Two Multi-Wavelength Secondary Eclipses of WASP-18b

Sarah Nymeyer[1], Joseph Harrington[1], Ryan Hardy[1], Kevin B. Stevenson[1], Christopher J. Campo[1], Nikku Madhusudhan[2], Andrew Colier-Cameron[3], Jasmina Blecic[1], William C. Bowman[1], Christopher B.T. Britt[1], Patricio Cubillos[1], Coel Hellier[4], Michael Gillon[5], Pierre F. L. Maxted[3], Leslie Hebb[6], Peter J. Wheatley[7], Don Pollacco[8], and David Anderson[4]

[1]University of Central Florida, [2]Massachusetts Institute of Technology, [3]University of St. Andrews, [4]Keele University, [5]Université de Liège, [6]Vanderbilt University, [7]University of Warwick, [8]Queen's University

ABSTRACT

The transiting exoplanet WASP-18b was discovered in 2008 by the Wide Angle Search for Planets (WASP) project. The Spitzer Exoplanet Target of Opportunity Program observed secondary eclipses of WASP-18b using Spitzer's Infrared Array Camera (IRAC) in the 3.6-μm and 5.8-μm bands on 2008 December 20, and in the 4.5-μm and 8.0-μm bands on 2008 December 24. We present a pressure-temperature profile, eclipse depths and brightness temperatures of WASP-18b, which is one of the hottest planets yet discovered - as hot as an M-dwarf star.

OBSERVATIONS

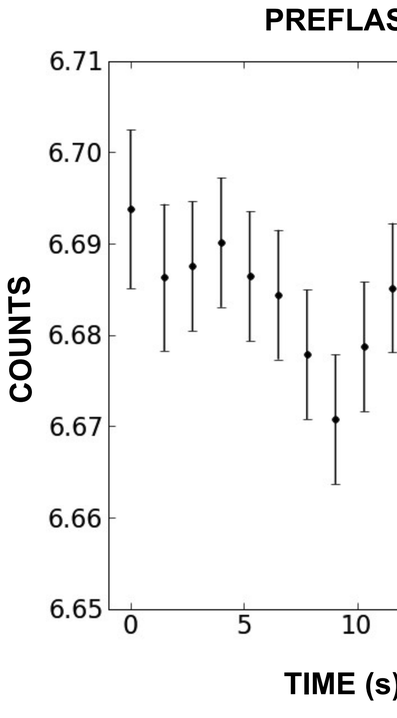
- 3.6 and 5.8 μm on 20 December 2008
- 4.5 and 8.0 μm on 24 December 2008

