Preliminary Detection of a Terrestrial Exoplanet Atmosphere with JWST

Thematic Areas (Check all that apply):

☐ (Theme A) Key science themes that should be prioritized for future JWST and HST observations
☒ (Theme B) Advice on optimal timing for substantive follow-up observations and mechanisms for enabling exoplanet science with HST and/or JWST
☐ (Theme C) The appropriate scale of resources likely required to support exoplanet science with HST and/or JWST
☐ (Theme D) A specific concept for a large-scale (∼500 hours) Director's Discretionary exoplanet program to start implementation by JWST Cycle 3.

Summary: To provide context for suggested themes for the exoplanet DDT program, we present recent unpublished results on the possibility of an atmosphere on the warm (700 K) rocky exoplanet Gl 486b. Gl 486b has been observed in both transit (as part of program GO 1981, PIs Stevenson and Lustig-Yaeger) and eclipse (as part of program GO 1743, PI Mansfield). The transit observations, published by [1], show a spectral slope that is consistent with the presence of water in the planet's atmosphere (see Figure 1). However, the slope is fit equally well with cool, unocculted starspots on the host star, without any atmosphere on Gl 486b.

The recently observed eclipse observations are unpublished, but a preliminary analysis shows a cooler secondary eclipse spectrum than what would be expected for a bare rock planet (see Figure 2; M. Mansfield, private communication). Such a cool eclipse could be consistent with the presence of an atmosphere on Gl 486b, either because the planet's atmosphere recirculates heat to the nightside [2] or the atmosphere hosts high-albedo clouds that lower the dayside brightness temperature [3].

While both of these results present only tentative evidence for an atmosphere, and more modeling work is needed to fully interpret the preliminary secondary eclipse result, these observations suggest that JWST has detected an atmosphere on a terrestrial planet orbiting an M dwarf. Thus far, all published terrestrial planet observations with JWST have shown results that are either inconclusive or consistent with a lack of atmospheres. We share this result with the working group

because we think it may be important for evaluating proposed DDT programs related to terrestrial planet observations.

As this result is preliminary and unpublished, we request that this white paper not be made publicly available after the final DDT report.

Anticipated Science Objectives: N/A

Urgency: N/A
Risk/Feasibility: N/A
Timeliness: N/A
Cannot be accomplished in the normal GO cycle: N/A

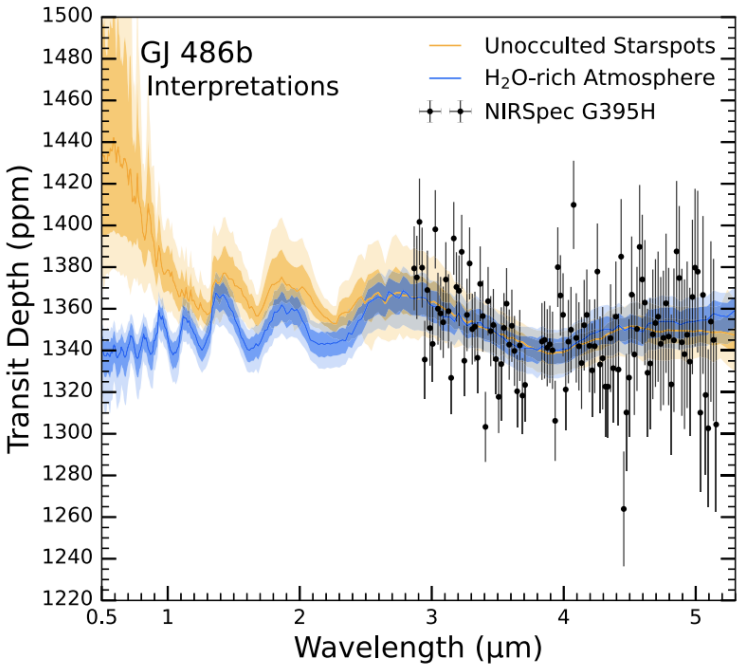

Figure 1: Transmission spectrum of Gl 486b as observed with NIRSpec/G395H. The transmission spectrum (black points) shows a slope toward blue wavelengths that could be fit by either water absorption in an H_2O-rich atmosphere (blue line) or unocculted starspots (yellow line). Figure from Moran et al. (2023) [1].

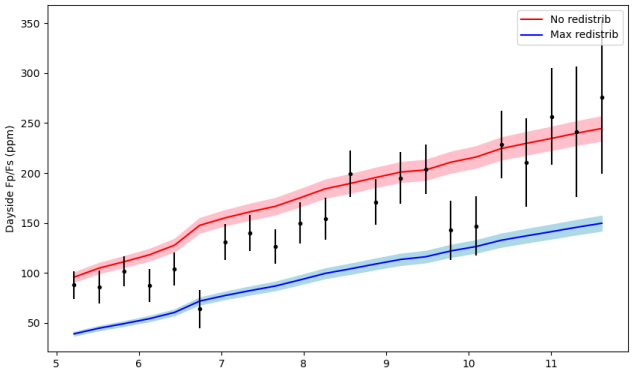

Figure 2: Eclipse spectrum of Gl 486b as observed with MIRI/LRS, from unpublished data (M. Mansfield private communication). The red and blue lines indicate theoretical temperature limits for no heat redistribution (i.e., a bare rock at zero albedo) and maximum heat redistribution, respectively. The eclipse depths are 2.5σ lower than expected for a zero albedo, zero heat redistribution blackbody.

References

[1] Sarah E. Moran et al. "High Tide or Riptide on the Cosmic Shoreline? A Water-rich Atmosphere or Stellar Contamination for the Warm Super-Earth GJ 486b from JWST Observations". In: 948.1, L11 (May 2023), p. L11. DOI: 10.3847/2041-8213/accb9c. arXiv: 2305.00868 [astro-ph.EP].

[2] Daniel D. B. Koll et al. "Identifying Candidate Atmospheres on Rocky M Dwarf Planets via Eclipse Photometry". In: 886.2, 140 (Dec. 2019), p. 140. DOI: 10.3847/1538-4357/ab4c91. arXiv: 1907.13138 [astro-ph.EP].

[3] Megan Mansfield et al. "Identifying Atmospheres on Rocky Exoplanets through Inferred High Albedo". In: 886.2, 141 (Dec. 2019), p. 141. DOI: 10.3847/1538-4357/ab4c90. arXiv: 1907.13150 [astro-ph.EP].