Do the TRAPPIST-1 Planets Have Hydrogen-rich Atmospheres?

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Six inner planets form a (near-) resonant chain. (Gillon et al. 2017)

TRAPPIST-1f, 1g, and 1h are likely to be in the Laplace resonance. (Leger et al. 2017)

All the planets are on a nearly co-planar orbit.

Transit spectroscopy of the TRAPPIST-1 planets using HST/WFC3

No prominent absorption features at NIR wavelengths in transmission spectra of the atmospheres of the TRAPPIST-1 planets rule out cloud-free hydrogen-rich atmospheres.

(de Wit et al. 2016; 2018; Zhang et al. 2018; Wakeford et al. 2019; Burdanov et al. 2019)
Accumulation and Retention of H₂-rich Atmospheres

The amount of an accreted hydrogen-rich gas:

\[ < 10^{-2}\text{wt\%}, < 0.1\text{wt\%}, < 1\text{wt\%}, < \text{a few wt\%}, < \text{a few wt\%}, < 1\text{wt\%} \]

Mass loss rate:

Energy-limited hydrodynamic escape (e.g. Erkaev et al. 2007)

\[ \dot{M}_{esc} = \frac{\eta F_{XUV} \pi R_{XUV}^3}{G M_p K_{tide}} \]

All the hydrogen-rich atmospheres that TRAPPIST-1 planets accreted from the ambient disk were lost!