 ± 1.7	9.0	5.6	−4.80	7.1	6.8

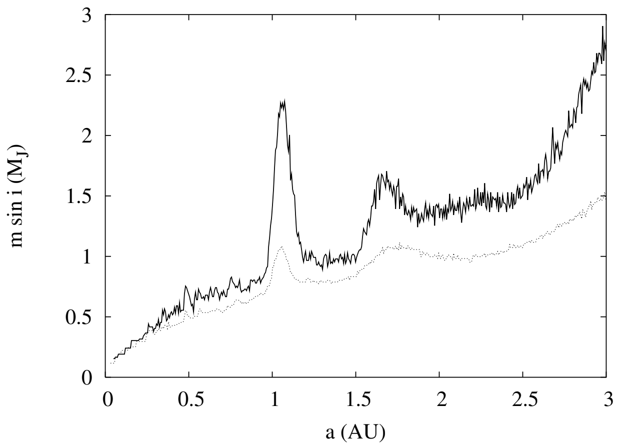

Fig. 4. Limits on planets around HD 219542 B in circular orbits (dotted line) and eccentric orbits (solid line).

period of 18.5 days is compatible within the uncertainties to that obtained using the Noyes et al. (1994) calibration.

In spite of the moderate activity level of the star our *RV*s are anyway of some usefulness for planet search. We derived the upper limits on the planets which are still compatible with our data (Fig. 4). We use the same technique developed in Paper I, that allows the determinations of the upper limits on the mass of companions in eccentric orbits, while most of the upper limits determinations in literature consider only circular orbits. With the exclusion of a small window around 1 year period, planets with $m \sin i > 1 M_J$ can be excluded within 1.5 AU. The peak around 1 year can be explained considering that a planet with period close to 1 year, fairly high eccentricity, and longitude of periastron and orbital phases in suitable ranges would cause a radial velocity curve nearly flat most of the time with *RV* variations concentrated on the times on which the target is not observable.

5. Conclusion

The continuation of the radial velocity monitoring and the multi-epoch measurements of the Ca II H&K emission indicate that the low amplitude *RV* variations of HD 219542 B presented in Paper I are likely due to stellar activity. This star should therefore be removed from the list of extrasolar planet host stars.

The available data suggest that the star underwent a relatively short-lived phase of enhanced activity during the 2002 season.

This study confirms the relevance of the activity-related phenomena in the *RV* planet searches and, on the other hand, the great impact of the high precision Doppler surveys in improving our understanding of the stellar activity cycles. Even for stars with modest activity level, the discovery of planets with amplitude of 10–15 m s^{-1} requires a long term monitoring to check for the stability of the signal as well as ancillary measurements of activity indicators (see e.g. Hatzes et al. 2000).

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References

Baliunas, S. L., Donhaue, R. A., Soon, W. H., et al. 1995, ApJ, 438, 269
Desidera, S., Gratton, R. G., Endl, M., et al. 2003, A&A, 405, 207 (Paper I)
Donahue, R. A. 1993, Ph.D. Thesis, New Mexico State University
Endl, M., Kürster, M., & Els, S. 2000 A&A, 363, 585
Gratton, R. G., Bonanno, G., Bruno, P., et al. 2001, Exp. Astron., 12, 107
Hatzes, A. P. 2002, Astron. Nachr., 323, 392
Hatzes, A. P., Cochran, W. D., & Bakker, E. J. 1998, Nature, 391, 154
Hatzes, A. P., Cochran, W. D., McArthur, B., et al. 2000, ApJ, 544, L145
Henry, G. W., Donahue, R. A., & Baliunas, S. L. 2002, ApJ, 577, L111
Henry, T. J., Soderblom, D. R., Donahue, R. A., & Baliunas, S. L. 1996, AJ, 111, 439
Kürster, M., Endl, M., Rouesnel, F., et al. 2003 A&A, 403, 1077
Lomb, N. R. 1976, Ap&SS, 39, 477
Noyes, R. W., Hartmann, L. W., Baliunas, S. L., Duncan, D. K., & Vaughan, A. H. 1984, ApJ, 279, 763
Paulson, D., Saar, S. H., Cochran, W. D., & Henry, G. W. 2004, AJ, 127, 1644
Queloz, D., Henry, G. W., Sivan, J. P., et al. 2001, A&A, 379, 279
Rice, J. B. 2002, Astron. Nachr., 323, 220
Saar, S. H. 2003, in Scientific Frontiers in Research on Extrasolar Planets, ed. D. Deming, & S. Seager, ASP Conf. Ser., 294, 65
Saar, S. H., Butler, R. P., & Marcy, G. W. 1998, ApJ, 498, L153
Saar, S. H., & Fischer, D. A. 2000, ApJ, 534, L105
Santos, N. C., Udry, S., Mayor, M., et al. 2003, A&A, 406, 373
Scargle, J. D. 1982, ApJ, 263, 835
Strassmeier, K. G. 2002, Astron. Nachr., 323, 309
Wright, J. T., Marcy, G. W., Butler, R. P., & Vogt, S. S. 2004, ApJS, in press [arXiv:astro-ph0402582]