Atmospheric, Orbital, and Eclipse Depth Analysis of the Hot Jupiter HAT-P-30-WASP-51b

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Abstract

HAT-P-30-WASP-51b is a hot Jupiter that orbits an F star in 2.8106 days at 0.0419 AU. Using *Spitzer* in 2012 (Program 70084), we observed two secondary eclipses at 3.6 μm on 3 January and at 4.5 μm on 17 January. We present eclipse-depths and infrared brightness temperatures from our Photometry for Orbits, Eclipses, and Transits (POET) pipeline. We refine the orbit from our secondary-eclipse measurements in combination with radial-velocity and transit timing observations from the Hungarian Array Telescope Network (HATNet), the discovery papers (Johnson et al. 2011 and Enoch et al. 2011), and TRESCA's Exoplanet Transit Database (ETD). We then characterize the atmosphere's temperature-pressure profile and molecular abundances using our open-source Bayesian Atmospheric Radiative Transfer code (BART).

Points of Interest (Our results in Red):

- F star with M dwarf companion at 750 AU (Ngo et al. 2015)
- Planet's orbit misaligned from rotation of star λ= 73.5 ± 9.0 ° (Johnson et al. 2011)
- **Small but significant eccentricity from the eclipse phase**
- **Brightness temperatures significantly above theoretical equilibrium**
- **Better-constrained orbital parameters**
- **Atmospheric constraints**

About The Author

I am a senior undergraduate Mathematics and Physics dual major **currently applying to grad schools.** Please contact me if you are looking for graduate students.

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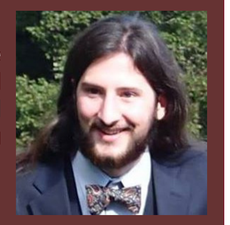
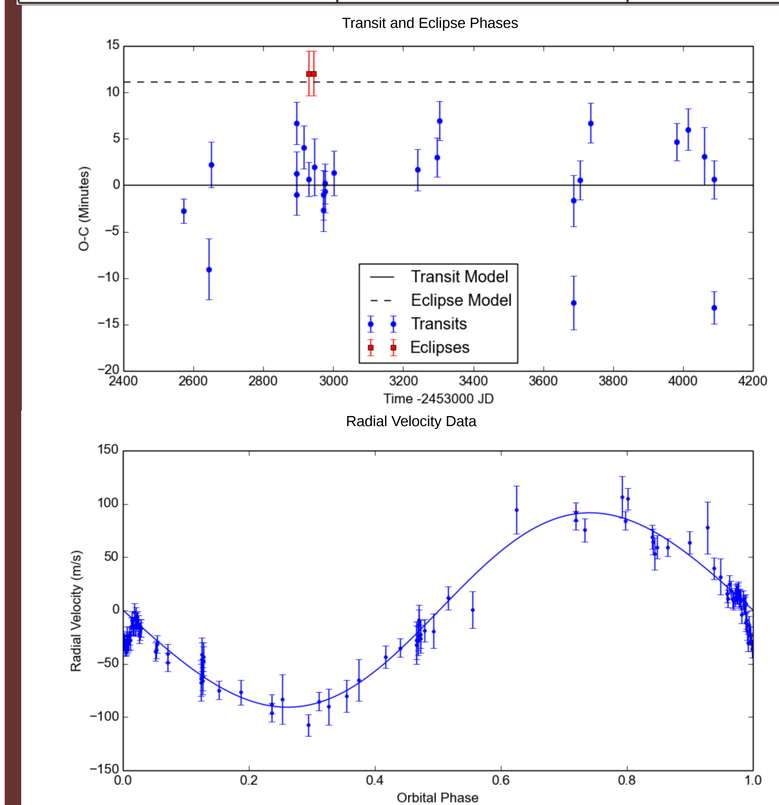
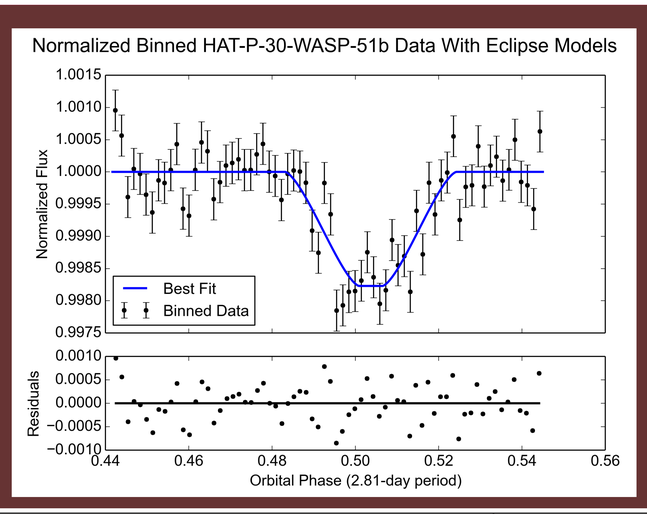
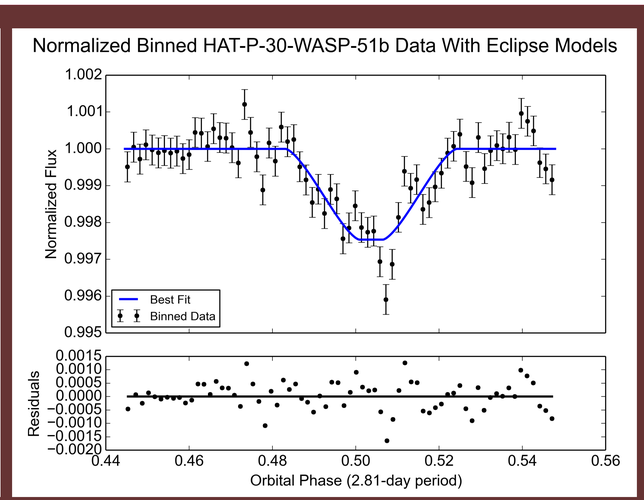


