Extrasolar planets and brown dwarfs around A–F type stars. **

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\[\text{Table 2 is only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/} \]

** A giant planet orbiting the young star HD113337

Aims. In the frame of the search for extrasolar planets and brown dwarfs around early-type main-sequence stars, we present the detection of a giant planet around the young F-type star HD113337. We estimated the age of the system to be 150^{+60}_{-50} Myr. Interestingly, an IR excess attributed to a cold debris disk was previously detected on this star.

Methods. The SOPHIE spectrograph on the 1.93m telescope at Observatoire de Haute-Provence was used to obtain \approx 300 spectra over 6 years. We used our SAFIR tool, dedicated to the spectra analysis of A and F stars, to derive the radial velocity variations. The data reveal a 324±83 over 6 years. We used our SAFIR tool, dedicated to the spectra analysis of A and F stars, to derive the radial velocity variations.

Results. The data reveal a 324±83 over 6 years. We used our SAFIR tool, dedicated to the spectra analysis of A and F stars, to derive the radial velocity variations.

Key words. techniques: radial velocities - stars: early-type - stars: planetary systems - stars: individual: HD113337

ABSTRACT

1. Introduction

Thanks to hundreds of planets discoveries (http://exoplanet.eu/ [Schneider et al., 2011]) mainly by radial velocity (RV) or transit surveys since Mayor & Queloz (1995), our knowledge on exoplanets has dramatically improved. From these surveys, we now know that exoplanets are frequent around solar-type stars. More than 50% of these stars have planets with all kind of masses and, among them, about 14% have planets with masses larger than 50 \(M_{\text{Earth}}\) (Mayor et al., 2011). An unexpected diversity of planet properties in separations, eccentricities and orbital motions (e.g. retrograde orbits) was revealed. These discoveries highlight the importance of dynamics, either through planet-planet or planet-disk interactions, in the building of the planet systems architectures. Meanwhile, many open questions remain regarding several aspects of planet formation, even in the case of giant planets. RV and transit explorations, after mainly characterizing Jupiter-like planets, are now detecting Neptune-like planets (10-40 \(M_{\text{Earth}}\)) and Super Earths (1.2-10 \(M_{\text{Earth}}\)). However, these techniques are still mostly limited to planets within a separation of typically 5 AU from their parent stars. Moreover, they target generally solar-type main sequence stars or evolved stars. Imaging techniques are sensitive only to giant planets orbiting at large separations, from 8 to 1000AU, around young stars, typically \approx 1-100 Myr. These limitations have several consequences. In particular, it is difficult to test the impact of the host star mass on the planets properties, while formation models predict different behaviors according to the stellar mass (roughly, for the core-accretion scenario, higher mass planets are expected around more massive stars; Kennedy & Kenyon 2008, Mordasini et al. 2009). RV and microlensing surveys revealed so far very few massive planets around M-stars (see e.g. Batista et al. 2011), but these low-mass stars show an abundance of light planets at short distance (Bonfils et al., 2013). At the other end of the stellar mass spectrum, several giant planets have been found around massive, evolved stars at orbital distances typically greater than 0.7 AU (see e.g., Johnson et al., 2011 and references there-in). It is not yet clear how the stellar evolution impacts the observed planetary distributions and properties. The fact that transit surveys detect planets at very short periods seems to confirm an evolutionary effect. Close/intermediate sep-
arations have then to be investigated by observing massive main-sequence stars. Massive, early-type main-sequence stars show few spectral lines that are in addition generally broadened by a high stellar rotation rate (Galland et al., 2005 hereafter Paper I). Classical techniques used for solar-type stars, such as masking techniques, are therefore not adapted to these stars. In this frame, we developed the SAFIR tool, dedicated to the measurement of the RV in spectra of A–F type stars. SAFIR is described in Paper I and is based on the Fourier interspectrum method (Chelli, 2000). We initiated a survey dedicated to the search for extrasolar planets and brown dwarfs around a volume-limited sample of A–F main-sequence stars i) with the ELODIE fiber-fed echelle spectrograph (Baranne et al., 1996) mounted on the 1.93-m telescope at the Observatoire de Haute-Provence (OHP, France) in the northern hemisphere, and then with its successor SOPHIE (Bouchy & Sophie Team, 2006), and ii) with the HARPS spectrograph (Pepe et al., 2002) mounted on the 3.6-m ESO telescope at La Silla Observatory (Chile) in the southern hemisphere. A few giant planets or planet candidates were reported around these targets (Galland et al., 2005, 2006; Desort et al., 2008; 2009, Lagrange et al., 2012).

We present here the detection of a giant planet around HD113337 observed in the course of our SP4 program with the SOPHIE Consortium (Bouchy et al., 2009). We present the stellar properties of HD113337 in Sect. 2, and the SOPHIE data in Sect. 3. In Sect. 4, we discuss the origin of the observed RV variations before concluding in Sect. 5.

2. Stellar characteristics

2.1. General properties

HD113337 (HIP63584, HR4934) is a bright F6V star (Hofleit & Jaschek, 1991), located at 36.9 ± 0.4 pc from the Sun (van Leeuwen, 2007). The main stellar parameters are reported in Table 1. Rhee et al. (2007) estimated a radius of 1.5 R⊙ from the stellar spectral energy distribution and the parallax. Reid et al. (2007) identified an M4 star companion (2MASS J13013268+6537496) at 120 arcsec (≥ 4000AU). This companion is associated to an X-ray emission detected with ROSAT (Haakonsen & Rutledge, 2009). An IR excess was detected by IRAS that Rhee et al. (2007) attributed to a cold dust of 100 K in a ring at 18 AU from the star. On the other hand, using Spitzer data, Moor et al. (2011) estimated that the dust is located at 55 ± 3 AU and has a temperature of 53 ± 1 K.

