K2-29 b/WASP-152 b: AN ALIGNED AND INFLATED HOT JUPITER IN A YOUNG VISUAL BINARY

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1. INTRODUCTION

In the present paper we report the discovery of a new hot Jupiter, K2-29 b, first detected by the Super-WASP observatory and then by the K2 space mission during its campaign 4. The planet has a period of 3.25 days, a mass of 0.73 ± 0.04 M⊙ and a radius of 1.19 ± 0.02 RJ. The host star is a relatively bright (V = 12.5) G7 dwarf with a nearby K5V companion. Based on stellar rotation and the abundance of lithium, we find that the system might be as young as ~450 Myr. The observation of the Rossiter–McLaughlin effect shows that the planet is aligned with respect to the stellar spin. After the deep transit (20 mmag), the magnitude of the star and the presence of a nearby stellar companion, the planet is a good target for both space- and ground-based transmission spectroscopy, in particular in the near-infrared where both stars are relatively bright.

Key words: planets and satellites: detection – stars: individual (EPIC21189792) – techniques: high angular resolution – techniques: photometric – techniques: radial velocities – techniques: spectroscopic

1. INTRODUCTION

while small exoplanets are currently the most searched-for objects, giant planets are still interesting to characterize for two main reasons: (1) there are still open questions that are not fully understood, such as their formation and their inflation (Santerne et al. 2016, and references therein) and (2) they are still the best targets for atmosphere characterization from space (e.g., Stevenson et al. 2014) or from the ground (e.g., Croll...
Table 1

Various Identification (IDs), Magnitudes, and Coordinates of the Target Star

| Value       | Reference           |
|-------------|---------------------|
| EPIC ID     | 211089792           | Huber et al. (2015) |
| TYC ID      | 1818-1428-1         | Heg et al. (2000)   |
| WASP ID     | 152                 |                      |
| K2 ID       | 29                  |                      |
| R.A.        | 04:10:40.955        | Huber et al. (2015) |
| Decl.       | +24:24:07.35        | Huber et al. (2015) |
| pmR.A. (mas yr\(^{-1}\)) | 4.99  | Fedorov et al. (2011) |
| pmDecl. (mas yr\(^{-1}\)) | −39.73 | Fedorov et al. (2011) |
| Kepler \(K_\circ\) | 12.91  | Huber et al. (2015) |
| Johnson B   | 13.597 ± 0.062      | this work            |
| Johnson V   | 12.526 ± 0.044      | this work            |
| 2MASS J     | 10.622 ± 0.035      | Cutri et al. (2013)  |
| 2MASS H     | 10.168 ± 0.041      | Cutri et al. (2013)  |
| 2MASS Ks    | 10.062 ± 0.034      | Cutri et al. (2013)  |
| WISE 3.4 \(\mu\)m | 10.095 ± 0.037 | Cutri et al. (2013)  |
| WISE 4.6 \(\mu\)m | 10.142 ± 0.037 | Cutri et al. (2013)  |
| WISE 12 \(\mu\)m | 9.991 ± 0.082 | Cutri et al. (2013)  |

et al. 2015). The latter requires planet hosts much brighter than the typical stars targeted by the CoRoT (Baglin et al. 2006) and Kepler (Borucki et al. 2009) space missions (\(V\) magnitudes mostly between 14 and 16).

After the failure of two of the reaction wheels, the resurrected Kepler mission, K2 (Howell et al. 2014) is now targeting different fields of view along the ecliptic plane. K2 targets are proposed by the community through international calls. As a result, K2 is observing much brighter stars than during the prime mission (\(V\) magnitudes up to 12) to allow for spectroscopic follow-up and atmosphere characterization, as well as many more M dwarfs (e.g., Almenara et al. 2015; Crossfield et al. 2015).

In this paper we present the discovery of a new giant planet, K2-29 b, transiting a relatively bright (\(V = 12.5\)) and young (~450 Myr) star in a visual binary observed during the K2 campaign 4. In Section 2, we present the target star and the observations, which we then analyze in Section 3. We draw our conclusions and discuss the interest of this new planet in the context of ground-based atmospheric characterization in Section 4.

