UV observations of atmospheric escape in exoplanets

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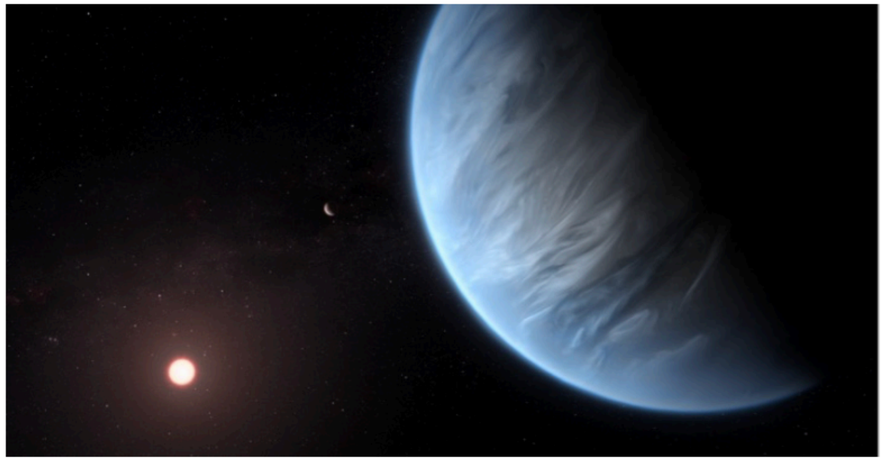
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Pathways to Discovery in Astronomy and Astrophysics for the 2020s



