Fast-photometry ground-based NIR detection of the thermal emission from extrasolar planetary atmospheres

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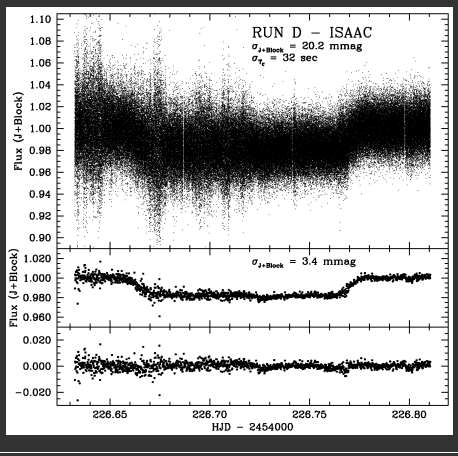
The observation of the occultations of transiting extrasolar planets is a powerful tool to detect the thermal emission from the atmosphere of the planet, and to constrain its physical parameters. We developed a fast-photometry high-cadence near-IR method with ground-based telescopes able to detect the thermal emission from the atmospheres of hot extrasolar planets. We present the application of this method to the highly irradiated planet WASP-4b, with the significant detection (>10σ) of the occultation of the planet, whose atmosphere emits thermal radiation with an associated brightness temperature of 2000K, and shows an absence of a strong thermal inversion and an extremely inefficient redistribution of heat from the day-side to the night-side of the planet.

We started an observational programme to detect the thermal emission from hot transiting extrasolar planets in the near-infrared bands, using ground-based high-cadence photometry with the VLT.

We use the *Fast-Phot* mode of ISAAC@UT3, which produces a series of data-cubes, with zero dead time between exposures, and allow to observe with short exposure times.

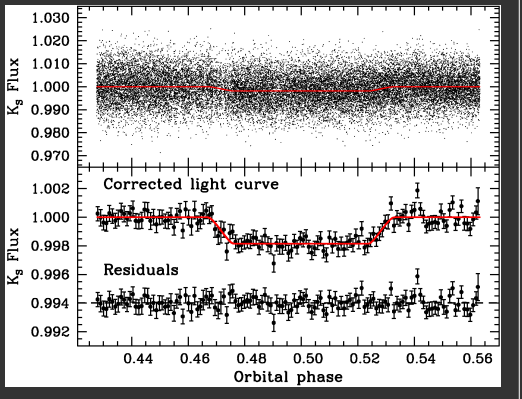


The high-cadence J-band photometry of the primary transit of the exoplanet XO-1b, taken under poor weather conditions, that has been used for a Transit Timing Variations analysis.
The light curve consists of around 200 000 points (1900 frames per data-cube), obtained over an interval of ~4.5h, and with an integration time per frame of 0.08 sec., implying a near-complete sampling of the transit (Caceres et al. 2009).

The highly irradiated planet WASP-4b is the first target we applied this method. We obtained a high-cadence light curve of this planet during its occultation phase, obtaining a significative detection of its day-side thermal emission at 2.16μm, with a fractional eclipse depth of 0.185% (Cáceres et al. 2011).

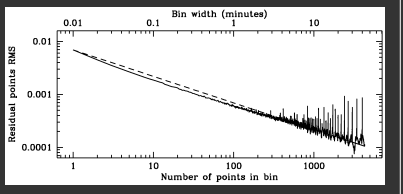
The high cadence light curve has 24 000 points, in a ~5h long observing run, with an exposure time of 0.6 seconds per frame, and 250 frames per data-cube.

The 2-minute bin figure shows the 0.7 mmag r.m.s. light curve, with the best fitting model overlaid.



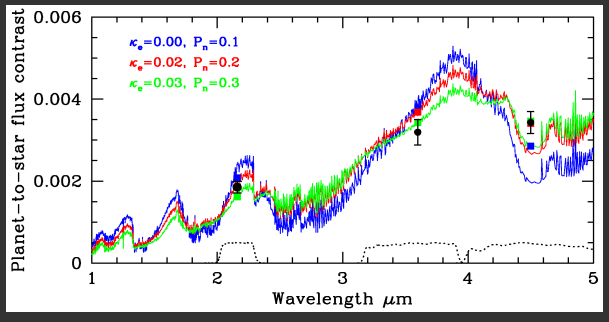
The rednoise could play an important role in the determination of the occultation parameters for infrared observations.

The effect of rednoise in the obtained fast-photometry of the planet WASP-4b. A small contribution from correlated noise comes from binning values of the order of ten of minutes.



The calculated fractional depth implies that the day-side atmosphere of WASP-4b emits thermal radiation compatible with a brightness temperature of 2000 K.

Specific atmosphere models for WASP-4b, compatible with our measurement and two Spitzer mid-infrared detections (Beerer et al. 2011), suggest an absence or a very weak presence of a thermal inversion in its atmosphere, and an extremely inefficient redistribution of heat from the day-side to the night-side of the planet.



The models are parametrized by the redistribution factor P_n, and the opacity of an extra absorber in the upper atmosphere of WASP-4b κ_e (Burrows et al. 2008, and references therein).

Our high-cadence ground based observations allows to detect the minute thermal emission from some extrasolar planets.

The near-infrared observations of transiting planets represent a valuable complement to the mid-infrared space-based detections. Further observations of other southern targets would contribute to the characterization of the atmospheric properties of extrasolar planets.

References

Beerer et al. 2011, ApJ, 727, 23.
Burrows et al. 2008, ApJ, 678, 1436.
Cáceres et al. 2009, A&A, 507, 481.
Cáceres et al. 2011, A&A, 530, A5.

Acknowledgements

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