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The *SOPHIE* search for northern extrasolar planets[⋆,⋆⋆]

I. A companion around HD 16760 with mass close to the planet/brown-dwarf transition

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ABSTRACT

We report on the discovery of a substellar companion or a massive Jupiter orbiting the G5V star HD 16760 using the spectrograph *SOPHIE* installed on the OHP 1.93-m telescope. Characteristics and performances of the spectrograph are presented, as well as the *SOPHIE* exoplanet consortium program. With a minimum mass of 14.3 $M_{\rm Jup}$, an orbital period of 465 days and an eccentricity of 0.067, HD 16760b seems to be located just at the end of the mass distribution of giant planets, close to the planet/brown-dwarf transition. Its quite circular orbit supports a formation in a gaseous protoplanetary disk.

Key words. planetary systems – techniques: radial velocities – stars: individual: HD 16760

1. Introduction

The vast majority of 350 known exoplanets have been found thanks to radial velocity measurements. Far from beeing an old-fashioned technique, Doppler measurements have illustrated these past years their capabilities extending the exoplanet search around a wide variety of stars. The sensitivity of this technique continuously increases, opening the possibility of exploring the domain of low-mass planets down to a few Earth masses, to discover and characterize multiple planetary systems, to perform long-term surveys to find true Jupiter-like planets, to establish the planetary nature and to characterize the transiting candidates of photometric surveys. Doppler surveys for exoplanet require high-precision spectrographs and a significant amount of telescope time over a long duration.

The *SOPHIE* spectrograph (Bouchy et al. 2006; Perruchot et al. 2008) has been in operation since October 2006 at the 1.93-m telescope of Observatoire de Haute-Provence. To benefit from experience acquired on HARPS (Pepe et al. 2002) and take the limitations of the ELODIE spectrograph into account (Baranne et al. 1996), *SOPHIE* was designed to obtain precise radial velocities with much higher throughput than its predecessor and to be operated as a northern counterpart of HARPS. This instrument is briefly described in Sect. 2. In October 2006, the *SOPHIE* consortium started a large and comprehensive program to search for and characterize exoplanets described in Sect. 3. We report in Sect. 4 the detection of a substellar companion or a massive Jupiter around HD 16760 and discuss in Sect. 5 the properties and nature of this object located at the upper limit of the mass distribution of giant planets.

2. The *SOPHIE* spectrograph

SOPHIE architecture mainly benefits from experience with ELODIE and HARPS. A detailed technical description of this instrument is given by Perruchot et al. (2008). In this section we briefly describe the main properties of the spectrograph and its different observing modes. *SOPHIE* is a cross-dispersed, environmentally stabilized echelle spectrograph dedicated to high-precision radial velocity measurements. The detector (EEV-4482) is a thinned, back-illuminated, anti-reflection coated 4 k × 2 k 15-μm-pixel CCD cooled at -100°C, with slow- and fast-readout modes. It records 39 spectral orders covering the wavelength domain from 3872 to 6943 Å. The spectrograph is fed through a pair of 3″-wide optical fibers for the high-resolution mode (R = 75 000, obtained from an extra slit), and another pair for the high-efficiency mode (R = 40 000, allowing one magnitude gain). The high-resolution mode is equipped with a double-fiber scrambler (Brown 1990) to homogenize and stabilize the illumination of the spectrograph entrance. For each

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[⋆] Based on observations made with *SOPHIE* spectrograph on the 1.93-m telescope at Observatoire de Haute-Provence (CNRS/OAMP), France (program 07A.PNP.CONS).