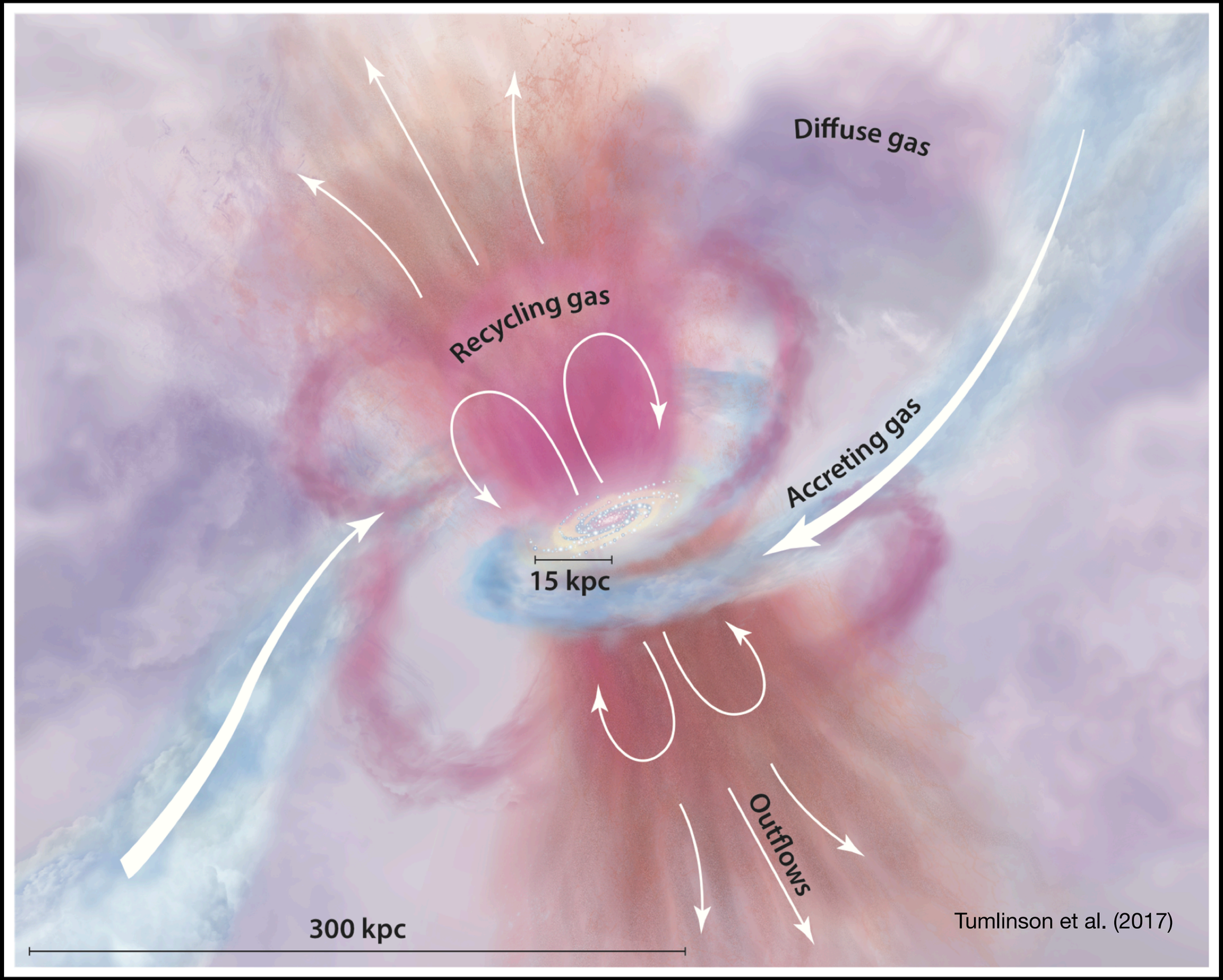
Worlds and Suns in Context

Priority Area: Pathways to Habitable Worlds

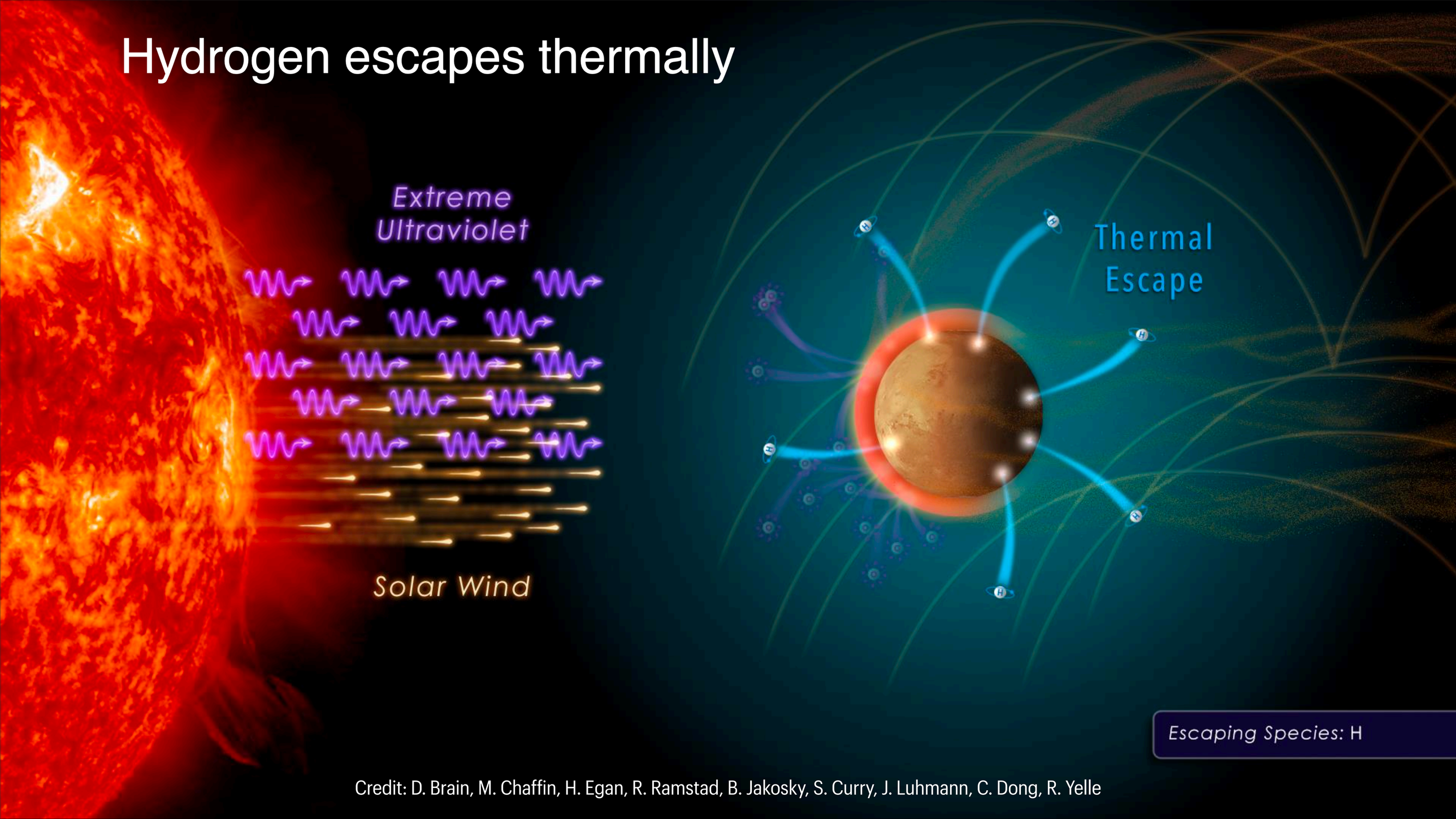
Understanding the connections between stars and the worlds that orbit them, from nascent disks of dust and gas through formation and evolution, is an important scientific goal for the next decade. The effort to identify habitable Earth-like worlds in other planetary systems and search for the biochemical signatures of life will play a critical role in determining whether life exists elsewhere in the universe.

KEY RECOMMENDATIONS:

1. What drives the evolution of exoplanets?
2. How well can small planets retain their atmospheres?
3. Are transiting rocky planets Earth-like?

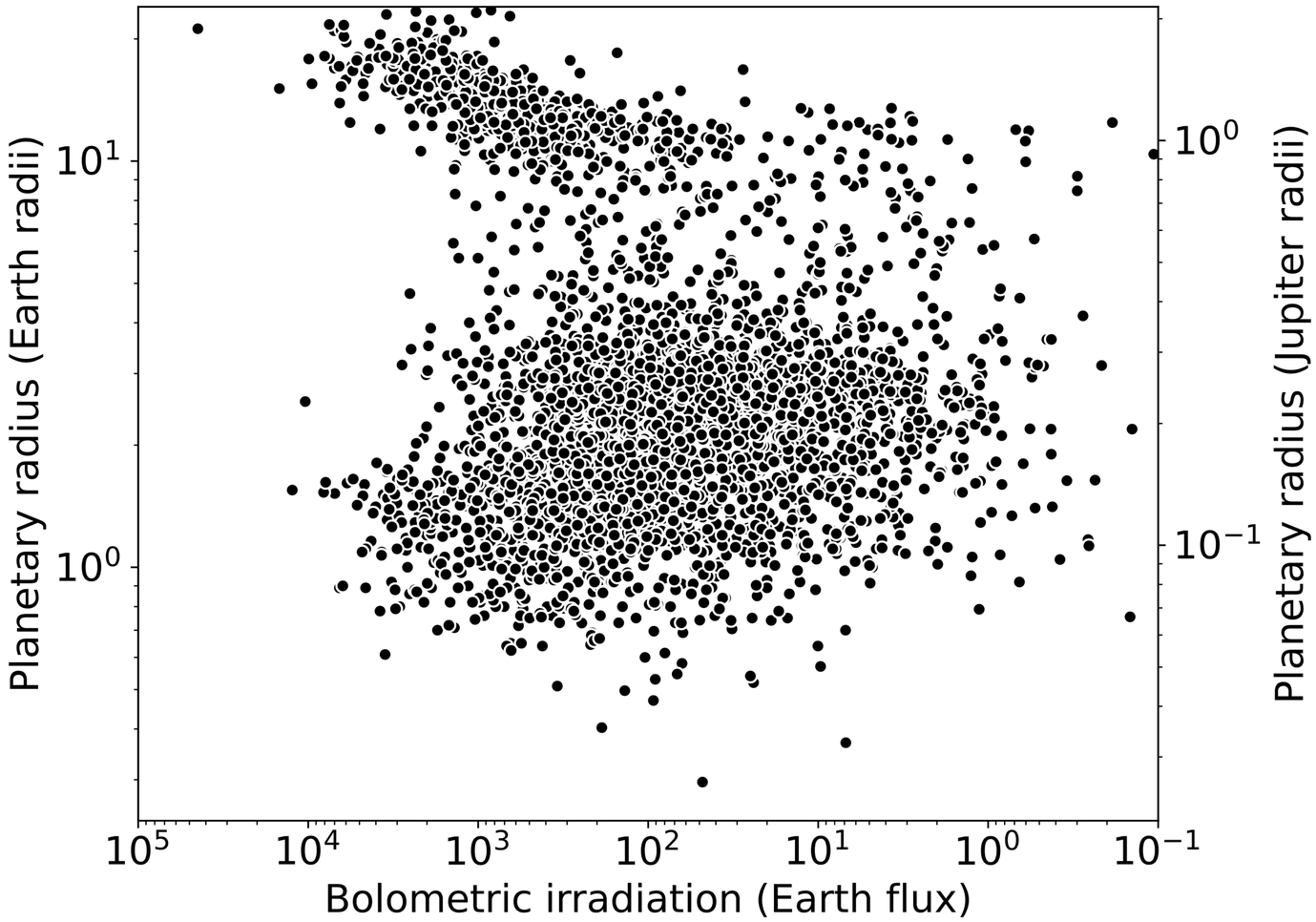

Diffuse gas
Recycling gas
Accreting gas
15 kpc
Outflows
300 kpc
Tumlinson et al. (2017)