2.2. Age of the star

Several approaches to estimate the age of the star have led to different and initially incompatible results. The Geneva catalog assigns an age of 1.5 Gyr to HD113337 (Holmberg et al., 2009), based on the Padova stellar evolution model (Holmberg et al., 2007). However, based on this model, most of the members of young associations (e.g. the Beta Pic moving group) are also assigned an age of 1-2 Gyr, much older than their actual age (< 100 Myr). The same discrepancy being possible for HD113337, we therefore do not rely on the age estimation based on this model. F-type stars that have an effective temperature around 6000 K are known to present a lithium (Li) gap that depends on the age (see e.g. Boesgaard & Tripicco, 1987). Our star’s effective temperature is estimated to be 6545 K (Boesgaard & Tripicco, 1986). We therefore calculated its Li abundance and used the age-dependent relation derived by Boesgaard & Tripicco (1987) to estimate its age. A look at SOPHIE high signal-to-noise ratio (SNR) spectrum of the primary star shows no sign of the signature of the lithium line at 6707.8 Å. The analysis suggests an upper value for the equivalent width of this line to be 1 mÅ, that corresponds to an upper limit for the Li abundance in HD113337 of A(Li)=1.5 dex. This value was derived using the radiative transfer code MOOG (Sneden, 1973), and a grid of Kurucz ATLAS 9 model atmospheres (Kurucz, 1993). The input effective temperature and metallicity are the same as presented in Table 1. We compared the derived Li abundance with those of other Li-gap stars in the open cluster M35 (Steinhauer & Deliyannis, 2004). HD113337 abundance value is lower than any of the Li abundances observed in this 160±20 Myr cluster. Although some upper limit Li abundances are observed by Steinhauer & Deliyannis (2004), this result suggests that HD113337 is likely older than ~150 Myr. Its Li abundance is however compatible with those observed in the older 700 Myr old Hyades cluster (Steinhauer & Deliyannis, 2004). We note that Li abundances are most sensitive to the effective temperature (see e.g. Israelian et al., 2004). However, adopting a slightly different value, for example by 100 K, will only change the derived Li abundance by 0.08 dex.

On the other hand, we can determine the age from an analysis of the M dwarf companion detected by Reid et al. (2007). Rhee et al. (2007) estimated the age of the companion to be about 50 Myr based on its (K_V − K_S) properties and showed that the galactic UVW motion of the system is typical of a young population. We did a more robust isochronal analysis, using absolute K_S-band magnitude and a spectroscopic determination of the spectral type by Moor et al. (2011). We converged to a similar age of 40±20 Myr, also incompatible with the Li age determination of the primary. This discrepancy could put into question that the M star is actually a companion to HD113337. But, a recent lucky-imaging study by Janson et al. (2012) offered a way to reconcile the age estimations. These authors observed that the companion is a close, moderate brightness contrast M-type binary. Binarity affects the isochronal age estimation in two different ways that both work towards an older age. First the

| Table 1. HD113337 stellar properties. |
| Parameter | HD113337 |
| Spectral Type | F6V*a |
| B − V | 0.43b |
| V | 6.0c |
| v sin i | [km s⁻¹] 6.1c |
| π | [mas] 27.11 ± 0.29c |
| [Fe/H] | 0.07a |
| log(T eff) | [K] 3.818 ± 0.01a |
| log g | [dex] 4.21 ± 0.08d |
| Mass | [M⊙] 1.40 ± 0.14f |
| Radius | [R⊙] 1.50 ± 0.15g |
| Age | [Myr] 150±100 |

Notes. (a) Hofleit & Jaschek (1991) (b) Perryman & ESA (1997) (c) estimation from the SAFIR software (d) es-

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actual absolute magnitude of the main component is fainter by 0.4 magnitude in \( K \)-band when accounting for the flux coming from the secondary component. Second, the presence of a cooler companion biases the spectral type determination using unresolved spectra towards cooler temperature estimates. When accounting for both effects, we find that the primary component of the M dwarf companion has a temperature of 3350\( \pm \)100 K and an absolute \( K \) magnitude of 7.0. Using the BT-Settl isochrones of [Allard et al. 2012] derived from the stellar evolution models of [Chabrier et al. 2000], we find an age of 100\( \pm \)100 Myr. We note that our temperature estimate includes larger error bars than the estimation of [Moor et al. 2011] which had an uncertainty of 70 K. The reason is that we corrected the systematic error in effective temperature arising from binarity. This correction is quite crude because we can only use one single low SNR point of resolved photometry (\( \Delta z' \pm 0.27 \), [Janson et al. 2012]). A solution to increase our accuracy would be to obtain resolved spectroscopy. Moreover, it would permit to establish whether the M-dwarf system is only a binary, or contains more components.

Finally, using the constraints from both analysis, we adopt the most probable age of 150\( \pm \)100 Myr for the HD113337AB system.

### 3. Spectroscopic data

#### 3.1. Description of the observations

We obtained 312 high signal-to-noise ratio (SNR) spectra with SOPHIE, in the 3872–6943 Å range, in high-resolution mode \( (R = 75 \,000 \text{ at } 550 \text{ nm}) \). The time span of the data is 2193 days, between Jan. 2007 and Jan. 2013, but all the data except three were taken after Feb. 2008. The exposure times, typically between 180 and 500s, were adapted to obtain an average SNR of 155. The exposures were performed with simultaneous-thorium spectra to follow and correct for the drift of the instrument due to local temperature and pressure variations.

The RVs are computed using SAFIR. We selected spectra resting on two criterions:

- first, the SNR has to be greater than 80;
- second, the atmospheric absorption has to be lower than 3.

For each spectrum, the absorption corresponds to the deviation between the stellar apparent magnitude in the V band and an empirical magnitude derived from the exposure time and the SNR.

