Ground-based detections of thermal emission from the dense hot Jupiter WASP-43b in H and Ks

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Abstract: We report new detections of thermal emission from the transiting hot Jupiter WASP-43b in the H and Ks-bands as observed at secondary eclipses. The observations were made with the WIRCam instrument on the CFHT. We obtained a secondary eclipse depth of 0.103±0.017% and 0.194±0.029% in the H and Ks-bands, respectively. The Ks band depth is consistent with previous measurement in the narrow band centered at 2.09 um (Gillon et al. 2012). Our eclipse depths in both bands are consistent with a blackbody spectrum with a temperature of ~1850 K, slightly higher than the dayside equilibrium temperature without day-night energy redistribution. Based on theoretical models of the dayside atmosphere of WASP-43b, our data constrain the day-night energy redistribution in the planet to be ≤ 15-25%, depending on the metal content in the atmosphere. A strong thermal inversion in the dayside atmosphere is ruled out by our current data. Future observations are required to place detailed constraints on the chemical composition of the atmosphere.

Background

Observations of thermal emission from transiting exoplanets during their secondary eclipse provide important constraints on the thermal structures and chemical compositions of the dayside atmospheres. Such observations have been reported for over 30 exoplanets to date (Seager & Deming 2010), including hot Jupiters, hot Neptunes and even super-Earths, mostly using space facilities like SST and HST. Given that most hot exoplanets have their spectral energy distribution (SED) peak in the near-infrared (NIR) (Barman 2008), making them particularly good candidates to observe using ground-based NIR instruments. Such work have been done in several IR channels ranging from z′ (0.9 μm; e.g. Smith et al. 2011) to K-band (2.1 μm; e.g. Deming et al. 2012). By combining such NIR ground-based data with space-borne data obtained with HST (~ 1 − 2 μm; Swain et al. 2012) and Spitzer (between 3.6 - 24 μm; Knutson et al. 2012), a long spectral baseline is obtained, allowing one to place stringent constraints on the thermal profiles and chemical compositions of the atmospheres (e.g. Madhusudhan et al. 2011b).

The WASP-43 planetary system

M × sin *i*	2.034 ± 0.052 M_J	Spectral type	K7V
Semi-major axis	0.01526 ± 0.00018 AU	Apparent magnitude V	12.4
Orbital period	0.813478 ± 7e-07 days	Mass	0.717 ± 0.025 M_{Sun}
Eccentricity	$0.0035^{+0.0025}_{-0.0025}$	Age	< 0.4 Gyr
ω	-32^{+34}_{-34}	Effective temperature	4520 ± 120 K
Radius	1.036 ± 0.019 R_J	Radius	0.667 ± 0.01 R_{Sun}
Inclination	82.33 ± 0.2°	Metallicity [Fe/H]	-0.01 ± 0.012

Table. 1: The planetary (left) and stellar (right) parameters of the WASP-43 system. Data taken from the extrasolar planets Encyclopaedia (http://exoplanet.eu). In this table, the peculiarities of WASP-43b can be seen or inferred including its **high bulk density, short period, young stellar age and small stellar mass,** making this planet a favorable one for follow-up detailed studies.

Observations

- With CFHT/WirCAM in staring mode in 2012.
- Ks and H band in two nights
- Each run consists of ~600 exposures
- Defocused largely to avoid saturation and improve SNR
- High SNR sky measurements
- Standard image reduction

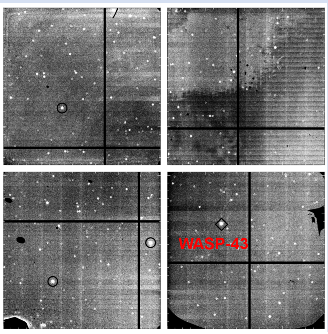

Fig. 1: WASP43 in Ks with WirCAM

Data analysis and the reduced light curve

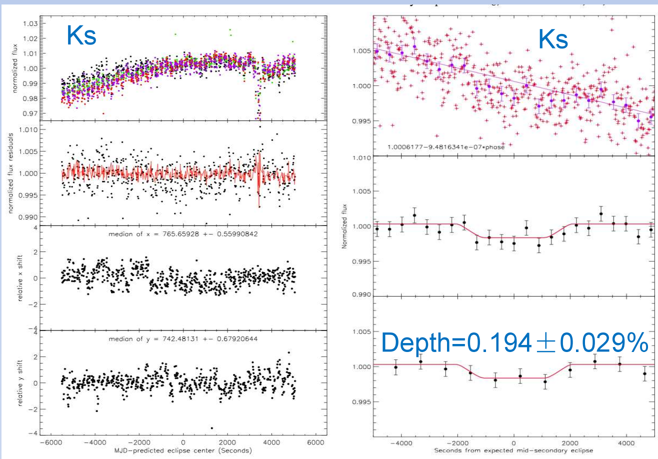

Fig. 2: ***Left:*** shown are the original light curves for the target and 4 reference stars in Ks band, and the correlation between centroid positions and light curves. ***Right*** : The differential light curve of WASP-43 relative to the 4 reference stars. Top panel shows the curve before background subtraction, with solid line for the background model. Middle and bottom panels present the final corrected light curves with best-fit model in solid lines. The filled circles with error bars are rebinned data with bin sized of 24 and 48 respectively.

The scientific interpretations

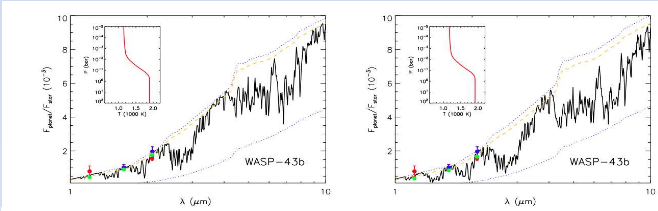

Fig. 3: Observations (filled circles with error bars, blue are from this work) and model spectra of thermal emission from WASP-43b. The black curve shows a model spectrum and the red curve shows the corresponding temperature profile, with solar metallicity in the left and 5 times solar metallicity in the right panel.

Conclusions:

- Consistent with a blackbody spectrum with a temperature of ~1850 K, slightly higher than the dayside *T*eq.
- The day-night energy redistribution in the planet to be ≤ 15-25%, depending on the metal content in the atmosphere.
- A strong thermal inversion in the dayside atmosphere is ruled out with our current data set