2. OBSERVATIONS AND DATA REDUCTION

2.1. Ground- and Space-based Photometry

2.1.1. K2 Data

The target star K2-29\(^{34}\) was observed by the Kepler telescope from 2015 February 07 to April 23. Basic information about this target is provided in Table 1. We reduced the K2 raw pixel data using both the Warwick (Armstrong et al. 2015a, 2015b) and the LAM-K2 (Barros et al. 2015) pipelines which gave similar results, except that the Warwick light curve has more noise. We therefore adopted the light curve produced by the LAM-K2 pipeline. A transiting candidate was easily detected by both pipelines as it presents a 2%-deep transit-like event with a periodicity of about 3,258 days. This period is close to 153.5 times the integration time of the long-cadence mode of Kepler. This means that the orbital phases covered by K2 coincide every two periods. As a consequence the transit is poorly sampled by the K2 data, hence the transit parameters are degenerated and thus they are not precisely determined. To correct for instrumental effects and stellar variability, we normalized the transits by fitting a parabola to 5 hr of out-of-transit data each side of the transit. This reduced light curve is the one used for the analysis described in Section 3. The star also exhibits a clear variability at the level of 1% with a rotation period of about 11 days (see Figure 1). Following the work of McCullan et al. (2013, 2014), we computed the autocorrelation function of the light curve. We find that the host star has a rotation period of 10.79 ± 0.02 days, which is close to three times the orbit of the planet.

2.1.2. Archival Super-WASP Data

A 2% transit depth on a star of magnitude 12.5 could be easily detected from the ground. We checked the SuperWASP (Pollacco et al. 2006) public data available in the NASA exoplanet archive 35 and found that the K2 star K2-29 was observed at least from 2004 July 29 to 2008 March 16. This candidate was found in the WASP data with the same period, but a quick analysis of the spectrum misclassified it as an evolved star, and the star was no longer considered for precise radial velocity follow-up (Super-WASP team 2016, private communication). To allow a comparison of the WASP data with the K2 data, we converted the heliocentric Julian dates from the WASP data to barycentric Julian dates (BJD) in the barycentric dynamical time (TDB) reference using the online tool kindly provided by Eastman et al. (2010). We then normalized the WASP transits by fitting a parabola in the out-of-transit parts, as for the K2 transits.

2.1.3. Professional and Amateur Ground-based Photometry

To improve the sampling of the transit and the precision of the ephemeris we performed a photometric campaign to observe the transit that occurred on 2016 January 15 using a network of professional and amateur facilities in Europe (France, Portugal, and Italy). In total 19 observatories detected the same transit and are listed in Table 2. The data were extracted using aperture photometry with the software Munipack (Hroch 2014) or AstroImageJ (Collins

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\(^{34}\) Guest Observer program GO4007.

\(^{35}\) http://exoplanetarchive.ipac.caltech.edu
et al. 2016). We converted all the times into BJD TDB and normalized the transits as for the K2 and Super-WASP data.

2.2. High-resolution Imaging

2.2.1. FTN Seeing-limited Imaging

The SDSS DR9 (Ahn et al. 2012) images of the star K2-29 revealed the presence of a close companion. To characterize this companion further, we obtained seeing-limited images with the Faulkes Telescope North (FTN), operated by the LCOGT network (Brown et al. 2013). We collected three exposures of 20 s each in the B, V, and R bands. We clearly detected a stellar companion located at about 4′′3 and ≈35′′ north-to-east (see Figure 2).

We searched for archival data in the Digitalized Sky Survey. Images taken in 1949 and 1993 do not resolve this stellar companion but one can clearly see an elongated point-spread function. The angular separation is about 3′ and 35′′, respectively. The 5σ sensitivity curve from the Faulkes Telescope North (FTN) observations is presented in Figure 2.