Hydrogen escapes thermally



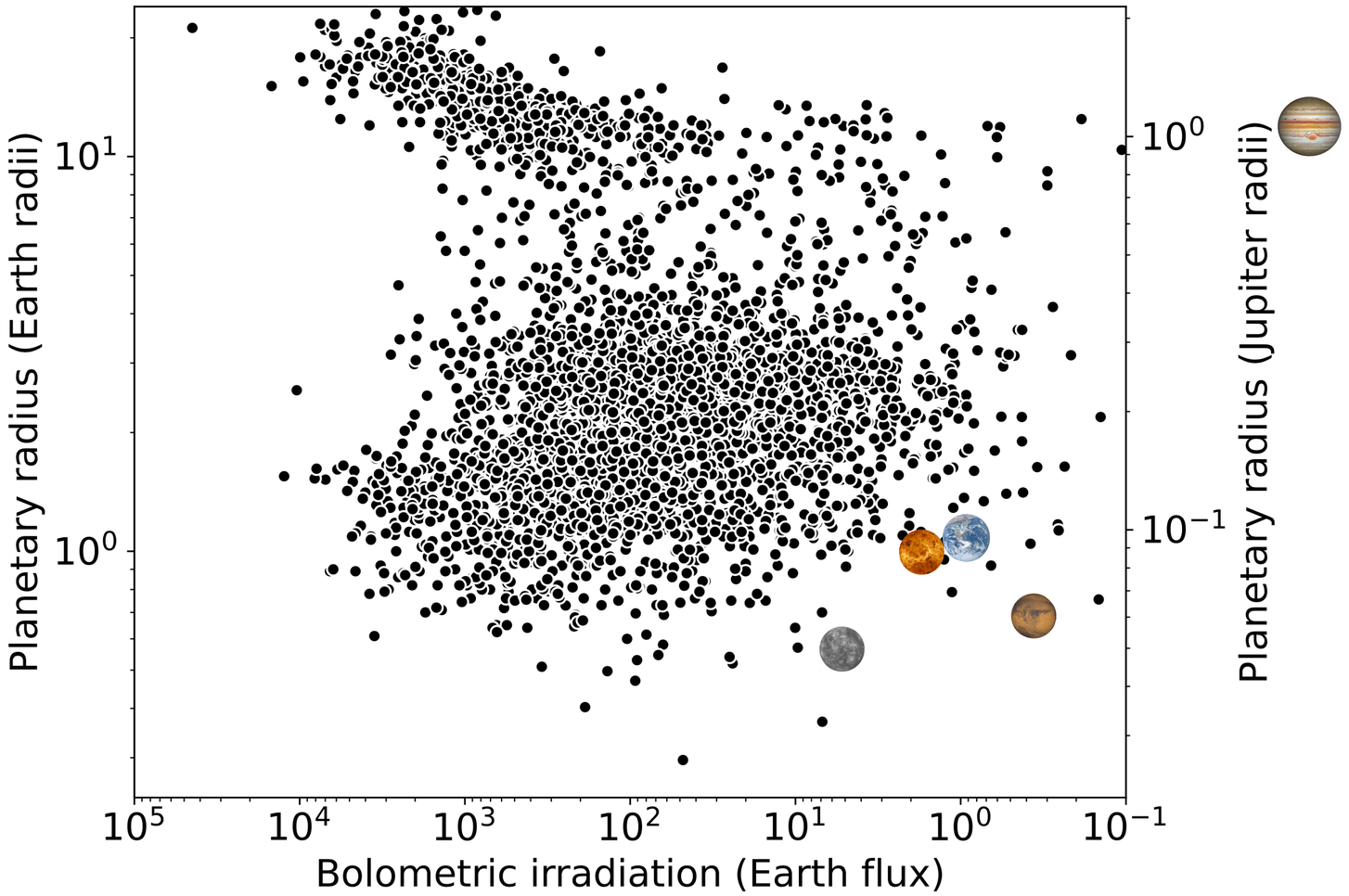
Credit: D. Brain, M. Chaffin, H. Egan, R. Ramstad, B. Jakosky, S. Curry, J. Luhmann, C. Dong, R. Yelle