[⋆⋆] Table 2 is also 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/505/853`

fiber pair, one aperture is used for starlight, whereas the other one, 2′ away from the first one, can be used either on a Thorium-Argon lamp for tracking spectrograph drift (*thosimult* mode), or on the sky to estimate background pollution, especially in case of strong moonlight (*objAB* mode). Both aperture can also be simultaneously put on Thorium-Argon or tungsten lamps for wavelength or flat-field calibrations, respectively. Apart from thermal precautions, the key point for stability is the encapsulation of the dispersive components in a constant pressure tank. This solution stabilizes the air refractive index sensitive to atmospheric pressure variations. With such a concept, typical intrinsic drift of the spectrograph is less than 3 $\mathrm{m\,s^{-1}}$ per hour. The ELODIE front-end adaptor (Baranne et al. 1996) is still used for *SOPHIE*. It holds the calibration lamps, the atmospheric dispersion corrector and the guiding system. Compared to ELODIE, *SOPHIE* leads to 1) gain on photon efficiency by a factor of 10 in high-efficiency mode; 2) increase in the spectrograph's radial velocity stability by a factor of 3; and 3) increase in the spectral resolution from 42 000 to 75 000 for the high-resolution mode.

The spectra are extracted from the detector images and the radial velocities are measured online with the *SOPHIE* pipeline derived and adapted from the HARPS one[1]. The spectra extraction includes localization of the 39 spectral orders on the 2D-images, optimal order extraction, cosmic-ray rejection, wavelength calibration, and spectral flat-field correction, yielding a two dimension spectra (E2DS). The orders are then merged and rebinned after correction of the blaze function, yielding a one-dimensional spectrum (S1D). The E2DS spectra are cross-correlated with numerical masks corresponding to different spectral types (F0, G2, K0, K5, M4), and the resulting cross-correlation functions (CCFs) are fitted by Gaussians to get the radial velocities (Baranne et al. 1996; Pepe et al. 2002).

Following the approach of Santos et al. (2002), we calibrated the CCF to determine the projected rotational velocity $v\sin i$ and the metallicity index [Fe/H]. We also calibrated the CCF to compute the RV photon-noise uncertainty σ_{VR}. Following the approach of Santos et al. (2000), we computed and calibrated the chromospheric-activity index R'_{HK} based on our *SOPHIE* spectra.

The *SOPHIE* radial velocity measurements were initially affected by a systematic effect at low signal-to-noise ratio caused by CCD charge transfer inefficiency (CTI), which increases at a low flux level. This effect was calibrated and is now corrected by the pipeline, which reallocates the charge lost during the readout process on each extracted pixel (Bouchy et al. 2009). Uncertainties on the radial velocity measurements include photon noise, uncertainties in the wavelength calibration, and systematic instrumental errors. The photon-noise RV uncertainty depends on the signal-to-noise of the spectra, as well as on the spectral type and the rotation velocity $v\sin i$ of the observed star (Bouchy et al. 2001). It can be approximated by the semi-empirical estimator $\sigma_{\mathrm{RV}} = A \times \sqrt{FWHM}/(S/N \times C)$, where $FWHM$ is the full width at half maximum of the CCF (in same unit as σ_{RV}), C is its contrast (in percent of the continuum), S/N is the signal-to-noise ratio per pixel at 550 nm, and the scaling factor $A = 1.7$ or 3.4 in high-resolution or high-efficiency mode, respectively. For a non rotating K-dwarf star, an S/N per pixel of 150 provides a photon-noise RV uncertainty of 1 $\mathrm{m\,s^{-1}}$. Such an S/N is obtained on 5-mn on a 6.5 mag star. The uncertainty of the wavelength calibration was estimated to 1 $\mathrm{m\,s^{-1}}$. Telescope guiding and centering errors in average weather conditions are typically of 0.3−1 arcsec. In high-resolution mode, these errors imply an RV jitter of 3−4 $\mathrm{m\,s^{-1}}$ due to the insufficient scrambling gain of the fiber. This corresponds to the dispersion obtained on the *SOPHIE* measurements around the orbit of HD 189733b, after correction for the stellar jitter (Boisse et al. 2009). Uncertainties due to guiding errors are more than twice this level in high-efficiency mode because of the absence of scrambler in this instrumental setup.