2.2.2. AstraLux Lucky-imaging Observations

To search for other stellar companions in the system we performed high-resolution imaging with the AstraLux lucky-imaging instrument (Hormuth et al. 2008) mounted at the 2.2 m telescope in the Calar Alto Observatory (Spain). We observed this target in the i′ and z′ bands on 2015 November 20 under relatively good weather conditions (seeing of around 0″9 and fair transparency with about 0.2 mag of extinction at the zenith). We obtained 90,000 frames of 30 ms in full frame mode (24 × 24″) for the i′ band and 57,000 frames of 30 ms for the z′ band. The frames were reduced using the observatory pipeline described in Hormuth et al. (2008). The pipeline performs a basic reduction of the individual frames (bias and flat-field correction), sorts them by image quality in terms of the Strehl ratio (Strehl 1902), then aligns and combines the best 10% of the frames to produce the final near-diffraction limited image. We found no extra star besides star B. We used an image from the M15 globular cluster to obtain the astrometric calibration (see Lillo-Box et al. 2014, for details). In the z′ band image star B is located at 4.30′′ ± 0″018. According to our aperture photometry, star B is fainter than star A by 1.59 ± 0.01 mag and 1.42 ± 0.01 mag in the i′ and z′ bands, respectively. The 5σ sensitivity curves of the two images within the first 3″ were then computed by following the prescriptions in Lillo-Box et al. (2014). The result is presented in Figure 2. No additional objects are found within these limits.
2.3. Spectroscopic Follow-up

2.3.1. CAFE

We obtained three observations with the CAFE spectrograph (Aceituno et al. 2013) mounted at the 2.2 m telescope at the Calar Alto Observatory (Spain). CAFE is a high-resolution spectrograph ($R = 63,000$) with no movable pieces and a fixed wavelength coverage in the range 4000–9500 Å. Since the spectrograph is not stabilized for temperature and pressure, the ambient conditions of the chamber where the instrument is located are continuously monitored to check for possible changes during the observations. The three spectra were reduced with the observatory pipeline, using the closest ThAr frame to perform the wavelength calibration and master bias and flats for the basic reduction. The radial velocity was extracted by using the cross-correlation technique, using a solar spectrum mask with more than two thousand specifically selected lines (see Lillo-Box Table 3).
et al. 2015, for details). The radial velocities, bisector, and full width half maximum (FWHM) are provided in the Table 3 together with their uncertainties.

2.3.2. SOPHIE

We observed the target star 27 times with the SOPHIE spectrograph35 (Bouchy et al. 2013) mounted at the 1.93 m telescope at the Haute-Provence Observatory (France). These observations were carried out from 2015 October 8 to 2016 January 16 as part of a large program to characterize Kepler and K2 candidates. SOPHIE is a fiber-fed high-resolution echelle spectrograph stabilized in temperature and pressure. We used the high-efficiency (R ∼ 40,000) mode which allows about 10 m s⁻¹ precision in exposure times of less than one hour for this star. We reduced the data using the online pipeline which computes the weighted cross-correlation function (CCF) between the spectra and a numeric mask which corresponds to a G2V star (Baranne et al. 1996; Pepe et al. 2002). The choice of this mask is driven by the spectral type of the host star (see Section 3).

We corrected the data for the charge transfer inefficiency of the CCD (Bouchy et al. 2009) following the procedure described in Santerne et al. (2012). We also corrected the radial velocities from second-order instrumental drifts (not corrected by the wavelength calibration) using the radial velocities from the constant star HD 56124 observed during the same nights, as done in Santerne et al. (2014). We list in Table 3 the radial velocities, bisector, and FWHM of the star with their uncertainties estimated following the methods of Boisse et al. (2010) and Santerne et al. (2015).

Among the 27 observations done with SOPHIE, 16 spectra were collected during the transit night of 2016 January 15 in order to detect the Rossiter–McLaughlin effect.

The fiber of the SOPHIE spectrograph has an aperture on the sky of 3″. Depending on the seeing condition and telescope tracking precision, the light from the component B might have affected the data. If both components are physically bound, it is expected that they have the same center of mass and thus have nearly the same radial velocity. As a consequence, both stars are expected to be unresolved spectroscopically. Using the formalism developed by Santerne et al. (2015), we estimated that in the worst case, i.e., where star B fully contributes to the observed spectrum and both stars have exactly the same systemic radial velocity, and given their difference of magnitudes, the observed radial velocities would be diluted by up to 2%. This is substantially below the radial velocity photon noise we have for individual measurements and thus we concluded that star B should not significantly affect the radial velocities of star A.

