Constraining the thermal emission of TRAPPIST-1's innermost planets using the JWST

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The seven TRAPPIST-1 planets are the best-known terrestrial planets after the Earth, Mars, Venus, and Mercury (in terms of masses, radii and orbital parameters) and the most amenable targets for the first characterization of temperate rocky worlds with the James Webb Space Telescope (JWST). (Gillon et al. 2020). In that regard, nine JWST programs (~270 hours of telescope time) are dedicated to the observations of this system. In particular, the two inner planets have irradiations large enough to enable the photometric measurement of their dayside's thermal emission by observing secondary eclipses -when the planet passes behind the star as seen from the observer - with JWST/MIRI in the 10-18 microns spectral range. In this talk, I will discuss the analysis of three JWST programs consisting in: 1) the observation of 5 secondary eclipses of TRAPPIST-1 b at 15 microns (GTO 1177), 2) the observation of 4 secondary eclipses of TRAPPIST-1 c at 15 microns (G0 2304), and 3) the observation of 5 secondary eclipses of TRAPPIST-1 b at 12.8 microns (GTO 1279)

First, I will present the results from Greene et al. 2023 showing that the secondary eclipse of TRAPPIST-1 b at 15 microns is detected at 8.7 sigma with a corresponding brightness temperature of 503 +/- 47 K. Such a high temperature is consistent with a null albedo and a very poor efficiency at redistributing the heat from the dayside to the nightside, as expected with little to no atmosphere. Then, I will present the results from Zieba et al. 2023 showing that the secondary eclipse of TRAPPIST-1 c at 15 microns is also detected by MIRI, and that the planet's brightness temperature in this band is 369 +/- 30 K. This makes TRAPPIST-1c the coolest rocky exoplanet detected in thermal emission (over 600 K cooler than the previous record-holder, LHS 3844b, Kreidberg et al. 2019). Finally, I will present our very recent observations of TRAPPIST-1 b in emission at 12.8 microns (acquired in July 2023, Ducrot & Lagage et al. *in prep*). From the data we measure a brightness temperature lower than the one expected from the best fit of the 15 microns measurements. This allows us to start the construction of the broadband emission spectrum of the planet and to set a constrain on the albedo of TRAPPIST-1 b (now the smallest and coolest planet for which this parameter is measured). We infer that the planet is best fitted with a bare rock whose albedo is 0.18 +/- 0.11, in the solar system this is comparable to the albedo of Vesta. To conclude I will discuss the implication of these results in terms of realistic surface composition, planet evolution and future observations.

References:

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