The present radial velocity precision obtained on stable stars is about 4−5 $\mathrm{m\,s^{-1}}$ over several semesters. This limitation is mainly caused by guiding and centering effects on the fiber entrance at the telescope focal plan and the insufficient scrambling provided by the fiber and the double scrambler. An upgrade of the Cassegrain fiber adapter is presently being carried out, including a new high-precision guiding camera and a new double scrambler, with the goal of reaching the precision level of 1−2 m/s.

3. The *SOPHIE* exoplanet program

The *SOPHIE* consortium program is devoted exclusively to study and characterizing exoplanets, in continuation of a planet-search program initiated 15 years ago with the ELODIE spectrograph (Queloz et al. 1998) and to complement the HARPS program performed in the southern hemisphere (Mayor et al. 2003). We started a key program on October 2006 with the aim of covering a large part of the exoplanetary science and constraining on the formation and evolution processes of planetary systems. Our observing strategies and target samples are optimized to achieve a variety of science goals and to solve several important issues: 1) mass function of planets below the mass of Saturn; 2) planetary statistical properties to constrain the formation and evolution models; 3) relationships between planets and the physical and chemical properties of their stars; 4) detection of exoplanets around nearby stars, allowing space and ground-based follow-up; 5) deep characterization of known transiting exoplanets including long term follow-up and spectroscopic transit analysis. All these aspects are treated through 5 complementary subprograms discussed below and using about 60 nights per semester with *SOPHIE* at the 1.93-m telescope.

– *High precision search for super-Earths*

Only a few percent of the 350 detected planets have masses less than 0.1 M_{Jup}, and the present precision of radial velocity surveys means that the distribution of planetary masses is heavily biased against low-mass planets. Recent HARPS discoveries indicate that these low-mass exoplanets are not rare and suggest that 30% of inactive G and K dwarfs solar-type harbor Neptune or rocky planets with periods shorter than 50 days (Lovis et al. 2009; Mayor et al. 2009). From the ELODIE survey and from our volume-limited subprogram, we pre-selected a sample of about 200 inactive bright solar-type stars to explore this domain of low-mass planets.

– *Giant planets survey on a volume-limited sample*

For a large volume-limited sample of 2000 stars, we are performing a first screening to identify new Hot Jupiters and other Jovian-type planets orbiting near and bright stars. Increasing the list of Hot Jupiters offers a chance to find a transiting one orbiting a bright star appropriate for additional study of planetary atmosphere. This survey will also provide better statistics to search for any new properties of the distribution of exoplanet parameters. We include on this subprogram

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[1] `http://www.eso.org/sci/facilities/lasilla/instruments/harps/`

the long-term follow-up and the spin-orbit analysis – from the Rossiter-McLaughlin effect – of known transiting giant exoplanets to respectively detect additional companions and determine the spin-orbit angle of the system.

– *Search for exoplanets around M-dwarfs*

A systematic search for planets is being made for a volume-limited sample of 180 M-dwarfs closer than 12 parsecs. This survey of low-mass stars will give us a chance to derive the frequency of planets as a function of the stellar mass. The objectives are 1) to detect exoplanets of few Earth masses in the habitable zone; 2) to determine the statistics of planetary systems orbiting M-dwarfs in combining these 180-M dwarfs sample with 100-M dwarfs monitored with HARPS; and 3) to identify new potential transiting Hot Neptunes.

– *Search for exoplanets around early-type main sequence stars*

A systematic search for planets around a sample of 300 early-type main sequence stars (A and F stars) is being performed to study the impact of the host star mass on the exoplanet formation processes. Such stars were previously not included in the exoplanet surveys due to their lack of spectral lines and high rotation broadening. A specific pipeline was developed to compute radial velocity on these specific targets (Galland et al. 2005a) with an accuracy allowing the detection of planets from massive hot Jupiters for fast-rotating A stars, and down to Neptune-mass planets for the slowest F stars.