We thus ended up with 266 RV values. As HD113337 is an F6 star, its spectra contain sufficient lines for the SOPHIE automatic data reduction software (DRS) to derive RVs ([Bouchy et al. 2009]). We verified that DRS RV values are consistent with the SAFIR ones. Before June 2011 an instrumental effect due to the insufficient scrambling of one multimode fiber that led to non-uniform illumination of the entrance of the spectrograph ([Boisse et al. 2011a]) was observed in the data (later referred as SOPHIE data). This effect was significantly decreased thanks to a fiber-link modification, which includes a piece of octagonal-section fiber ([Perruchot et al. 2011] [Bouchy et al. 2013] later referred as SOPHIE+ data). We adapted to SAFIR the method of [Diaz et al. 2012] to correct the SOPHIE data. The RVs quadratic mean is 57.1 m s\(^{-1}\), divided in 57.8 m s\(^{-1}\) and 43.8 m s\(^{-1}\) for SOPHIE and SOPHIE+ values, respectively. Accounting for 3.2 m s\(^{-1}\) of photon noise and 5 m s\(^{-1}\) of assumed instrumental stability, the RV uncertainty is 8.2 m s\(^{-1}\) on average for SOPHIE+ values. The error bars on the SOPHIE RVs also take into account the correction applied, and their average uncertainty is 12.4 m s\(^{-1}\). The RV measurements of HD113337 are listed in Table 2 and are available at the Strasbourg astronomical Data Center (CDS). It contains in its Cols. 1-4, the time of the observation (barycentric Julian date), the RV, its error, and a flag to distinguish SOPHIE and SOPHIE+ values, respectively.

#### 3.2. Radial velocity variations

The RV data are displayed in Fig. 1. They show a periodic signal with a peak-to-peak amplitude of about 300 m s\(^{-1}\) over the whole period of time considered, and of about 200 m s\(^{-1}\) if we consider only the data recorded in 2008 and later. Such amplitudes are much larger than the uncertainties \( (=10 \text{ m s}^{-1} \text{ in average, see above}) \). The Lomb-Scargle periodogram of the RV variations is given in Fig. 2. It is calculated by SAFIR through an adapted version of the CLEAN algorithm ([Roberts et al. 1987]) and gives the normalized power spectrum of the RV data \( (\text{i.e., the square modulus of the RV data Fourier Transform}) \) versus the period range. The significance of the periodogram peaks is tested thanks to the False Alarm Probabilities (FAP). The FAP are estimated using a bootstrapping approach, where the RV data are randomly shuffled and the corresponding periodograms are calculated. The highest peak is at a period of \( \sim 316 \text{ days} \) (power \( \sim 82 \)), which we will attribute to a planet (see below). A peak can also be found at about 2146 days (power = 36), and some other peaks with a FAP smaller than 1%, at 214 days (power = 20), 176 days (power = 18) and 157 days (power = 16), the latter being an alias of the planet period. Other smaller peaks between 10 and 80 days can be attributed to the temporal sampling. For comparison, the periodogram of the window is also given, as well as an example of a periodogram that would be induced by a planet on a circular orbit with a period of 316 days. As expected, apart from the peak at the planet period, several other peaks, due to the temporal sampling are also observed at periods similar to the observed ones.

#### 3.3. Line profile variations

The SOPHIE automatic pipeline cross-correlates the spectra with a G2-type mask. This is relevant as this spectral type is near that of HD113337. Each resulting cross-correlation function (CCF) is fitted by a Gaussian. Two parameters of the CCF, the bisector velocity span (BIS) and the full width half maximum

![Fig. 1. Top: Keplerian fit of HD113337 RV variations with a planet plus a quadratic law (SOPHIE and SOPHIE+ values are plotted in red and blue, respectively). Bottom: Residuals of the fit as a function of time.](image)
(FWHM), allow the monitoring of line profile deformations, that could induce RV variations not related to a Doppler shift due to orbital motion.

We show in Figure 3 the BIS as a function of time and its Lomb-Scargle periodogram, together with values of FAP. No BIS temporal variations are seen with a period of ≳300 days, and the periodogram does not show any peak at 300-400 days. But, a long-term low amplitude BIS variation could be seen, highlighted by the highest peak in the periodogram at a period greater than 1000 days. No significant correlation is seen between RVs and BISs (i.e. Pearson’s correlation coefficient < 0.4).

The temporal variations of the FWHM of the CCF are reported in Figure 4. We do not see any variability with periods in the range 300 days. But we see a low amplitude long term variation. The FWHM values are well correlated with the BIS ones (see Fig. 4).

4. Origins of the observed periodic RV variations

We observe both a 320-days periodic variability and a long term variability in the RV signal. We first note that given its very large projected separation, the M-type companions have no detectable impact on the spectrum and the RV variations of HD113337. The weak long-term variations observed in the BIS and the FWHM of the CCFs are well correlated and present a similar long-term trend than the RV. This indicates that the long term signal is most probably not related to a gravitationally bound companion, but may be associated with long term stellar variability such as convection effects. In the following, we discuss the 320-days periodic RV variation.

4.1. Stellar variability

Stellar pulsations are a very improbable origin as they would induce significant BIS variations (see examples in Galland et al., 2006) and because a ≥ 300 days periodicity is far larger than the ones of pulsations known for this type of main sequence stars. Stellar spots can be excluded as they would lead to signals with periods of a few days or less. Assuming a radius of 1.5 R\(_\odot\) and a \(v \sin i\) of 6.1 km s\(^{-1}\), the rotation period would be less than 12 days. This is clearly not compatible with the observed ≳320 days period. A mean \(\log R_{HK}\) value of -4.8 is derived (Boisse et al., 2010), which excludes a high level of activity and no variability is seen in the \(\log R_{HK}\) data. Moreover, with this level of \(v \sin i\) (i.e. > 6 km s\(^{-1}\)), activity-induced RV variations would induce correlated BIS variations. The fact that no periodic signal is seen in the BIS at a period of 320 days allows us to dismiss stellar activity as an explanation to the 320 days variability.
We treated the corrected Marquardt algorithm, after selecting values with a genetic algorithm and a Keplerian model and a quadratic law using a Levenberg-Marquardt algorithm (Segransan et al., 2011). We attribute them to the presence of a planetary companion.