2.3.3. HARPS-N

We observed K2-29 with HARPS-N37, a fiber-fed high-resolution (R ∼ 110,000) echelle spectrograph (Cosentino et al. 2012) mounted on the 3.6 m Telescopio Nazionale Galileo at the La Palma Observatory (Spain). We obtained 22 spectra from 2016 January 4 to 7, among which 19 were collected during the transit night of 2016 January 6 in order to detect the Rossiter–McLaughlin effect. As for SOPHIE, the spectra were reduced using the online pipeline and the radial velocities, bisector, and FWHM were measured on the CCF computed with a G2V mask. The fiber of HARPS-N has an aperture on the sky of 1″ and only star A was observed. The derived radial velocities, bisector, and FWHM are listed in Table 3, together with their uncertainties.

3. MODELING OF THE EXO-PLANETARY SYSTEM

3.1. Spectral Characterization of Stars A and B

The spectral analysis was performed on the co-added HARPS-N spectra of star A. The spectroscopic parameters were derived with the ARES+MOOG method (see Sousa 2014, for details) which is based on the measurement of the equivalent widths of iron lines with ARES (Sousa et al. 2015). This method has been used to derive homogeneous parameters for planet-host stars (e.g., Sousa et al. 2011; Santos et al. 2013). We corrected the log g using the asteroseismic calibration of Mortier et al. (2014). We find that star A has a $T_{\text{eff}}$ of 5363 ± 43 K, a log g of 4.49 ± 0.20 g cm⁻², a micro-turbulence velocity $v_{\text{micro}}$ of 1.05 ± 0.08 km s⁻¹, and an iron abundance [Fe/H] of 0.16 ± 0.03 dex. Using the method described in Boisse et al. (2010) on the CCF, we find a $v \sin i_1$ of 4 ± 1 km s⁻¹. We find evidence of lithium in the co-added spectrum with an abundance of A(Li) = 1.05 ± 0.2 dex.

We attempted to take a spectrum of star B with HARPS-N but the automatic guiding of the telescope was moving to star A. Therefore, to characterize star B, we used the magnitude differences measured by the FTN and AstraLux facilities (see Section 2). We modeled the spectral energy distribution (SED) of both stars using the BT-SETTL atmosphere models (Allard 2014) which we integrated in the B, V, R, i', and z' bands. We used the result from the spectral analysis to estimate the magnitudes of star A and we derived the spectroscopic parameters of star B by fitting the observed differences of magnitude through a Markov chain Monte Carlo algorithm (MCMC). We assumed that both stars are at the same distance, and hence have the same interstellar extinction, and that they have the same iron abundance. At each step of the MCMC we checked that the stellar parameters did not correspond to unphysical stars or stars older than the universe, according to the Dartmouth evolution tracks of Dotter et al. (2008). We find that star B has a $T_{\text{eff}}$ of 4400 ± 66 K and a log g of 4.60 ± 0.04 g cm⁻². This corresponds to a spectral type of K5V according to Cox (2000).

This allows us to determine precisely the contamination of the star B in the light curves of star A. The contaminant fully contributes to the flux measured either by K2, WASP, or the other professional and amateur facilities. By integrating the SED models in the Kepler, r', and V bands, we find that the contamination is 15.3 ± 0.4%, 15.4 ± 0.4%, and 12.8 ± 0.4%, respectively.