The transiting exoplanet population as of 2023



More irradiated ← Less irradiated

The transiting exoplanet population as of 2023



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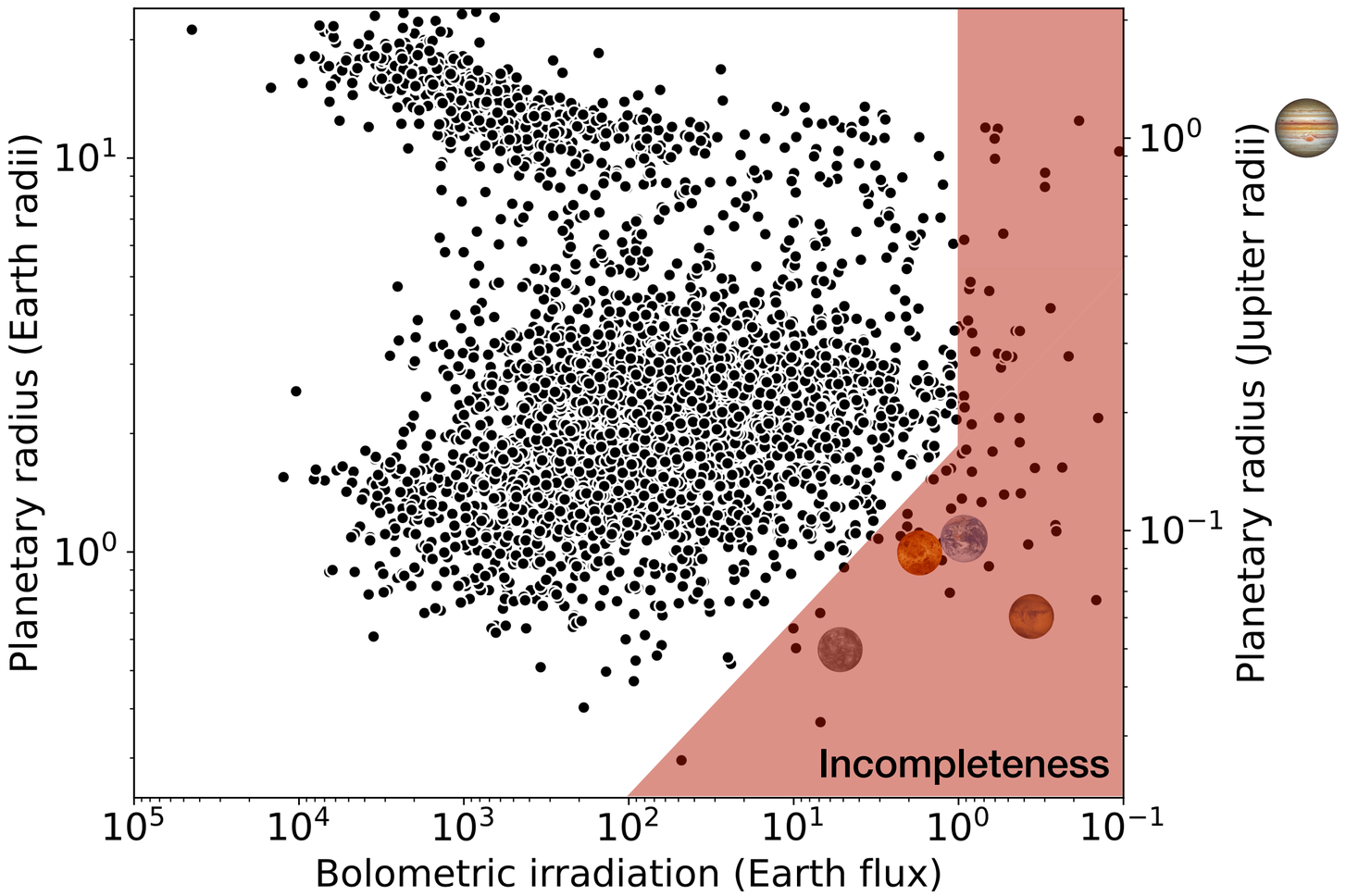
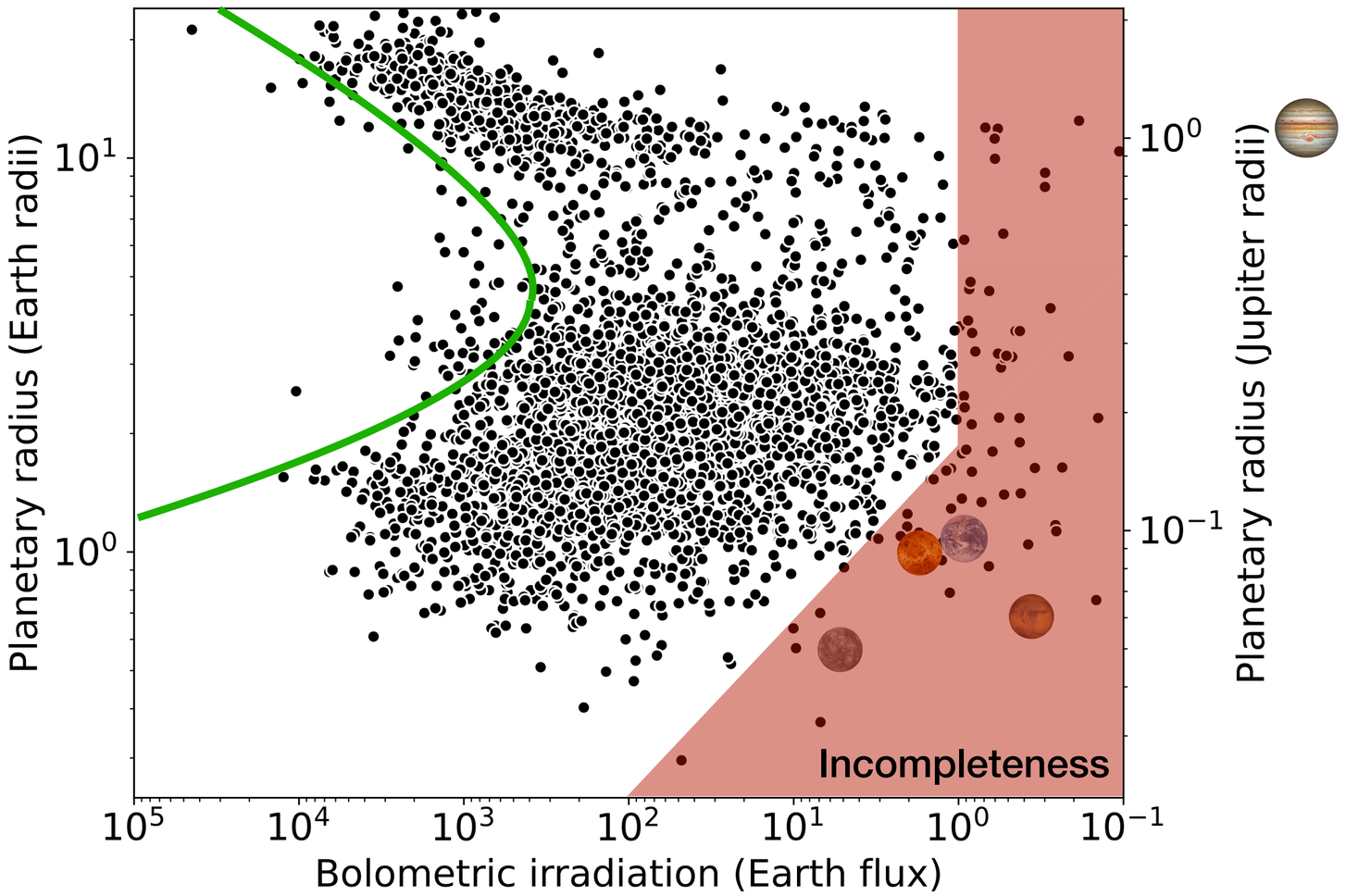