– *Long-term follow-up of ELODIE long period candidates*

The ELODIE program for exoplanet search that started in 1994 was performed on a sample of 320 G and K stars. About 40 of these stars present evidence of long-term trends that may come from giant planets with Jupiter or Saturn-like orbits. A long-term follow-up of these candidates is being performed to explore the domain of long period (≥10 years) planets.

As part of the *SOPHIE* consortium programs, the detection of four exoplanets have been published up to now: HD 43691b and HD 132406b (Da Silva et al. 2008), HD 45652b (Santos et al. 2008), and θ Cygni b (Desort et al. 2009). These planets respectively have minimum masses of 2.5, 5.6, 0.5, and 2.3 M_{Jup} with 37, 975, 44, and 154 day periods. There were first found from the ELODIE or CORALIE survey then monitored by *SOPHIE*. Spectroscopic transits of the massive planets HD 147506b and XO-3b have been also observed (Loeillet et al. 2008 and Hébrard et al. 2008, respectively), allowing refinement of the parameters of the system, and detection of a first case of misaligned spin-orbit for XO-3 (recently confirmed by Winn et al. 2009). A study of the stellar activity of the transiting planet host star HD 189733 is also presented by Boisse et al. (2009). Recently the transit of the 111-day period exoplanet HD 80606b was established by Moutou et al. (2009).

Outside of the consortium programs, *SOPHIE* plays an efficient role in the Doppler follow-up of photometric surveys for planetary transit searches. It allowed the planetary nature to be established for transiting candidates found by SuperWASP (e.g. Collier Cameron et al. 2007; Pollacco et al. 2008; Hebb et al. 2008), by HAT (Bakos et al. 2007), and by the CoRoT space mission (e.g. Barge et al. 2008; Bouchy et al. 2008; Moutou et al. 2008; Deleuil et al. 2008; Rauer et al. 2009), as well as the parameters of these new planets to be characterized, including measuring the masses.

Table 1. Adopted stellar parameters for HD 16760.

Parameters	Values	References
m_v	8.744	Nordström et al. (2004)
Spectral type	G5V	Hipparcos catalog
$B-V$	0.71 ± 0.02	Hipparcos catalog
Distance [pc]	50 ± 7	Hipparcos catalog
pmRA [mas/yr]	82.8 ± 3.1	Hipparcos catalog
pmDEC [mas/yr]	−110.6 ± 3.1	Hipparcos catalog
$v \sin i$ [km s^{-1}]	2.8 ± 1.0	this work
$\log R'_{\mathrm{HK}}$	−5.0 ± 0.1	this work
[Fe/H]	−0.02 ± 0.03	this work
T_{eff} [K]	5620 ± 30	Nordström et al. (2004) & this work
$\log g$ [cgi]	4.51 ± 0.1	this work
Mass [$M_\odot$]	0.88 ± 0.08	Nordström et al. (2004) & this work

In the next section we present the detection of the substellar companion orbiting HD 16760 as part of our subprogram 2 "*Giant planets survey on a volume-limited sample*".

4. The substellar companion of HD 16760

4.1. Stellar properties of HD 16760

HD 16760 (HIP 12638, BD+37 604) is a G5V star located 50 pc away according the Hipparcos parallax. Table 1 summarizes the stellar parameters. From spectral analysis of the *SOPHIE* data using the method presented in Santos et al. (2004), we derived $T_{\mathrm{eff}} = 5608 \pm 20$ K, $\log g = 4.51 \pm 0.10$, [Fe/H] $= -0.02 \pm 0.03$, and $M_* = 0.86 \pm 0.06\ M_\odot$, which agrees with values from the literature. For the temperature and the mass, the values we adopt in Table 1 are compromise values between ours and those obtained by Nordström et al. (2004) ($T_{\mathrm{eff}} = 5636$ K and $M_* = 0.91^{+0.08}_{-0.04}\ M_\odot$). We derive $v \sin i = 2.8 \pm 1.0$ km s^{-1} from the parameters of the CCF using a calibration similar to those presented by Santos et al. (2002), in agreement with the value $v \sin i = 3$ km s^{-1} from Nordström et al. (2004). The CCF also allows the value [Fe/H] $= 0.06 \pm 0.05$ to be measured, which agrees with but is less accurate than the metallicity obtained above from spectral analysis. This target has a quiet chromosphere with no emissions in the Ca II lines ($\log R'_{\mathrm{HK}} = -5.0 \pm 0.1$), making it a favorable target for planet searches from radial velocity measurements.