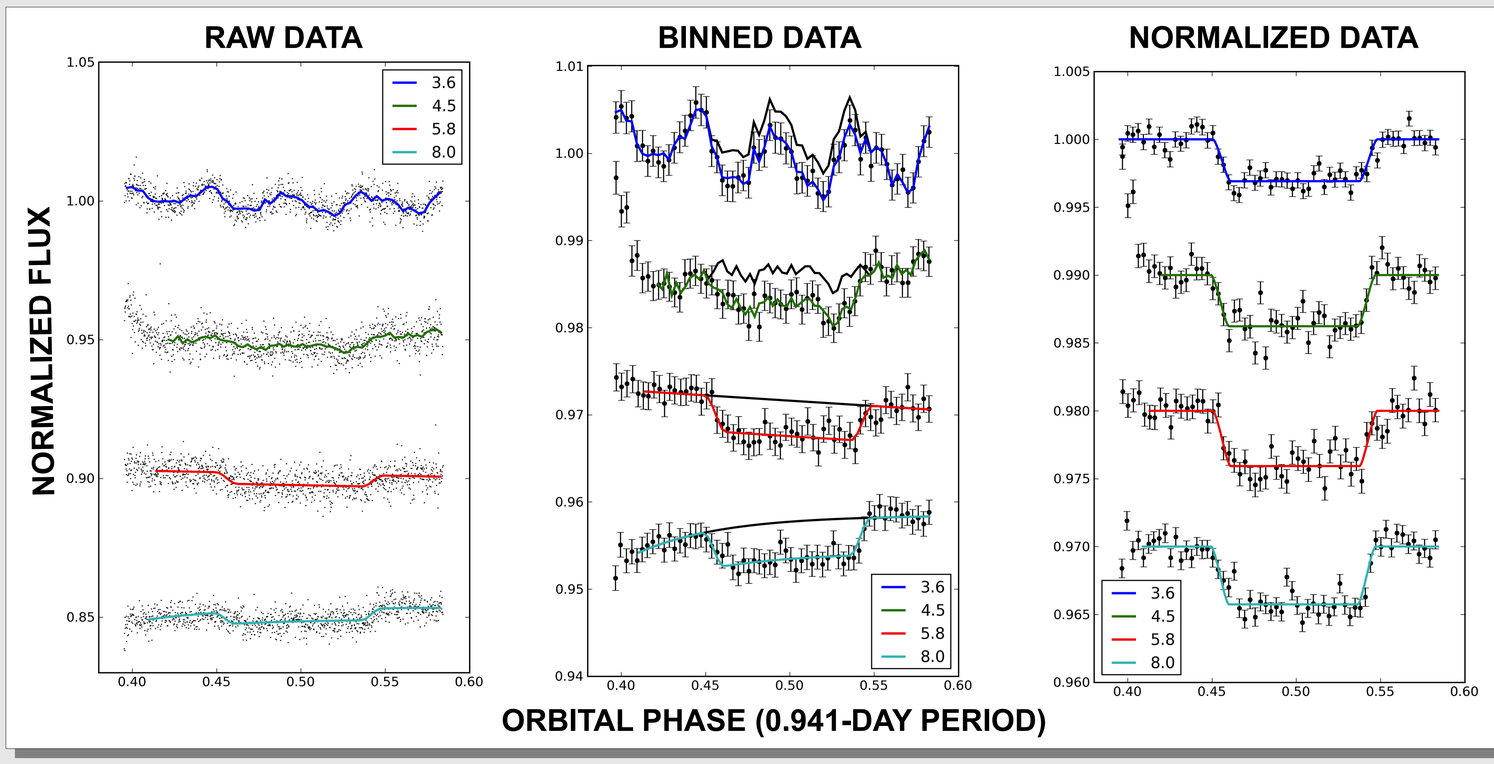
SYSTEMATICS & CORRECTIONS

- Positional sensitivity in 3.6 and 4.5 μm
  - Used fixed pointing for both observations
- Time-varying sensitivity in 5.8 and 8.0 μm
  - Increased observation by 1 hour prior to the December 20 event
  - Used a preflash prior to the December 24 event

PREFLASH

- Time-varying sensitivity at 8.0 μm
- Increase in flux with time
- Rate of increase depends on number of photons
- Believed to be caused by charge trapping
- Effect is reduced by staring at a bright, diffuse source
- Stared at an HII ionized region for 30 minutes
- Ramp observed is atypical for 8.0 μm observations
- Increase in flux values expected, not a decrease as seen
- Attributed to the previous IRAC observation of a bright extended source (IC1396a).





ANALYSIS RESULTS

λ	ECLIPSE CENTER (ORBITS)	ERROR	ECLIPSE DEPTH (%)	ERROR	BRIGHTNESS TEMP. (K)	ERROR
3.6 μm	0.4994	0.0005	0.31	0.02	2920	90
4.5 μm	0.4984	0.0004	0.38	0.03	3150	130
5.8 μm	0.4994	0.0005	0.41	0.02	3040	130
8.0 μm	0.4984	0.0004	0.43	0.03	2960	130