### 4.2. A planet orbiting around HD113337

We fitted simultaneously the RV data of HD113337 with a Keplerian model and a quadratic law using a Levenberg-Marquardt algorithm, after selecting values with a genetic algorithm (Segransan et al., 2011). We treated the corrected SOPHIE and SOPHIE+ data as independent samples. The best solution is an eccentric orbit ($e = 0.46 \pm 0.04$) with a period of $P = 324.0^{+1.7}_{-3.3}$ days and a semi-amplitude $K = 75.6^{+3.7}_{-3.6}$ m s$^{-1}$. Taking into account the error bar on the stellar mass ($M_* \approx 1.40 \pm 0.14$ M$_\odot$), the RV signature corresponds to a planet of minimum mass $m_p \sin i = 2.83 \pm 0.24$ M$_{Jup}$. The best-fit Keplerian model is plotted superimposed to the SOPHIE and SOPHIE+ velocities in Fig[. The final orbital elements are listed in Table[. They were computed using 5000 Monte Carlo simulations and the uncertainties in the final parameters correspond to their 1-sigma confidence intervals. The difference between the mean RV values from SOPHIE and SOPHIE+ is consistent with observations from constant stars (Bouchy et al., 2013). We checked that removing the first three data points does not change the parameters of the fit within 1-$\sigma$.

The residuals are greater than the mean error bars, $\sim 25$ and $\sim 19$ m s$^{-1}$ for SOPHIE and SOPHIE+, respectively. However, no periodic variation is detected. This high variability may originate both from an under-estimation of the instrument stability and from contaminant signal (e.g. moonlight).

### Table 3. Best orbital solutions for HD113337 RVs.

| Parameter          | Values                   |
|--------------------|--------------------------|
| $P$ [days]         | 324.0$^{+1.7}_{-3.3}$    |
| $T_0$ [JD–2400000] | 56074.5$^{+2.3}_{-2.3}$  |
| $e$                | 0.46$^{+0.04}_{-0.04}$   |
| $\omega$ [deg]     | $-140.8^{+3.6}_{-3.7}$   |
| $K$ [m s$^{-1}$]   | 75.6$^{+3.7}_{-3.6}$     |
| linear [m s$^{-1}$ y$^{-1}$] | $-41.2 \pm 3.6$ |
| quadratic [m s$^{-1}$ y$^{-2}$] | $-15.9 \pm 0.6$ |

$\sigma_{o_c}$-SOPHIE [m s$^{-1}$] = 24.80 (60.45) $^*$
$\sigma_{o_{c}+}$-SOPHIE+ [m s$^{-1}$] = 18.82 (44.46) $^*$
$RV_{\text{mean}}$ SOPHIE [km s$^{-1}$] = $-0.039 \pm 0.005$
$RV_{\text{mean}}$ SOPHIE+ [km s$^{-1}$] = $-0.021 \pm 0.006$
reduced $\chi^2$ = 4.55 (11.60) $^*$
$m_p \sin i$ [M$_{Jup}$] = $2.83 \pm 0.24$ $^*$
$a_p \sin i$ [AU] = $0.92 \pm 0.009$ $^*$

$^*$ The number in parenthesis refer to the model assuming a constant velocity. $^\dagger$ Assuming $M_*=1.40\pm0.14$ M$_\odot$.

### 5. Discussion and concluding remarks

Using our age estimation, HD113337 would be a particularly young planetary system detected by RV. Very few RV planets have yet been found around young stars. A giant planet of $6.1 \pm 0.4$ M$_{Jup}$ was reported around the ~100 Myr-old G1V star HD70573 (Setiawan et al., 2007). More recently, van Eyken et al. (2010a) reported a possible close-in giant planet around a 7-10 Myr old T Tauri star, using both photometric and spectroscopic observations. Young stars being very active and rapidly rotating objects, one has to be particularly cautious when finding periodic RV variations which can be attributed to a planet. Indeed, stellar activity manifestations, such as cold spots, could mimic planet signatures, particularly with periodicity smaller or close to the stellar rotation period. There are some cases of RV signatures initially announced as a planet ones that later became controversial or were even rejected. An example is the signature of a $10 \text{ M}_{Jup}$ planet reported by Figueira et al. (2005) around the young (8-10 Myr) which turned out to be the trace of a cold stellar spot, according to Huélamo et al. (2008) and to Figueira et al. (2010a). Another case is the $\sim 6.5 \pm 0.5$ M$_{Jup}$ planet reported around the young (35-80 Myr) active K5V dwarf BD+201790 (Hernán-Obispo et al., 2010), which was also rejected later by Figueira et al. (2010a). It is valuable to stress that in the case of HD113337, the reasons that lead to such false detections can be rejected: i) the 324-days period is far greater than the estimated stellar rotational period, ii) the level of stellar activity is much lower than for the mentioned cases, and iii) with a stellar $v \sin i > 6$ km s$^{-1}$, RV variations induced by line profiles deformations would have been monitored by the BIS and FWHM parameters, which is not the case.