HD 16760 has a stellar companion, HIP 12635 (Apt 1988; Sinachopoulos 2007), located 14.562 ± 0.008 arcsec in the north and 1.521 ± 0.002 mag fainter. From the Hipparcos catalog (Perryman et al. 1997), HIP 12635 has similar distance (45 ± 17 pc) and similar proper motions (pmRA = 107 ± 17 mas/yr, pmDEC = −103 ± 12 mas/yr) with HD 16760, making them a likely physical system, with a separation >700 AU and an orbital period >10 000 years. This would induce tiny radial velocity variations on the stars, below 0.2 m s^{-1}yr^{-1}.

4.2. Radial velocity measurements and Keplerian fit

We acquired 20 spectra of HD 16760 within *objAB* mode with *SOPHIE* between December 2006 and October 2008 under good weather conditions. Two of these 20 spectra were significantly contaminated by the Moon. The velocity of the CCF due to the Moon was far enough from those of the target to avoid any significant effect on the radial velocity measurement. We did not use these two spectra, however, for the spectral analysis presented in Sect. 4.1.

Table 2. Radial velocities of HD 16760 measured with *SOPHIE*.

BJD $-2\,400\,000$	RV ($\mathrm{km\,s^{-1}}$)	$\pm 1\sigma$ ($\mathrm{km\,s^{-1}}$)	Exp. time (s)	S/N p. pix. (at 550 nm)
54 099.3679	−3.6736	0.0055	300	62.5
54 126.3439	−3.7916	0.0058	300	52.1
54 127.2914	−3.8085	0.0068	480	36.2
54 133.2541	−3.8478	0.0055	224	61.4
54 138.3414	−3.8366	0.0054	673	67.1
54 148.3393	−3.8898	0.0071	224	35.1
54 151.3375	−3.9150	0.0092	225	30.0
54 155.2737	−3.9168	0.0063	180	43.5
54 339.6353	−3.3666	0.0053	512	78.7
54 352.6607	−3.2786	0.0058	380	52.0
54 367.6375	−3.2481	0.0055	300	61.2
54 407.4733	−3.1806	0.0053	500	79.5
54 434.4441	−3.1703	0.0055	620	64.2
54 502.2489	−3.3798	0.0057	443	54.5
54 513.2880	−3.4358	0.0059	464	53.4
54 546.2900	−3.5725	0.0061	1304	47.3
54 683.6329	−3.9680	0.0058	393	51.4
54 705.6646	−3.9045	0.0058	379	51.2
54 739.5899	−3.7242	0.0059	350	50.1
54 755.5295	−3.6488	0.0058	270	51.2