The transiting exoplanet population as of 2023



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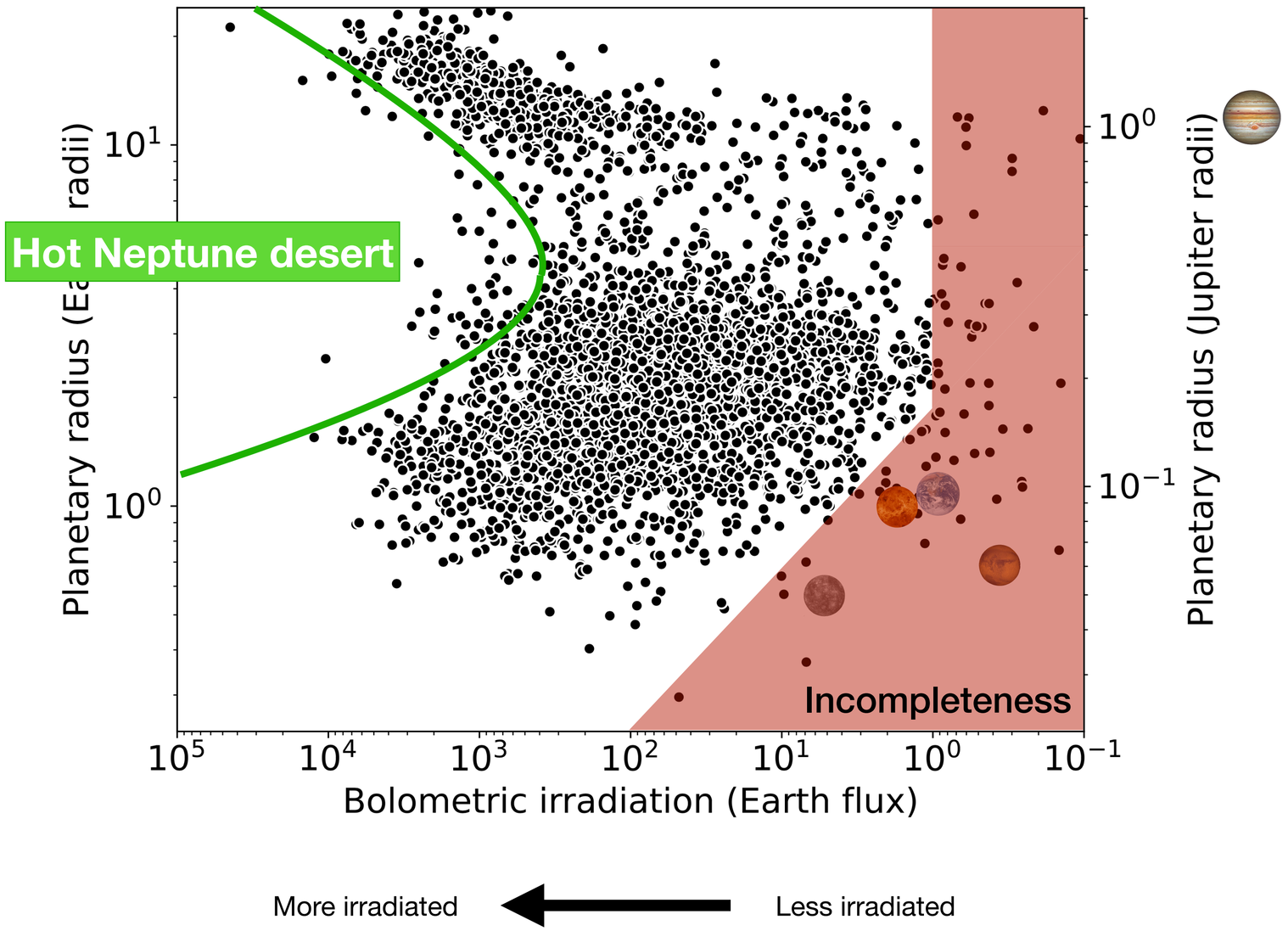
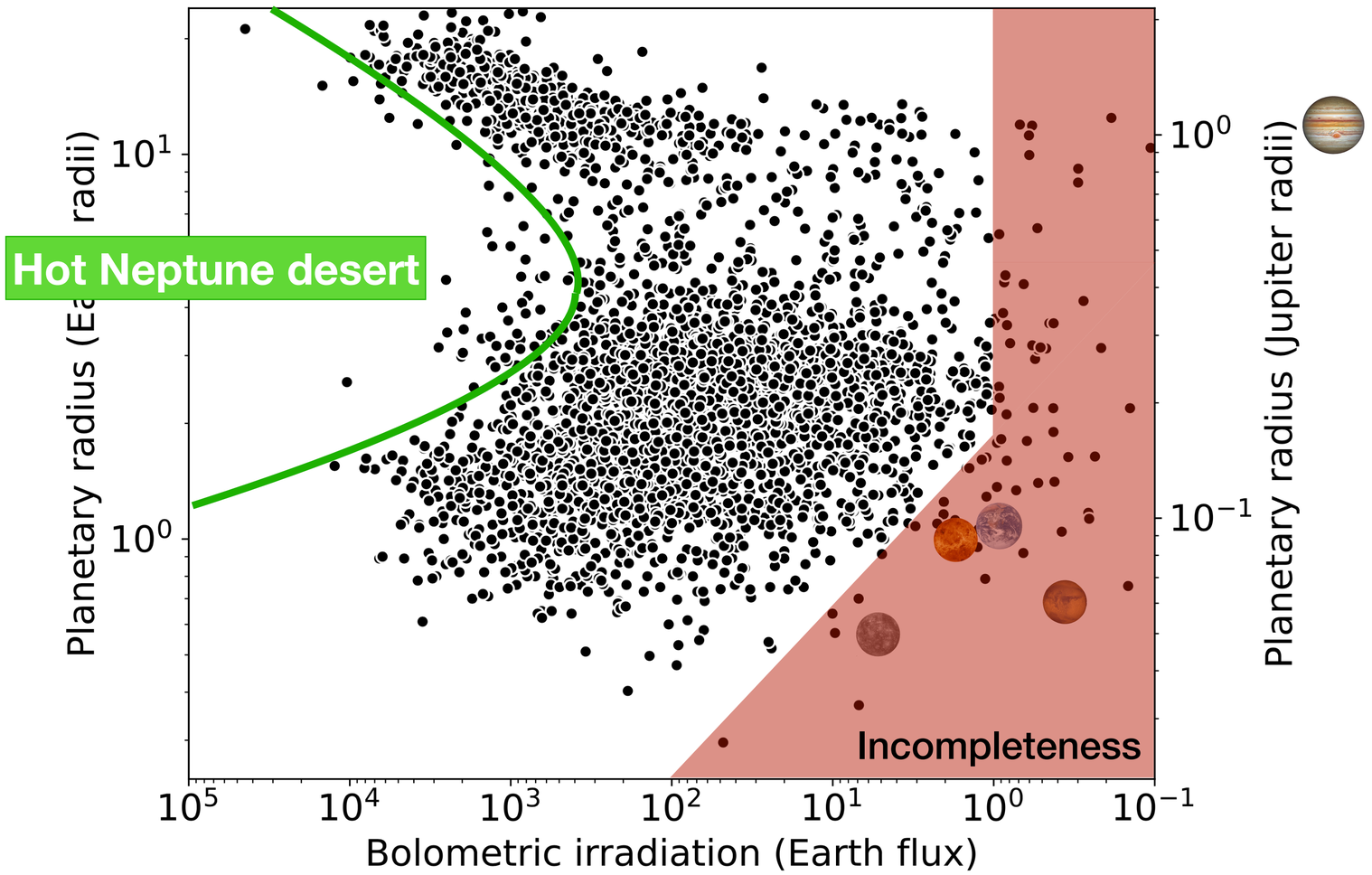
The transiting exoplanet population as of 2023