Interestingly, HD113337b properties are similar to those of the companion of 30 Ari B (Guenther et al., 2009), which has an orbital period and an eccentricity very close to those of
HD11337b, and a = 9.9 M_{Jup} minimum mass. 30 Ari B is a
\approx 1.1 M_\odot F4V star, with T_{eff} = 6462 K and a higher \text{v sin }i of
\approx 38 \text{ km s}^{-1}. According to the age estimation made by these au-
thors (0.91 \pm 0.83 \text{ Gyr}), it is much likely older than HD113337.
Whether the masses of 30 Ari Bb and HD11337b could be similar
depends on the actual stars rotational velocity and on the inclina-
tion of the systems, both are unknown. We note that in the
catalog of F-type dwarfs velocities of Nordstrom et al. (1997),
the mean \text{v sin }i of 72 F4–F6 stars is about 49 \text{ km s}^{-1},
while it is about 16 \text{ km s}^{-1} in our 49 F4–F6 stars sample. According to
Guenther et al. (2009), 30 Ari B rotational rate indicates that this
star is probably seen almost equator-on, or with a small inclina-
tion. On the contrary, HD11337 \text{v sin }i is significantly
lower than the average values for the two mentioned samples.
Combined with the fact that it is a young star, this could indicate
a large inclination (and hence a low \text{v sin }i). Assuming an actual
rotational velocity of 16 \text{ km s}^{-1} for HD11337 would lead to a
\approx 20° inclination for our star. If the orbital and the stellar spin
axes are aligned, 30 Ari Bb and HD11337b would then have
almost the same mass. However, this is quite speculative at this
stage.
Young planetary systems are of peculiar interest as they can be targeted both by RV and by forthcoming deep imagers (such as SPHERE on the VLT). Detecting planets both in RV and imaging is a very important goal as it would give the opportu-
nity to calibrate the brightness-mass relationships at young ages.
These relationships are used to derive masses in imaging, and are
still producing diverging results at young ages (see e.g., Fortney et al. 2008). An example of the kind of constraints derived when combining RV and imaging on a yet more distant target can be found in Lagrange et al. (2012).
Given its V-magnitude and declination, HD11337 is a good
target for an interferometric instrument such as the VEGA spec-
trograph, operating at the Mount Wilson observatory. Using the
largest baselines of the CHARA array, the star could be partially
resolved, allowing one to determine accurately its angular diam-
eter and to derive precise values of the stellar radius and mass.
(The mass can be deduced thanks to the radius and surface gravity,
see Leger et al. 2012. Thus the Keplerian model of the planet
could be better constrained. An example of peculiar interest is the case of the F-type star, HD185395, for which a variability of the
stellar angular diameter was detected (Leger et al. 2012). This variability is still of unknown origin has the same periodicity
as RV variations previously observed (Desort et al. 2009).

This system is also very interesting as it hosts at the same
time a planet and a debris disk. From a statistical point of view,
no correlation has been well defined between RV planets and IR
excesses due to cold debris disks around solar-type stars. But it is
not clear whether the absence of correlation can be due to evolu-
tion effects (the stars surveyed in RV are mature stars) or to other
biases (the planets are at rather short separations). In a recent
paper, Wyatt et al. 2012 suggested that systems composed of
only small-mass planets (mp \text{v sin }i < Saturn mass) host also preferen-
tially a debris disk. Although their result is subject to small
number statistics, they proposed that this correlation could be
a signature of dynamically stable systems where planetesimals
can remain unperturbed over Gyr timescale. We also note that
stars with imaged planets (at large separations) are surrounded
by disks and are young. Many more systems like HD113337 are
needed to further test the link between the debris disks and the
presence of planets from an evolution point of view. Finally, high
resolution imaging data of the inner part of the disk would be
valuable to search for possible signs of disk-planet interactions.
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## Table 2. HD113337 radial velocities.