3.2. Combined Analysis of the System

We analyzed all the light curves, radial velocities38, and the magnitudes (listed in Table 1) of the target star using PASTIS software (Díaz et al. 2014; Santerne et al. 2015). It models the transit light curves using a modified version of the JKTEBOP code (Southworth 2011, and references therein) that we

55 Program IDs: 15B.PNP.HEB.
37 Program ID: OPT15B_23.

38 We excluded for this analysis the two transit nights observed by SOPHIE and HARPS-N. By doing this, we avoid biasing the system parameters with possible instrumental systematics. The analysis of the Rossiter–McLaughlin effect is left to the next section.
oversampled by a factor of 10 to compensate for the long integration time of the Kepler data (Kipping 2010). Radial velocities are modeled with a Keplerian orbit and the SED is modeled with the BT-SETTL library (Allard 2014). Stellar parameters are determined with the Dartmouth stellar evolution tracks and limb darkening coefficients are taken from the theoretical values of Claret & Bloemen (2011).

The statistical analysis of the data was performed with a MCMC algorithm which is fully described in Díaz et al. (2014). The model is described by six free parameters for the star ($T_{\text{eff}}$, log g, [Fe/H], the systemic radial velocity $v_0$, the distance $d$, and the interstellar extinction $E(B-V)$), seven free parameters for the transiting planet (period $P$, epoch of first transit $T_0$, radial velocity amplitude $K$, the radius ratio $k_r$, the orbital eccentricity $e$, inclination $i$, and the angle of periastron $\omega$). We added to the model an extra source of white noise (jitter), an out-of-transit flux, and the contamination level for each of the 21 light curves listed in Table 2 which are left free in the analysis. Finally, we also added a jitter term for each of the radial velocity instruments, a radial velocity offset between them, and a jitter term for the SED. In total, the model is composed of 82 free parameters.

We choose uninformative priors as much as possible, except for the stellar parameters that we constrained using on the results of the spectral analysis and the orbital ephemeris to speed up the convergence. We choose a Beta distribution as the prior for the orbital eccentricity (Kipping 2013). The exhaustive list of free parameters and their priors is provided in Table 4.

We ran five exploratory MCMC chains of $10^5$ iterations with an initial guess randomly drawn from the joint prior distribution. We then ran 20 MCMC chains of $3 \times 10^5$ iterations starting from the best solution found in the exploratory MCMC, to further explore the posterior distribution in the vicinity of the global maximum. All chains converged toward the same solution which is assumed to be the global maximum. We then removed the burn-in phase of each chain before thinning (keep only one sample per maximum correlation length among all the parameters of each chain) and merging them to obtain more than 1000 independent samples of the posterior distribution. We finally determined the median and 68.3% confidence interval for each of the free parameters that we report in Table 4. Note that the uncertainties reported in this table are only the statistical ones and do not take into account the unknown uncertainties on the models.

We display in Figure 3 the phase-folded transit light curves from the 21 different instruments with the best-fit model. In Figure 4, we plot the phase-folded radial velocity data together with the best-fit model and the residuals. The rms of the radial velocity data are $23\text{ m s}^{-1}$, $12\text{ m s}^{-1}$, and $10\text{ m s}^{-1}$, for CAFE, SOPHIE, and HARPS-N, respectively. We find no significant drift in the radial velocity data, with an upper limit of $\pm 40\text{ m s}^{-1} \text{ yr}^{-1}$ at the 99% confidence interval.

3.3. Analysis of the Rossiter–McLaughlin Effect

We analyzed the radial velocity data obtained during the transit nights of 2016 January 6 and 15 with HARPS-N and SOPHIE, respectively. To model the Rossiter–McLaughlin effect, we used the formalism developed by Boué et al. (2013). We are neglecting here the effects of convective bluethrust and macro-turbulence. We fit the data using the MCMC procedure as described above. We used the results of the combined analysis, listed in Table 4, as the priors for the orbital and transit parameters. We used a uniform prior for the spin–orbit angle $\lambda$ and assumed a prior for the $v \sin i$ which follows a normal distribution with a mean of 4 km s$^{-1}$ and a width of 1 km s$^{-1}$. To account for the different integration times between HARPS-N (10 minutes) and SOPHIE (20 minutes) data, we oversampled the Rossiter–McLaughlin model to 1 minute before binning it back to the actual HARPS-N or SOPHIE cadence. This is similar to what was proposed for photometric transits by Kipping (2010).
We ran 20 chains of $3 \times 10^5$ iteration each started randomly from the joint prior distribution. We analyzed the chains as previously and found that the planet is aligned relative to the stellar spin with a value of $\lambda = 1.5 \pm 0.7$. The derived $v \sin i_*$ is $3.7 \pm 0.5 \text{ km s}^{-1}$. The HARPS-N and SOPHIE data are displayed in Figure 5 together with the best-fit model.