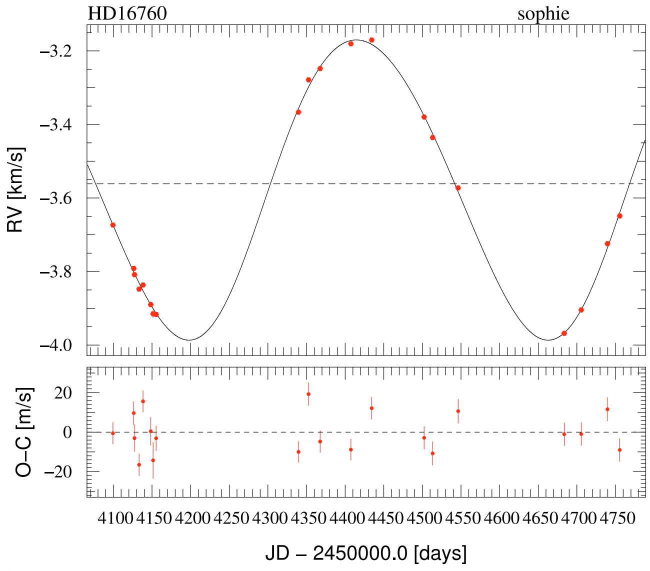

Fig. 1. *Top*: radial velocity *SOPHIE* measurements of HD 16760 as a function of time, and Keplerian fit to the data. The orbital parameters corresponding to this fit are reported in Table 3. *Bottom*: residuals of the fit with 1-σ error bars.

The derived radial velocities are reported in Table 2, together with the journal of observations. Their typical accuracy is around 6 $\mathrm{m\,s^{-1}}$, which is the quadratic sum of three sources of noise: photon noise (3 $\mathrm{m\,s^{-1}}$), guiding (4 $\mathrm{m\,s^{-1}}$), and spectrograph drift (3 $\mathrm{m\,s^{-1}}$).

The radial velocities, shown in Fig. 1, present clear variations on the order of hundreds of $\mathrm{m\,s^{-1}}$, without significant variations ($\sigma < 10\ \mathrm{m\,s^{-1}}$) in the CCF bisector (Fig. 2), thus in agreement with the reflex motion due to a companion. We fitted the data with a Keplerian model. The solution is a 465-day period oscillation with a semi-amplitude $K = 408\ \mathrm{m\,s^{-1}}$, corresponding to a substellar companion, with a minimum mass $m_{\mathrm{p}} \sin i = 14.3\ M_{\mathrm{Jup}}$. The derived orbital parameters are reported in Table 3, together with error bars, which were computed from χ^2 variations and Monte Carlo experiments.

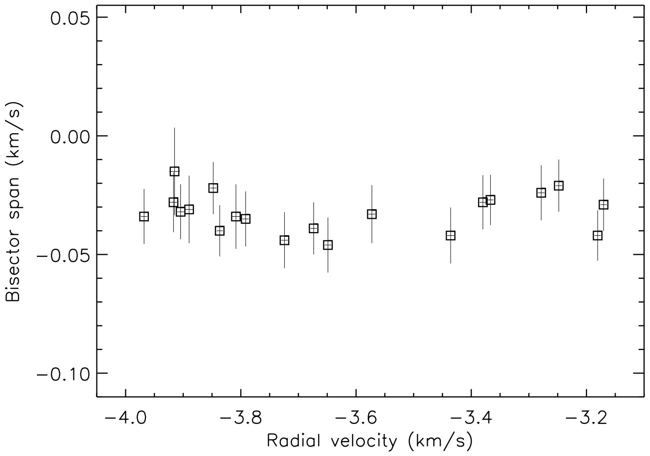

Fig. 2. Bisector span as a function of the radial velocity.

Table 3. Fitted orbit and planetary parameters for HD 16760b.

Parameters	Values and 1-σ error bars	Unit
V_r	-3.561 ± 0.004	$\mathrm{km\,s^{-1}}$
P	465.1 ± 2.3	days
e	0.067 ± 0.010	
ω	-128 ± 10	°
K	408 ± 7	$\mathrm{m\,s^{-1}}$
T_0 (periastron)	$2\,454\,723 \pm 12$	BJD
σ(O–C)	10.1	$\mathrm{m\,s^{-1}}$
reduced χ^2	2.0	
N_{obs}	20	
$m_{\mathrm{p}} \sin i$	$14.3 \pm 0.9^{\dagger}$	M_{Jup}
a	$1.13 \pm 0.03^{\dagger}$	AU

† Using $M_\star = 0.88 \pm 0.08\ M_\odot$.

