WASP-7: A BRIGHT TRANSITING-EXOPLANET SYSTEM IN THE SOUTHERN HEMISPHERE

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ABSTRACT

We report that a Jupiter-mass planet, WASP-7b, transits the V = 9.5 star HD 197286 every 4.95 d. This is the brightest discovery from the WASP-South transit survey so far and is currently the brightest transiting-exoplanet system in the southern hemisphere. WASP-7b is among the densest of the known Jupiter-mass planets, suggesting that it has a massive core. The planet mass is 0.96 +0.046 −0.040 M Jup, the radius is 0.915 +0.046 −0.040 R Jup, and the density is 1.26 +0.25 −0.21 ρ Jup (1.67 +0.31 −0.29 g cm−3).

Key words: stars: individual (WASP-7, HD 197286) – planetary systems

1. INTRODUCTION

Transiting exoplanets are valuable discoveries since they offer the most opportunities for parameterization and study. The WASP project (Pollacco et al. 2006) is one of the number of wide-area surveys, along with HAT (Bakos et al. 2002), TrES (O’Donovan et al. 2006), and XO (McCullough et al. 2005), all aimed at finding exoplanets transiting relatively bright stars, where they are easiest to observe. A prime aim is to fill out diagrams such as the exoplanet–mass–radius plot, which has the potential to be a diagnostic tool for exoplanets comparable to the Hertzsprung–Russell diagram for stars, possibly leading to an additional diagnostic of the ionization balance between Fe i and Fe ii from several clean and unblended Fe i lines, while the surface gravity (log g) comes from the Na i D and Mg i b lines. An estimate of the microturbulence (ξt) comes from several clean and unblended Fe i and Fe ii lines, while the ionization balance between Fe i and Fe ii was used as an additional diagnostic of Teff and log g.

In addition to the spectral analysis, we have also used TYCHO, DENIS, and 2MASS magnitudes to estimate the
effective temperature using the infrared flux method (Blackwell & Shallis 1977). This gives $T_{\text{eff}} = 6370 \pm 150$ K, which is in close agreement with that obtained from the spectroscopic analysis. These results are consistent with the F5V spectral-type determined by Houk (1982).

The rotation rate of WASP-7 is $v \sin i = 17 \pm 2$ km s$^{-1}$. This is in line with expectations for an F5V star (Gray 1992 quotes $(v \sin i) = 20$), but is the largest known among host stars of transiting planets, and leads to the prediction of a large Rossiter–McLaughlin effect of 98 $\pm$ 19 m s$^{-1}$ (e.g., Gaudi & Winn 2007).

We have investigated whether the star might be chromospherically active; however, there is no sign of Ca H+K line emission in the CORALIE spectra. We have also looked for variability in the WASP data at the predicted rotation period of 3.7 $\pm$ 0.5 days, but found no such variability with an upper limit of 0.02 mag.

The Li i 6708 Å line is not detected in the CORALIE spectra (EW $< 1$ mA, allowing us to derive an upper limit on the lithium abundance of log(n(Li/H) + 12 $< 1.0$), However, the $T_{\text{eff}}$ of this star implies that it is in the lithium gap (Böhm-Vitense 2004), and thus the lithium line does not provide an age constraint.

### 3.1. Planetary Parameters

The CORALIE radial-velocity measurements were combined with the WASP-South photometry in a simultaneous Markov-chain Monte Carlo (MCMC) analysis to find the parameters of the WASP-7 system. This process is described in detail in Collier Cameron et al. (2007b) and Pollacco et al. (2007). The optimal MCMC parameters are listed in Table 3.

An initial run found an eccentricity, $e < 0.17$, and we then adopted $e = 0$ for the solution presented here. In order to balance the weights of the photometry and radial velocities in the MCMC analysis, we added a systematic error of 20 m s$^{-1}$ in quadrature to the radial velocities (as might arise, for example, from stellar activity) to reconcile $\chi^2$ with the number of degrees of freedom. The rms residual to this fit is 0.03 km s$^{-1}$.

WASP-7b is among the densest of the Jupiter-mass planets (Figure 3), which suggests that it has a large core. The calculations presented by Fortney et al. (2007) suggest a core mass of $\approx 100$ Earth masses, or $\approx 0.3$ of the planet, with some dependence on the planetary age. Overall, WASP-7b adds to the finding that hot Jupiters show a wide disparity in densities, from...
### Table 3

System Parameters for WASP-7

| Parameter | Value |
|-----------|-------|
| \( P \) (days) | 4.954658 ±0.000055 \(-0.000043 \) \(-0.00012 \) |
| \( T_C \) (HJD) | 2453985.0149 +0.0009 \(-0.0012 \) |
| \( T_{14} \) (days) | 0.1573 +0.0024 \(-0.0018 \) |
| \( R_p^2 / R_\star^2 \) | 0.00579 +0.00013 \(-0.00026 \) |
| \( b \equiv \alpha \cos \ i \ / \ R_\star \) (\( R_\odot \)) | 0.08 +0.17 \(-0.08 \) |
| \( i \) (degs) | 89.6 ±0.4 \(-0.9 \) |
| \( e \) (adopted) | 0.6 |
| \( K_1 \) (km s\(^{-1}\)) | 0.097 ±0.013 \(-0.013 \) |
| \( \gamma \) (km s\(^{-1}\)) | \(-29.8506 \) ±0.0017 \(-0.0016 \) |
| \( M_\star \) (\( M_\odot \)) | 1.28 ±0.09 \(-0.19 \) |
| \( R_\star \) (\( R_\odot \)) | 1.236 ±0.059 \(-0.046 \) |
| \( T_{\text{eff}} \) (K) | 6400 ±100 |
| \( \log \ g \) (cgs) | 4.363 ±0.010 \(-0.027 \) |
| \( M_p \) (\( M_\oplus \)) | 0.96 ±0.12 \(-0.18 \) |
| \( R_p \) (\( R_\oplus \)) | 0.915 ±0.046 \(-0.040 \) |
| \( \rho_p \) (\( \rho_\oplus \)) | 1.26 ±0.25 \(-0.21 \) |
| \( \rho_p \) (g cm\(^{-3}\)) | 1.67 ±0.33 \(-0.38 \) |
| \( a \) (AU) | 0.0618 ±0.004 \(-0.0033 \) |
| \( \log g \rho \) (cgs) | 3.421 ±0.069 \(-0.071 \) |
| \( T_P \) (K) | 1379 ±35 |

**Note.** \( T_{14} \): duration, time from 1st to 4th contact. Errors are 1σ.

...the denser WASP-5b (Anderson et al. 2008) and WASP-7b to the bloated TrES-4 (Mandushev et al. 2007) and WASP-12b (Hebb et al. 2008).

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