Parameter	Value	Error
e	0.032	$^{+0.029}_{-0.020}$
ω	-82	$^{+29}_{-3}$
$esin\omega$	-0.031	0.027
$ecos\omega$	0.0043	0.0007
P (days)	2.810594	0.000002
t_0 (BJD_TDB)	2455456.4682	0.0006
K (m/s)	91.2	2.5



Deviation from an eclipse phase of 0.5 results in an e*cos(ω) of 0.0058 ± 0.0009, a positive detection of eccentricity independent of the influence of stellar tides which can distort radial velocity data. A Markov chain fit an orbit model to our eclipse midpoints as well as radial velocity and transit timing data from other sources.

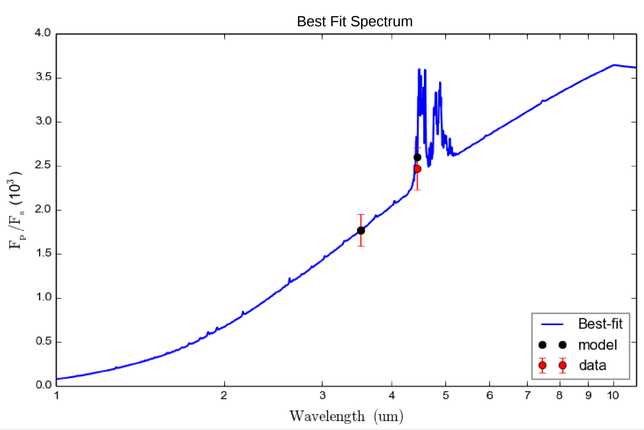


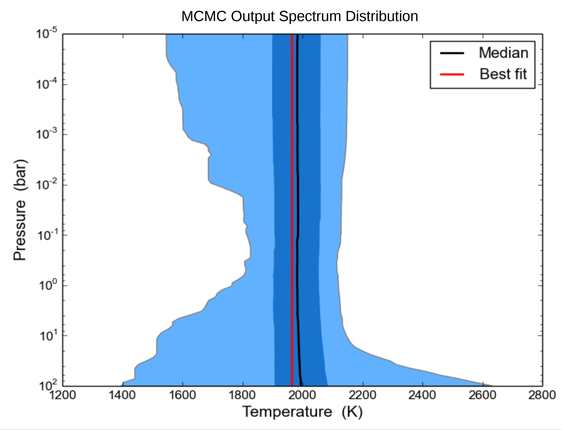


Parameter	Value	Error
Eclipse Phase	0.5037	$^{+0.0005}_{-0.0007}$
Eclipse Duration	0.0412	$^{+0.0027}_{-0.0022}$
Ingress Time	0.018	0.003
Channel 1 Eclipse Depth	0.001770	$^{+0.00019}_{-0.00018}$
Channel 2 Eclipse Depth	0.00247	$^{+0.00025}_{-0.00022}$
Channel 1 System Flux (μJy)	56137	6
Channel 2 System Flux (μJy)	36576	3
Channel 1 Ramp, Quadratic Term	-0.23	0.08
Channel 1 Ramp, Linear Term	0.0172	0.0027
Channel 2 Ramp, Linear Term	-0.011	0.004

POET masked out the stellar companion, applied a wide variety of treatments for all *Spitzer* systematics to each observation, then used a Markov chain to fit an eclipse lightcurve model.

Eclipse depths give brightness temperatures of 1990 ± 110 K at 3.6 μm (left) and 2080 ± 130 K at 4.5 μm (right). Both are significantly above the equilibrium temperature of 1700 ± 20 K, calculated from stellar parameters and assuming zero albedo and uniform redistribution.





BART used our eclipse depths to model the atmosphere. The radiative-transfer model uses seven free parameters but we are fitting it to only two data points, so the distribution is at best a limiting constraint on the true PT profile, and this spectrum is only one of many possible results that fit the data.

Acknowledgements

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Johnson et al: 2011ApJ...735...24J
Enoch et al: 2011AJ....142...86E
Campo et al: 2011ApJ...727..125C
Ngo et al: 2015ApJ...800..138N
HATNet data website: http://hatnet.org/planets/followup-data.html
TRESCA's ETD website: http://var2.astro.cz/ETD/