The standard deviation of the residuals to the fit is σ(O–C) = 10.1 $\mathrm{m\,s^{-1}}$. This is higher than the 6- $\mathrm{m\,s^{-1}}$ estimated uncertainty on the individual measurements. Although about 23% of gaseous giant planets are in a multiple planetary system, we have not yet identified any indication for a second body orbiting HD 16760. With a maximum semi-amplitude of 20 $\mathrm{m\,s^{-1}}$, the residuals of the fit do not exhibit structures, denying a possible inner planet with $m_{\mathrm{p}} \sin i \geq 0.7\ M_{\mathrm{Jup}}$. A longer period planet may induce a drift lower than 20 $\mathrm{m\,s^{-1}yr^{-1}}$ during our observational period.

5. Discussion and conclusion

Our RV measurements indicate that a substellar companion with a projected mass $m_{\mathrm{p}} \sin i = 14.3\ M_{\mathrm{Jup}}$ is orbiting HD 16760. With the degeneracy of inclination angle i, it is difficult to conclude anything about the exact nature of this companion. It may correspond to a massive planet, formed in a gaseous protoplanetary disk, or a brown dwarf issued from collapse in a giant molecular cloud.

Figure 3 shows the mass distribution of massive planets ($m_{\mathrm{p}} \sin i \geq 3\ M_{\mathrm{Jup}}$) and light brown dwarfs ($M_{\mathrm{c}} \sin i \leq 30\ M_{\mathrm{Jup}}$) found by radial velocity surveys. From the Extrasolar Planets Encyclopaedia list[2], we completed with HD 137510b (Endl et al. 2004), HD 180777b (Galland et al. 2005b), and HD 16760b (this paper), totaling 89 objects including 10 with masses between 15 and 30 M_{Jup}. It is worthwhile noticing that, although based on a small number of object, the mass distribution of transiting

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[2] `http://exoplanet.eu`

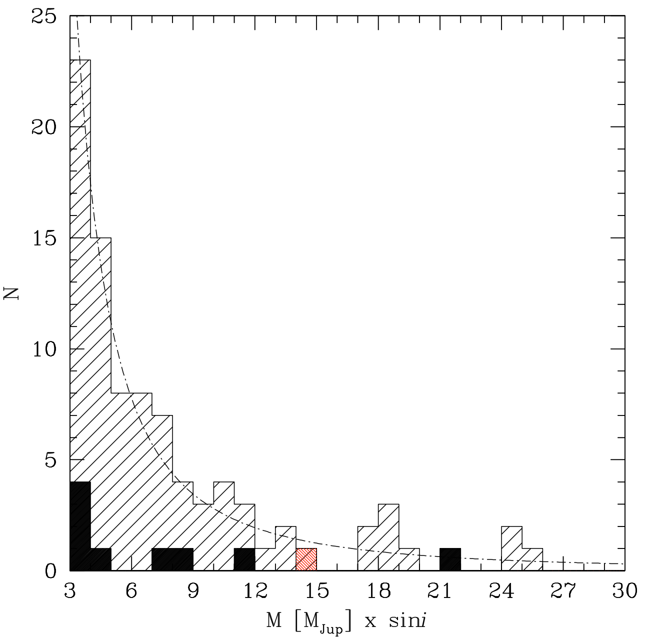

Fig. 3. Mass distribution of massive planets ($m_p \sin i \geq 3\ M_{\rm Jup}$) and light brown dwarfs ($M_c \sin i \leq 30\ M_{\rm Jup}$) found by radial velocity surveys. The dashed curve corresponds to the relation M^{-2} ($dN/dM = M^{-1}$). The black shaded histogram corresponds to the transiting planets with true masses (excluding non-confirming objects SWEEPS-11 and SWEEPS-04). HD 16760b, with $m_p \sin i = 14.3\ M_{\rm Jup}$, is identified by the red-filled box. Black-filled symbols correspond to transiting companions.