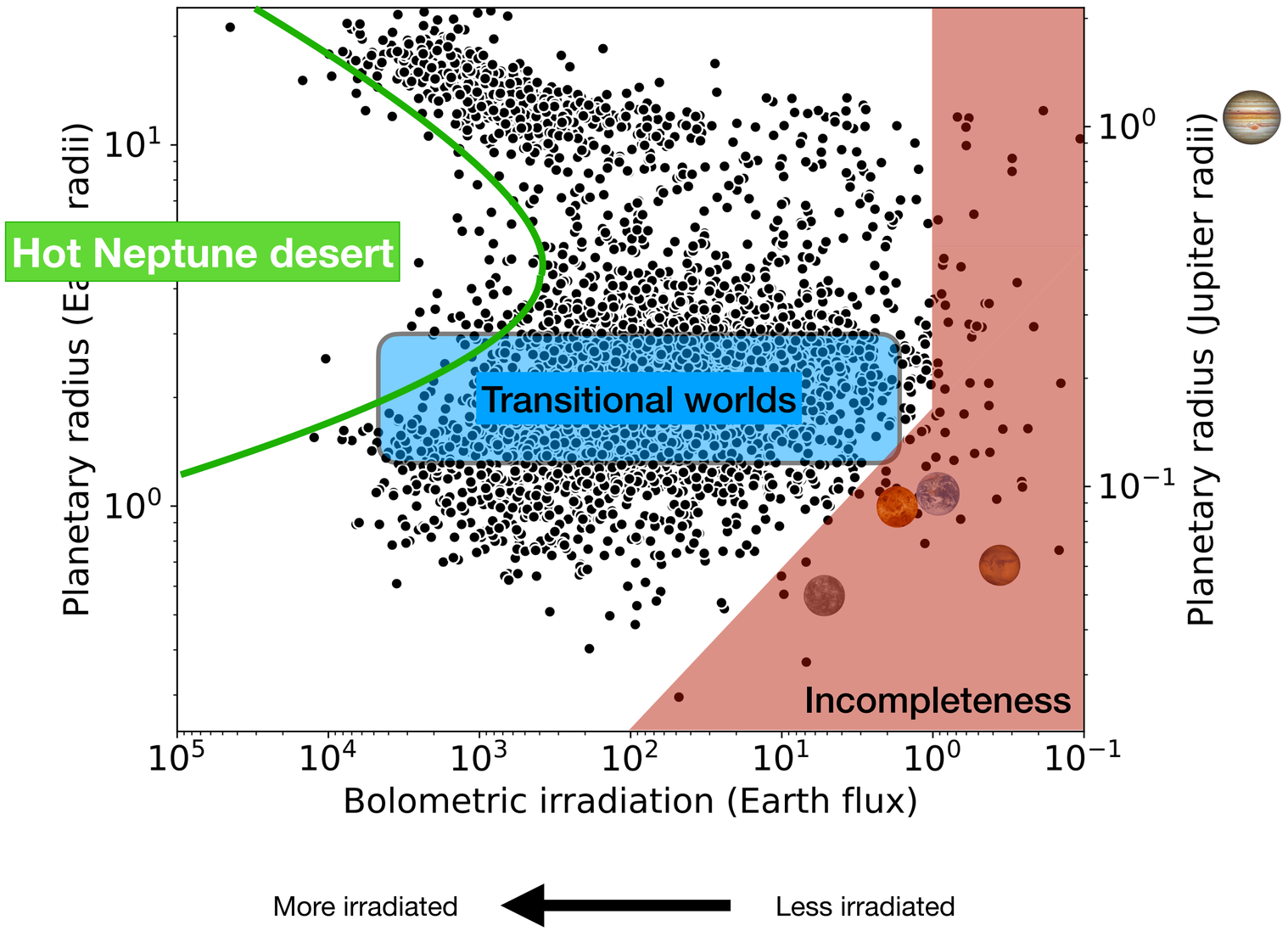
We think that hot Neptunes lose their atmospheres and shrink rapidly due to photoevaporation



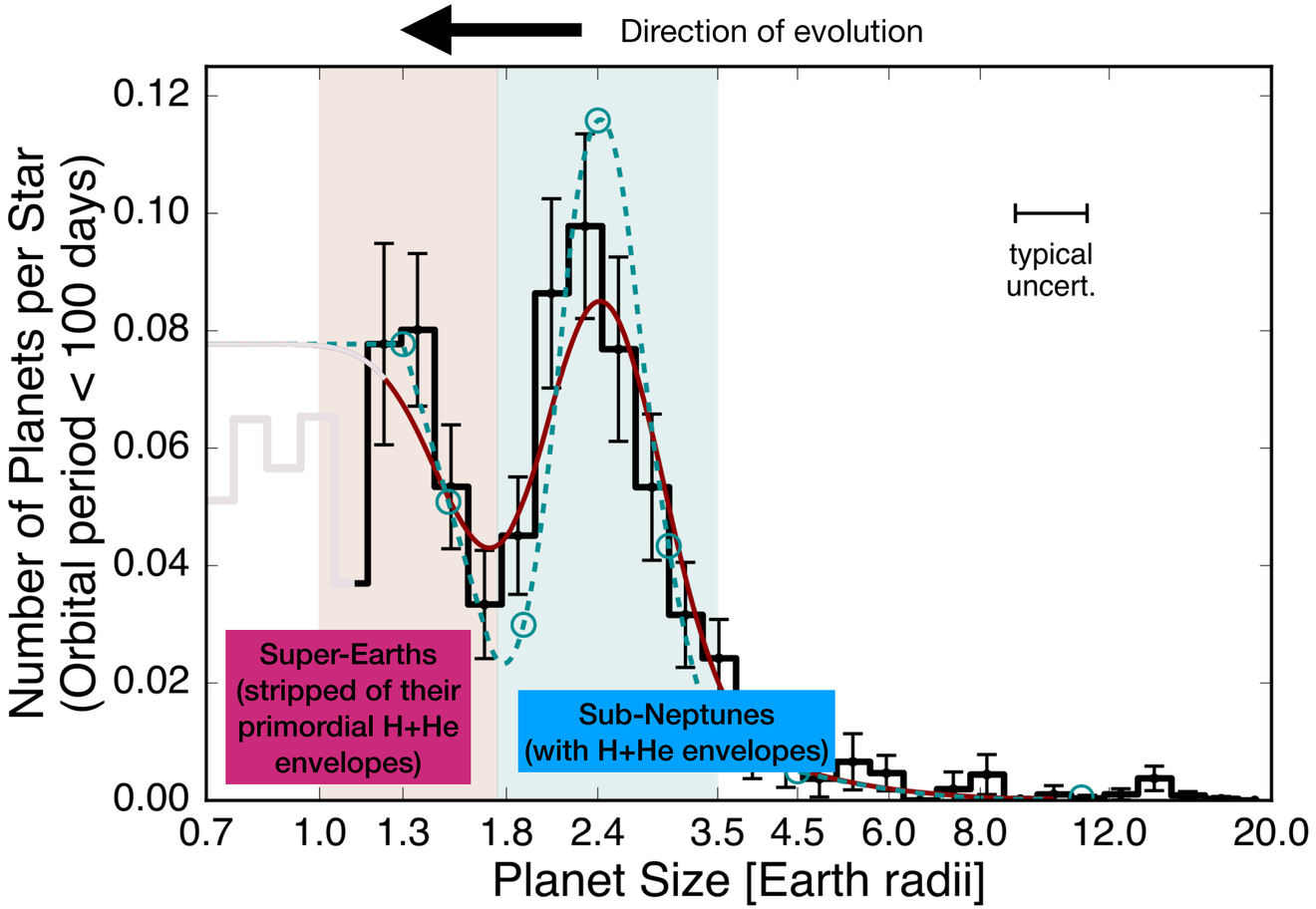
Direction of evolution by photoevaporation

More irradiated ← Less irradiated

The transiting exoplanet population as of 2023



A gap separates transitional worlds between sub-Neptunes and super-Earths



Is this gap formed by atmospheric escape?