| Date of observation (JD-2454000) | RV (km s\(^{-1}\)) | RV uncertainty (km s\(^{-1}\)) | Period Flag (0: SOPHIE) |
|----------------------------------|---------------------|-------------------------------|--------------------------|
| 126.71449                        | -0.2596167          | 0.0153933                     | 0                        |
| 127.67123                        | -0.2225158          | 0.0105579                     | 0                        |
| 127.68597                        | -0.2298054          | 0.0099728                     | 0                        |
| 524.63478                        | -0.0389689          | 0.0121061                     | 0                        |
| 536.64281                        | -0.0055641          | 0.0151627                     | 0                        |
| 543.56786                        | -0.0256958          | 0.0122984                     | 0                        |
| 543.57458                        | -0.0180662          | 0.0142921                     | 0                        |
| 549.54104                        | -0.016673           | 0.0121501                     | 0                        |
| 549.54906                        | -0.0274646          | 0.0122232                     | 0                        |
| 584.53667                        | -0.0061845          | 0.0130287                     | 0                        |
| 593.47478                        | -0.0158597          | 0.0147139                     | 0                        |
| 593.47865                        | -0.0068883          | 0.0116872                     | 0                        |
| 594.44039                        | -0.0665764          | 0.0119836                     | 0                        |
| 668.34569                        | -0.0224724          | 0.0119584                     | 0                        |
| 668.34882                        | -0.036648           | 0.0120270                     | 0                        |
| 682.67439                        | -0.0582648          | 0.0125285                     | 0                        |
| 852.68001                        | -0.0455546          | 0.0150484                     | 0                        |
| 852.63289                        | 0.0217796           | 0.0144921                     | 0                        |
| 852.6368                          | 0.0366221           | 0.0145534                     | 0                        |
| 852.70044                        | 0.0338246           | 0.0147837                     | 0                        |
| 852.70435                        | 0.0230074           | 0.0147639                     | 0                        |
| 853.69802                        | -0.0153359          | 0.0149740                     | 0                        |
| 853.70093                        | -0.0092295          | 0.0151613                     | 0                        |
| 872.54037                        | 0.0310181           | 0.0154554                     | 0                        |
| 872.54765                        | 0.0270524           | 0.0135919                     | 0                        |
| 879.61365                        | 0.0607119           | 0.0138140                     | 0                        |
| 879.61669                        | 0.054122            | 0.0129526                     | 0                        |
| 881.65862                        | 0.0350246           | 0.011487                      | 0                        |
| 881.66935                        | 0.034134            | 0.013855                      | 0                        |
| 882.63619                        | 0.0510694           | 0.0113607                     | 0                        |
| 882.64255                        | 0.0630943           | 0.0120050                     | 0                        |
| 883.68179                        | 0.042047            | 0.0117156                     | 0                        |
| 883.68984                        | 0.0375659           | 0.0113528                     | 0                        |
| 884.56559                        | 0.063648            | 0.0122771                     | 0                        |
| 884.56999                        | 0.0598469           | 0.0120770                     | 0                        |
| 885.55622                        | 0.0719913           | 0.0128611                     | 0                        |
| 885.56428                        | 0.0597266           | 0.0111951                     | 0                        |
| 890.62201                        | 0.0091506           | 0.0122064                     | 0                        |
| 890.62896                        | 0.019155            | 0.0116503                     | 0                        |
| 902.51826                        | 0.0450805           | 0.0161627                     | 0                        |
| 902.52116                        | 0.046029            | 0.0150230                     | 0                        |
| 904.48591                        | 0.0366957           | 0.0138832                     | 0                        |
| 904.4903                          | 0.037686            | 0.0143765                     | 0                        |
| 906.53037                        | 0.0668746           | 0.0110080                     | 0                        |
| 906.53841                        | 0.0517159           | 0.0115312                     | 0                        |
| 911.56387                        | 0.0096629           | 0.0122362                     | 0                        |