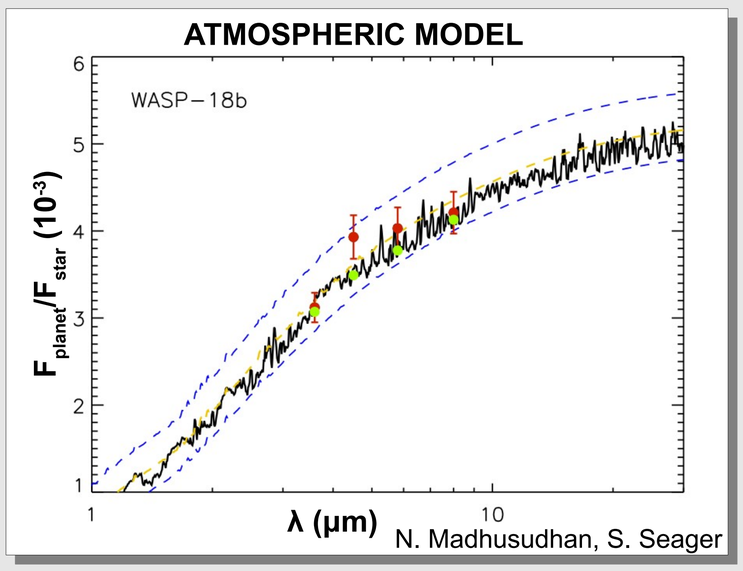
ATMOSPHERE

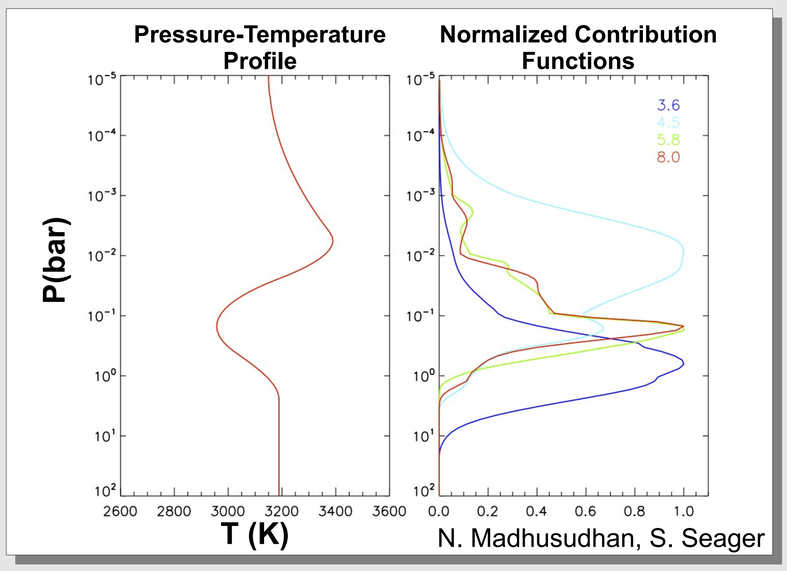
Atmospheric model:

- Red circles – IRAC observations
- Black curve – Model spectrum
- Green circles – Model spectrum integrated over the Spitzer bandpasses
- Orange dashed line – Blackbody at 3150K
- Blue dashed lines – Minimum and maximum temperatures in the atmosphere

Equilibrium chemistry at solar abundances. H_2O, CO, CO_2 are the major spectroscopically active molecules.

Near-zero albedo and day-night energy redistribution. Effective temperature: 3100K. Thermal inversion present on day-side.





CONCLUSIONS

The observed brightness temperatures are strongly suggestive of a thermal inversion in this atmosphere. Although a hypothetical black- body spectrum could also explain the observations, they cannot be explained with absorption features caused by a non-isothermal temperature structure with no thermal inversion. Because the planet is so much brighter than its predicted equilibrium temperature for uniform redistribution, the model requires near-zero albedo and very low day-night energy redistribution. The very small scale height makes this atmosphere interesting as an extreme example among irradiated planets.

REFERENCES

- Campo, Christopher J. et al. On the Orbit of Exoplanet WASP-12b. 2010, ApJ, submitted, arXiv:1003:2763
- Hellier, C. et al. An orbital period of 0.94 days for the hot-Jupiter planet WASP-18b. 2009, Nature, 460, 1098
- Madhusudhan, N. and Seager, S. A Temperature and Abundance Retrieval Method for Exoplanet Atmospheres. 2009, ApJ, 707, 24. arXiv:0910.1347
- Nymeyer, Sarah et al. Spitzer Secondary Eclipses of WASP-18b. 2010, ApJ, submitted, arXiv:1005.1017
- Stevenson, Kevin B. et al. Possible thermochemical disequilibrium in the atmosphere of the exoplanet GJ 436b. 2010, Nature, 464, 1161S

For more information of the UCF Planetary Sciences PhD and the UCF Physics Program, please visit:

PLANETS.UCF.EDU and PHYSICS.COS.UCF.EDU