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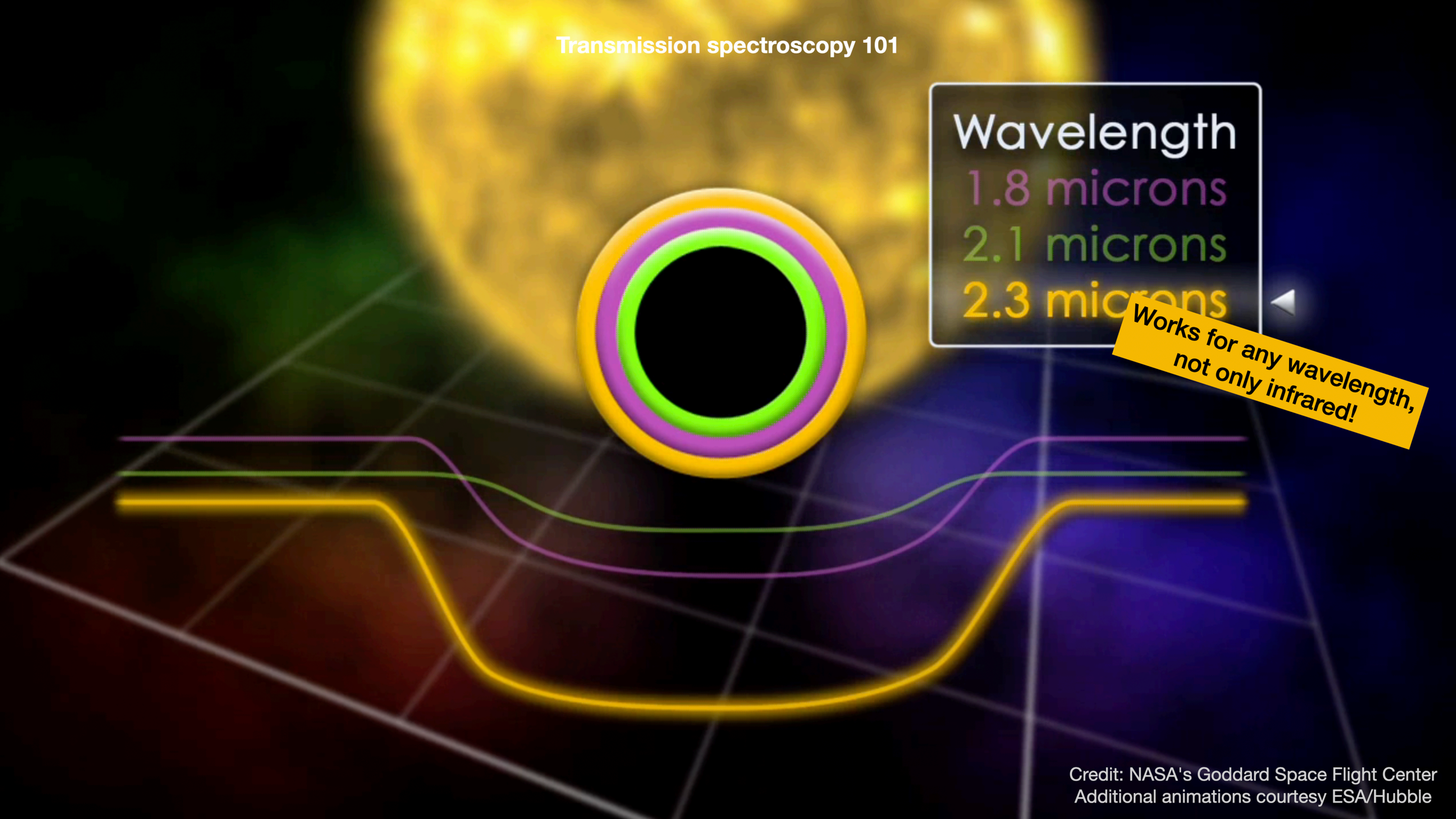
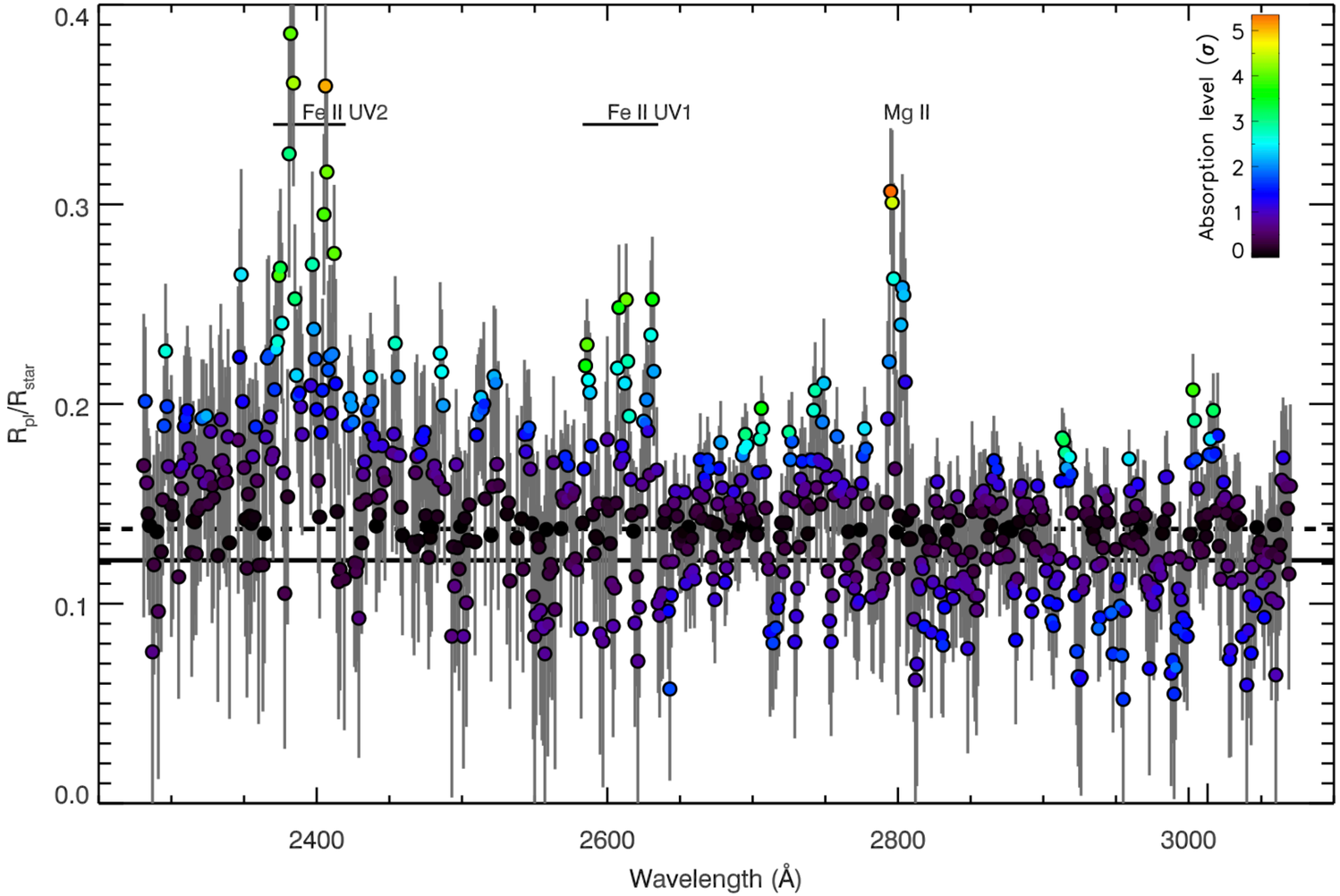
Mass-loss rates