| 911.57465                        | 0.0164869           | 0.0119630                     | 0                        |
| 913.48494                        | 0.0418106           | 0.0121906                     | 0                        |
| 913.4905                          | 0.059651            | 0.0116508                     | 0                        |
| 915.6173                          | 0.0353425           | 0.0164099                     | 0                        |
| 915.62175                        | 0.0227972           | 0.0171932                     | 0                        |
| 925.55332                        | 0.0249043           | 0.0116172                     | 0                        |
| 925.55676                        | 0.0174431           | 0.0116560                     | 0                        |
| 926.56987                        | 0.0161248           | 0.0145417                     | 0                        |
| 926.57277                        | 0.0305184           | 0.0146176                     | 0                        |
| 934.4908                          | 0.0333              | 0.0122084                     | 0                        |
| 934.49372                        | 0.0379068           | 0.0122182                     | 0                        |
| 936.4311                          | 0.0364464           | 0.0126999                     | 0                        |
| 941.5236                          | 0.0113076           | 0.0121404                     | 0                        |
| 941.5309                          | 0.015826            | 0.0119785                     | 0                        |
| 951.43237                        | 0.0128217           | 0.0107996                     | 0                        |
| 951.43746                        | 0.014196            | 0.0110105                     | 0                        |
| 952.43224                        | 0.0425062           | 0.0129868                     | 0                        |
| 952.43515                          | 0.0572271          | 0.0132158                     | 0                        |
| Time (s)  | Value1 | Value2 | Value3 | Value4 |
|-----------|--------|--------|--------|--------|
| 953.38015 | 0.0277884 | 0.0125816 | 0 | 0 |
| 953.38304 | 0.0238852 | 0.0126013 | 0 | 0 |
| 958.3955  | 0.0707394 | 0.0125476 | 0 | 0 |
| 958.40243 | 0.0770117 | 0.0128296 | 0 | 0 |
| 1006.3823 | 0.0409544 | 0.0128717 | 0 | 0 |
| 1006.3852 | 0.0579549 | 0.0130578 | 0 | 0 |
| 1012.3658 | -0.057519  | 0.0113091 | 0 | 0 |
| 1012.3662 | -0.051158  | 0.0126329 | 0 | 0 |
| 1029.3632 | -0.0510263 | 0.0125147 | 0 | 0 |
| 1029.3662 | -0.051158  | 0.0126329 | 0 | 0 |
| 1031.3606 | -0.0385713 | 0.0164968 | 0 | 0 |
| 1031.3648 | -0.0388165 | 0.0167477 | 0 | 0 |
| 1053.3419 | -0.094407  | 0.0133913 | 0 | 0 |
| 1058.387 | -0.0679094 | 0.0117131 | 0 | 0 |
| 1058.346  | -0.0656624 | 0.018423  | 0 | 0 |
| 1238.7008 | 0.0989002 | 0.0134204 | 0 | 0 |
| 1238.7081 | 0.0759548 | 0.0140823 | 0 | 0 |
| 1267.5764 | 0.0300148 | 0.013097  | 0 | 0 |
| 1267.5819 | 0.0353871 | 0.0118056 | 0 | 0 |
| 1269.5594 | 0.0462886 | 0.0106449 | 0 | 0 |
| 1269.5623 | 0.0432161 | 0.0106735 | 0 | 0 |
| 1270.52  | 0.0567584 | 0.0153135 | 0 | 0 |
| 1270.5229 | 0.0539644 | 0.0150571 | 0 | 0 |
| 1282.5496 | 0.0473729 | 0.0126118 | 0 | 0 |
| 1282.5525 | 0.0523341 | 0.0129308 | 0 | 0 |
| 1284.5731 | 0.0273371 | 0.0108279 | 0 | 0 |
| 1284.576  | 0.0081573 | 0.0108278 | 0 | 0 |
| 1286.4776 | 0.0510374 | 0.0104482 | 0 | 0 |
| 1286.4843 | 0.0716583 | 0.0104424 | 0 | 0 |
| 1288.4863 | 0.0493318 | 0.0115476 | 0 | 0 |
| 1288.4896 | 0.0448531 | 0.0111833 | 0 | 0 |
| 1292.4539 | -0.0019308 | 0.0114981 | 0 | 0 |
| 1292.4565 | 0.0021357 | 0.0114416 | 0 | 0 |
| 1295.4996 | 0.0671524 | 0.0102579 | 0 | 0 |
| 1295.5034 | 0.0735785 | 0.0102547 | 0 | 0 |
| 1316.462  | 0.0169111 | 0.0110343 | 0 | 0 |
| 1316.4663 | 0.0227399 | 0.0110413 | 0 | 0 |
| 1324.5011 | 0.0013523 | 0.0122251 | 0 | 0 |
| 1324.5056 | 0.0164634 | 0.0148875 | 0 | 0 |
| 1330.3752 | 0.0483305 | 0.0128452 | 0 | 0 |
| 1330.3781 | 0.0387688 | 0.0139012 | 0 | 0 |
| 1344.3962 | 0.0128634 | 0.011529  | 0 | 0 |
| 1344.3991 | 0.011788  | 0.0117061 | 0 | 0 |
| 1346.3494 | -0.0393047 | 0.0141665 | 0 | 0 |
| 1346.3523 | -0.007524  | 0.0134268 | 0 | 0 |
| 1361.3642 | -0.013428  | 0.0107473 | 0 | 0 |
| 1367.3946 | -0.0383995 | 0.0132958 | 0 | 0 |
| 1382.3636 | -0.0445566 | 0.0119291 | 0 | 0 |
| 1382.3665 | -0.0357518 | 0.0120646 | 0 | 0 |
| 1383.3715 | -0.048996  | 0.013358  | 0 | 0 |
| 1383.3745 | -0.0441935 | 0.0135168 | 0 | 0 |
| 1392.3596 | -0.0749329 | 0.0121567 | 0 | 0 |
| 1395.3515 | -0.0830119 | 0.0136584 | 0 | 0 |
| 1395.3544 | -0.0777054 | 0.0128558 | 0 | 0 |
| 1397.3438 | -0.0404038 | 0.0127475 | 0 | 0 |
| 1397.3468 | -0.0212646 | 0.0128647 | 0 | 0 |
| 1399.3546 | -0.0495331 | 0.0105173 | 0 | 0 |
| 1399.359  | -0.0530482 | 0.0104723 | 0 | 0 |
| 1401.3688 | -0.0374041 | 0.013479  | 0 | 0 |
| 1401.3761 | -0.0653215 | 0.0144244 | 0 | 0 |
| 1409.348  | -0.0660864 | 0.0121639 | 0 | 0 |
| 1409.3509 | -0.0554636 | 0.0120011 | 0 | 0 |
| 1498.2452 | 0.1039677 | 0.0118739 | 0 | 0 |
| 1503.229  | 0.0670044 | 0.0105982 | 0 | 0 |
| 1503.2351 | 0.0649353 | 0.0111255 | 0 | 0 |
| 1557.7089 | 0.0672138 | 0.0179282 | 0 | 0 |
| 1563.728  | 0.0826305 | 0.0126138 | 0 | 0 |
| 1579.6829 | 0.0478971 | 0.0111125 | 0 | 0 |
| Time (J2000) | m(J)  | e(J)  | r(J) |
|-------------|-------|-------|------|
| 1579.6859   | 0.0570132 | 0.0109404 | 0    |
| 1584.6415   | 0.0942919 | 0.0122702 | 0    |
| 1584.6457   | 0.0977787 | 0.0116229 | 0    |
| 1585.6586   | 0.0597548 | 0.0111127 | 0    |
| 1585.6808   | 0.0419338 | 0.0111421 | 0    |