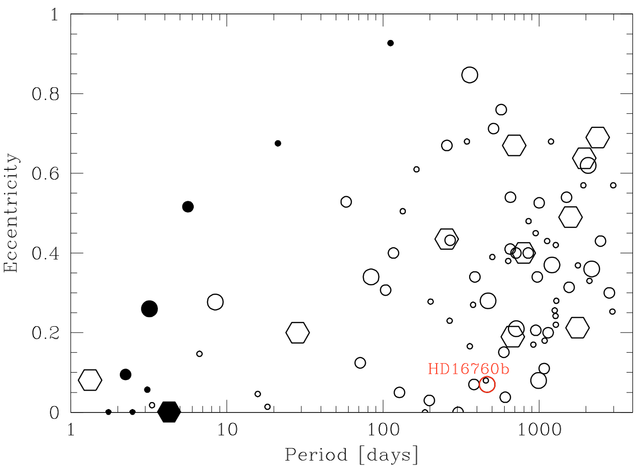

Fig. 4. Eccentricity–period diagram of massive exoplanets and light brown dwarfs. The size of circle is a function of the mass (3–5, 5–10, 10–15 $M_{\rm Jup}$). Hexagonal points correspond to objets with mass greater than 15 $M_{\rm Jup}$. HD 16760b, with $P = 465$ days and $e = 0.067$, is identified by the red circle. Black filled symbols correspond to transiting companions.

planets follows the same trend as non-transiting planets. Indeed, the ratio of transiting planets over non-transiting planets is about the same: 9.2, 9.5 and 10 for the bins 3–6, 6–9, and 9–12 $M_{\rm Jup}$, respectively. In this histogram, HD 16760b seems to be located just at the end of the mass distribution of giant planets. Although based on small numbers, substellar companions with minimum mass greater than 17 $M_{\rm Jup}$ do not seem to follow the M^{-2} relation.

Figure 4 shows the eccentricity–period diagram of massive exoplanets and light brown dwarfs. HD 16760b confirms the observed trend that more massive companions are found for longer period planets (Udry & Santos 2007). We also notice that all companions with masses over 15 $M_{\rm Jup}$ have an eccentricity greater than 0.2 except CoRoT-exo-3b (Deleuil et al. 2008) and HD 41004Bb (Zucker et al. 2004) in very close-in orbits (with periods of respectively 4.2 et 1.3 days) that are tidally circularized. The properties of HD 16760b make it an interresting substellar companion. With a mass greater than the Deuterium burning limit (13 $M_{\rm Jup}$), it may be defined as a brown-dwarf. However its quite circular orbit supports formation in a gaseous protoplanetary disk. Using another approach, Halbwachs et al. (2005) studied the eccentricity distribution for exoplanets and binary stars with a mass ratio lower than 0.8 (non twin binaries). They find that exoplanets have orbits with eccentricities significantly lower than those of the non-twin binaries, reinforcing the hypothesis that planetary systems and stellar binaries are not products of the same physical process.

HD 16760b is in a visual and physical binary system. However, in the mass-period and eccentricity-period diagrams, HD 16760b is located in a region not populated much by planets in binary systems. The discovery of this long-period, low-eccentricity planet thus adds to the growing evidence that, in contrast to short-period planets, long-period ($\gtrsim$100 days) planets residing in binaries possess the same statistical properties as their counterparts orbiting single stars (Eggenberger et al. 2004; Mugrauer et al. 2005; Desidera et al. 2007).

HD 16760b would induce a motion of its host star of at least ±0.35 milli-arcsec. The future Gaia ESA space mission scheduled for launch in late 2011 should be able to detect this system from astrometry, and thus would allow the inclination of the system to be measured and the true mass to be determined. Detailed caracterization of this substellar companion close to planet/brown-dwarf transition will help to distinguish the differences of formation processes between these two populations.

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