### 3.4. Blend Sanity Checks

The detection of both the reflex motion and the Rossiter–McLaughlin effect is not enough to firmly assess the planetary nature of a candidate (e.g., Santos et al. 2002; Torres et al. 2005; A. Santerne et al. 2016, in preparation). The radial velocity variation is detected on star A, thus we can exclude star B from being the transit host. Even if it is quite unlikely, the system might still be a triple system located within the detection limits of AstraLux. According to Santerne et al. (2015), this triple system would imprint a significant variation in the bisector and/or FWHM.

We find no variation in the bisector with rms of 20 m s$^{-1}$, 42 m s$^{-1}$, and 15 m s$^{-1}$ on SOPHIE, HARPS-N, and CAFE, respectively, which is compatible with the uncertainties (see Table 3). The FWHM has rms of 73 m s$^{-1}$, 63 m s$^{-1}$, and 50 m s$^{-1}$ (respectively). This is larger than the typical uncertainties (see Table 3). This variability is, however, not correlated with the observed radial velocity variation. We concluded that this FWHM scatter is caused by the variability of the star highlighted in the K2 light curve (see Figure 1).

We also derived the radial velocity amplitude for each instrument. As explained in Santerne et al. (2015), the difference of spectral resolution between SOPHIE ($R \approx 40,000$), CAFE ($R \approx 63,000$), and HARPS-N ($R \approx 110,000$) should lead to different radial velocity amplitudes in the case of a blend. We find that $K_{\text{SOPHIE}} = 99.4 \pm 6.1$ m s$^{-1}$, $K_{\text{CAFE}} = 260 \pm 10$ m s$^{-1}$, and $K_{\text{HARPS-N}} = 120 \pm 5$ m s$^{-1}$. The three values are compatible within 1σ.

Finally, we reduced the SOPHIE and HARPS-N data using a binary mask corresponding to a K5 dwarf. Even if this mask does not correspond to the spectral type of the host star, it might reveal the presence of an unresolved colder stellar companion (Santerne et al. 2015). The radial velocity amplitude derived with the K5V mask is consistent within the uncertainties with the one derived with a G2V mask.

From the absence of evidence of a blend in the spectroscopic and high-resolution imaging, we conclude that this candidate is a bona-fide planet.

### 3.5. The Planetary System

Based on the results of the combined and Rossiter–McLaughlin analyses, we derived the physical parameters for the K2-29 system and present the results in Table 5.

The host star has a mass of $0.94 \pm 0.02 M_\odot$ and a radius of $0.86 \pm 0.01 R_\odot$. The age derived using the Dartmouth stellar
tracks (Dotter et al. 2008) indicates that the system is 2.6 ± 1.2 Gyr old. The age can, however, be estimated as 450 ± 200 Myr based on both Al(Σ) and P_rot. Both values correspond to an age older than the M34 cluster (250 Myr). The star might be younger than the Hyades cluster (or Praesepe) but few members of this 625 Myr association display either lithium abundances or rotations similar to our estimates (Barrado y Navascues & Stauffer 1996; Jones et al. 1997; James et al. 2010; Barnes et al. 2015). We cannot use the activity index measured in the Ca ii lines as the signal-to-noise at these wavelengths is at the order of unity and thus too low for reliable measurements. A combined analysis of both stellar and planet models as done in Guillot & Havel (2011) could provide further constraints on the age of this system.

Several theoretical works have shown, however, that episodic accretion in the early ages can destroy lithium (Baraffe & Chabrier 2010) as well as the accretion of planetary material to fingering convection (Théado & Vauclair 2012). Considering these effects would give an even younger age for this system. Depending on the rotational evolution this star has experienced, the lithium depletion could be stronger or weaker, hence increasing the uncertainty on the age of this system.