| 1587.6931   | 0.0443352 | 0.0115056 | 0    |
| 1587.6986   | 0.0499658 | 0.0111196 | 0    |
| 1619.5325   | 0.0179725 | 0.0119274 | 0    |
| 1619.5381   | 0.0285496 | 0.0119833 | 0    |
| 1627.6883   | 0.023539  | 0.011277  | 0    |
| 1627.6914   | 0.0275496 | 0.0112617 | 0    |
| 1629.5694   | 0.0195472 | 0.011631  | 0    |
| 1629.5768   | 0.0240008 | 0.0123249 | 0    |
| 1631.4752   | 0.0015472 | 0.0123249 | 0    |
| 1631.4802   | 0.0184798 | 0.0126132 | 0    |
| 1638.5201   | 0.0059588 | 0.0120941 | 0    |
| 1638.5309   | 0.0027584 | 0.0119655 | 0    |
| 1640.5795   | 0.0453646 | 0.0109411 | 0    |
| 1640.5839   | 0.0374772 | 0.0100087 | 0    |
| 1641.5369   | -0.0084004| 0.0104148 | 0    |
| 1641.5425   | -0.0060748| 0.0103176 | 0    |
| 1659.4823   | -0.0350745| 0.011631  | 0    |
| 1659.4853   | -0.0362565| 0.0125192 | 0    |
| 1660.3919   | 0.0059588 | 0.0120943 | 0    |
| 1660.3948   | 0.0027584 | 0.0119655 | 0    |
| 1662.529    | -0.0127341| 0.0118991 | 0    |
| 1662.5319   | -0.0056402| 0.0118764 | 0    |
| 1669.4128   | -0.0207091| 0.0131353 | 0    |
| 1669.4158   | -0.0230812| 0.0129508 | 0    |
| 1671.4091   | -0.0177911| 0.012751  | 0    |
| 1671.412    | -0.0264192| 0.0129996 | 0    |
| 1678.3637   | -0.0098259| 0.0137968 | 0    |
| 1681.362    | -0.0153006| 0.0117559 | 0    |
| 1681.3653   | -0.0260836| 0.0113727 | 0    |
| 1682.4537   | -0.0429714| 0.0117408 | 0    |
| 1682.4593   | -0.0611066| 0.0127487 | 0    |
| 1685.4624   | -0.02706  | 0.0113371 | 0    |
| 1685.4692   | -0.0227569| 0.0109892 | 0    |
| 1686.4591   | -0.075625 | 0.0112994 | 0    |
| 1686.4633   | -0.07707  | 0.0117506 | 0    |
| 1694.4875   | -0.0868201| 0.0130581 | 0    |
| 1694.4908   | -0.0805795| 0.0133028 | 0    |
| 1698.4203   | -0.0882925| 0.0120913 | 0    |
| 1698.4233   | -0.1117705| 0.0119962 | 0    |
| 1699.3612   | -0.0713517| 0.0126621 | 0    |
| 1699.3641   | -0.089508  | 0.0120793 | 0    |
| 1702.3531   | -0.110292 | 0.0100354 | 0    |
| 1702.3573   | -0.0937016| 0.0100651 | 0    |
| 1704.4133   | -0.0834264| 0.0113492 | 0    |
| 1704.4171   | -0.0880817| 0.0113746 | 0    |
| 1706.3762   | -0.0787974| 0.0115273 | 0    |
| 1706.3797   | -0.0924939| 0.0116714 | 0    |
| 1756.3565   | -0.051511  | 0.00985   | 1    |
| 1756.3594   | -0.045695  | 0.009682  | 1    |
| 1758.3457   | -0.0466   | 0.007994  | 1    |
| 1758.349    | -0.051098  | 0.008035  | 1    |
| 1762.4088   | -0.030175  | 0.009685  | 1    |
| 1762.4121   | -0.038849  | 0.009402  | 1    |
| 1785.3224   | -0.012936  | 0.008697  | 1    |
| 1785.3253   | -0.012231  | 0.008725  | 1    |
| 1796.3177   | -0.04169   | 0.008272  | 1    |
| 1901.7161   | 0.001405   | 0.007796  | 1    |
| 1901.7212   | 0.048541   | 0.007807  | 1    |
| 1906.6979   | 0.020837   | 0.010047  | 1    |
| 1906.7004   | 0.020973   | 0.00887   | 1    |
| 1906.7039   | 0.01496    | 0.008802  | 1    |
| 1906.7064   | 0.011338   | 0.008841  | 1    |
| 1920.6899   | 0.02133    | 0.010006  | 1    |
| 1934.7266   | -0.001449  | 0.009231  | 1    |
| 1934.7296   | -0.004032  | 0.009507  | 1    |
| Year   | Value_a | Value_b | Value_c | Value_d |
|--------|---------|---------|---------|---------|
| 1963.6566 | -0.025239 | 0.009322 | 1 |
| 1963.6608 | -0.027487 | 0.009709 | 1 |
| 1981.5345 | -0.068348 | 0.007559 | 1 |
| 1981.5375 | -0.066563 | 0.007549 | 1 |
| 1982.5529 | -0.043742 | 0.007532 | 1 |
| 1982.5558 | -0.039288 | 0.007536 | 1 |
| 1984.4905 | -0.020948 | 0.008844 | 1 |
| 1984.4986 | -0.025738 | 0.007749 | 1 |
| 1995.6008 | -0.03791 | 0.007619 | 1 |
| 1995.6057 | -0.037477 | 0.007699 | 1 |
| 1996.562 | -0.054647 | 0.008197 | 1 |
| 1996.3649 | -0.053332 | 0.008107 | 1 |
| 1998.6163 | -0.029189 | 0.007863 | 1 |
| 1998.6196 | -0.026745 | 0.007897 | 1 |
| 2018.4838 | -0.05546 | 0.00731 | 1 |
| 2018.4922 | -0.046048 | 0.00752 | 1 |
| 2019.4596 | -0.050644 | 0.008063 | 1 |
| 2019.4634 | -0.058727 | 0.008022 | 1 |
| 2026.4421 | -0.054393 | 0.007671 | 1 |
| 2026.4495 | -0.056232 | 0.007906 | 1 |
| 2027.5577 | -0.043676 | 0.008045 | 1 |
| 2027.5606 | -0.043018 | 0.008092 | 1 |
| 2029.5431 | -0.053642 | 0.007951 | 1 |
| 2029.5469 | -0.058752 | 0.007932 | 1 |
| 2043.4663 | -0.109213 | 0.008561 | 1 |
| 2043.4712 | -0.097366 | 0.008237 | 1 |
| 2044.5994 | -0.081487 | 0.009118 | 1 |
| 2050.4761 | -0.136944 | 0.007081 | 1 |
| 2050.4846 | -0.146212 | 0.007678 | 1 |
| 2050.4884 | -0.142721 | 0.007704 | 1 |
| 2079.4877 | -0.095869 | 0.008347 | 1 |
| 2079.4926 | -0.0971 | 0.008644 | 1 |
| 2106.3847 | -0.038415 | 0.007722 | 1 |
| 2106.3879 | -0.03651 | 0.007783 | 1 |
| 2109.4098 | 0.010932 | 0.007777 | 1 |
| 2109.4149 | 0.013416 | 0.007887 | 1 |
| 2117.3609 | 0.006159 | 0.008002 | 1 |
| 2117.3638 | 0.014303 | 0.00807 | 1 |
| 2118.3685 | -0.017431 | 0.007982 | 1 |
| 2118.3714 | -0.020039 | 0.008045 | 1 |
| 2120.3517 | 0.00943 | 0.008179 | 1 |
| 2120.3546 | 0.01021 | 0.008153 | 1 |
| 2137.3487 | -0.02078 | 0.007059 | 1 |
| 2139.3716 | -0.013609 | 0.007915 | 1 |
| 2140.3568 | -0.012979 | 0.007513 | 1 |
| 2230.2358 | -0.022836 | 0.008152 | 1 |
| 2230.2387 | -0.021532 | 0.008337 | 1 |
| 2288.683 | -0.065531 | 0.007763 | 1 |
| 2288.6892 | -0.065992 | 0.008496 | 1 |
| 2289.7346 | -0.048047 | 0.009239 | 1 |
| 2289.738 | -0.045157 | 0.009032 | 1 |
| 2291.7296 | -0.07685 | 0.007755 | 1 |
| 2291.7335 | -0.075707 | 0.007637 | 1 |
| 2296.6789 | -0.052402 | 0.007641 | 1 |
| 2296.6821 | -0.057838 | 0.007919 | 1 |
| 2314.6812 | -0.091407 | 0.007693 | 1 |
| 2314.6863 | -0.091224 | 0.008491 | 1 |
| 2316.696 | -0.119523 | 0.007581 | 1 |
| 2316.6999 | -0.117391 | 0.007651 | 1 |
| 2319.6936 | -0.101297 | 0.008156 | 1 |
| 2319.6985 | -0.102347 | 0.008519 | 1 |