The system is located at 185 ± 3 pc. With a separation of ~4 arcsec, the stellar companion (star B) has a current sky-projected separation of about 800 AU.

We find that the transiting planet has a mass of 0.73 ± 0.04 M_⊕ and a radius of 1.19 ± 0.02 R_⊕. This gives a bulk density of 0.53 ± 0.04 g cm^-3. K2-29 b is therefore an inflated hot Jupiter. The orbit of the planet shows a 3σ detection of an eccentricity of 0.066 ± 0.022, but this might be caused by the effects of the stellar variability, clearly seen in the K2 light curve, affecting the radial velocity measurements. We find a sky-projected spin–orbit angle of 1.5 ± 8°. With a stellar radius of 0.86 ± 0.01 R_☉ and a rotational period of 10.79 ± 0.02 days, the rotational velocity of the star is 4.06 ± 0.05 km s^-1, which is consistent with the $v\sin i_\star$, measured with the Rossiter–McLaughlin effect of 3.7 ± 0.5 km s^-1. The star is therefore seen nearly equator-on and the transiting planet is well aligned with the stellar spin. With a central star T_eff < 6250 K, this aligned system is in agreement with the other systems of this kind reported in Albrecht et al. (2012).

4. CONCLUSION AND DISCUSSION

In this paper, we report the discovery of a new hot Jupiter co-discovered in the K2 and archival Super-WASP data. The host star is the primary of a visual binary system.

The star K2-29 was observed during K2’s campaign 4, which also targeted both the Pleiades and the Hyades clusters. It is unlikely that this system belongs to Pleiades (membership probability of less than 2%) as estimated by Bouy et al. 2015, in agreement with Sarro et al. (2014). Interestingly, we note that the system has lithium (for this stellar temperature) and iron abundances that are compatible with the Hyades. Moreover, the systemic radial velocity of the star also agrees with the Hyades (Perryman et al. 1998). However the system is too far away and the proper motion is not compatible with this cluster. We conclude it is unlikely that it belongs to the Hyades. Using the proper motion listed in Table 1, we find that the system has galactic velocities of $U = -17$ km s^-1, $V = 11$ km s^-1, and $W = -23$ km s^-1, and thus has a 99%
probability of belonging to the thin disk. This new hot Jupiter has also been reported in Johnson et al. (2016).

K2-29 is an inflated hot Jupiter amenable for precise spectrophotometric characterization of its atmosphere. Assuming an H₂ dominated atmosphere the planet gravity and equilibrium temperature would imply a scale height equal to about 418 km. The corresponding photometric precision on the transit depth measurement ($\frac{2R_p H}{R_*^2}$) is \(\sim\) 190 ppm. Such a precision can be achieved using, for example, ground-based differential spectrophotometry, given that the presence of a close-by companion will allow optimal control of systematics and subtraction of the Earth atmosphere. On a 4 m class telescope, considering the effect of atmospheric scintillation and assuming an optimized observing strategy ($t_{\text{exp}} \sim 15$ s), for one single transit event we expect to achieve a precision of around half the scale height on this target.

The two stars (target and companion) have a more favorable brightness contrast in the near-infrared ($K_S \sim 10.1$, $K_S \sim 10.9$). This means that K2-29 should be well suited for analysis in the near-infrared domain, in particular from space with the James Webb Space Telescope (Greene et al. 2015) or ARIEL (Tinetti 2015). In particular, the 1.4 \(\mu\)m water absorption band has been found to be a powerful tracer of exoplanet atmospheric chemistry (Sing et al. 2016). The strength of this absorption band appears to be related to the presence or absence of clouds and hazes in the atmosphere, as probed, for instance, by optical observations. Clear atmospheric models would imply a 1.4 \(\mu\)m absorption depth equal to about four scale heights (e.g., Hubbard et al. 2001). The equilibrium temperature of this exoplanet implies, however, that several compounds, in particular silicates, should be sequestered in the bottom atmosphere in the form of condensates (Burrows & Sharp 1999) and could potentially form cloud layers which can partially or totally mask the absorption features depending on the altitude at which they are found.

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