Transmission spectroscopy 101
Wavelength
1.8 microns
2.1 microns
2.3 microns
Works for any wavelength, not only infrared!
Credit: NASA's Goddard Space Flight Center
Additional animations courtesy ESA/Hubble

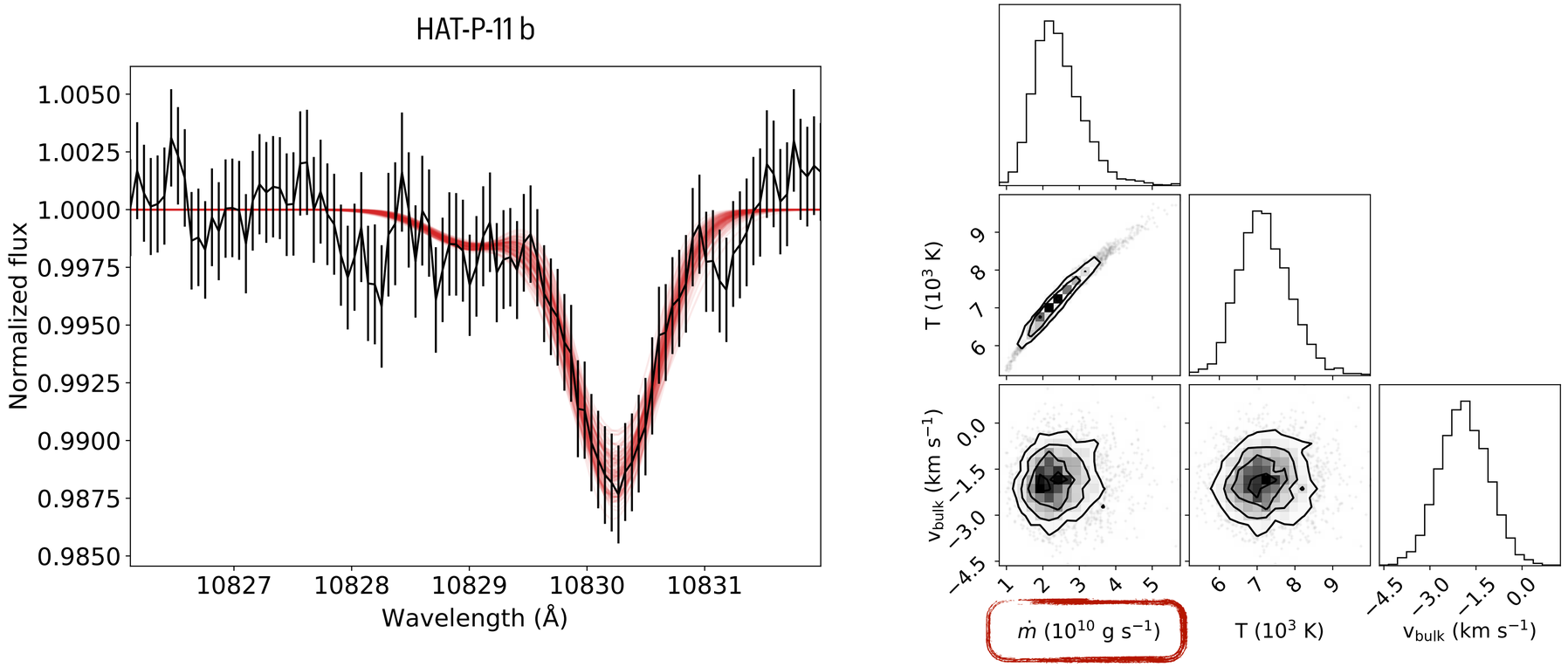
UV transmission spectroscopy reveals the presence of ionized metals in the upper atmospheres of WASP-121b



Sing et al. (2019, AJ 158)

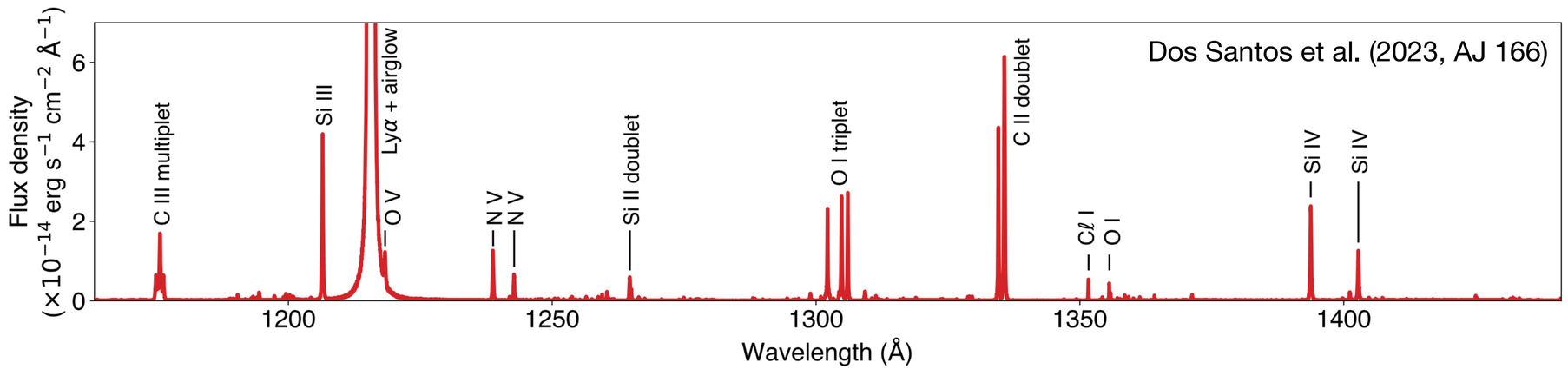
p-winds

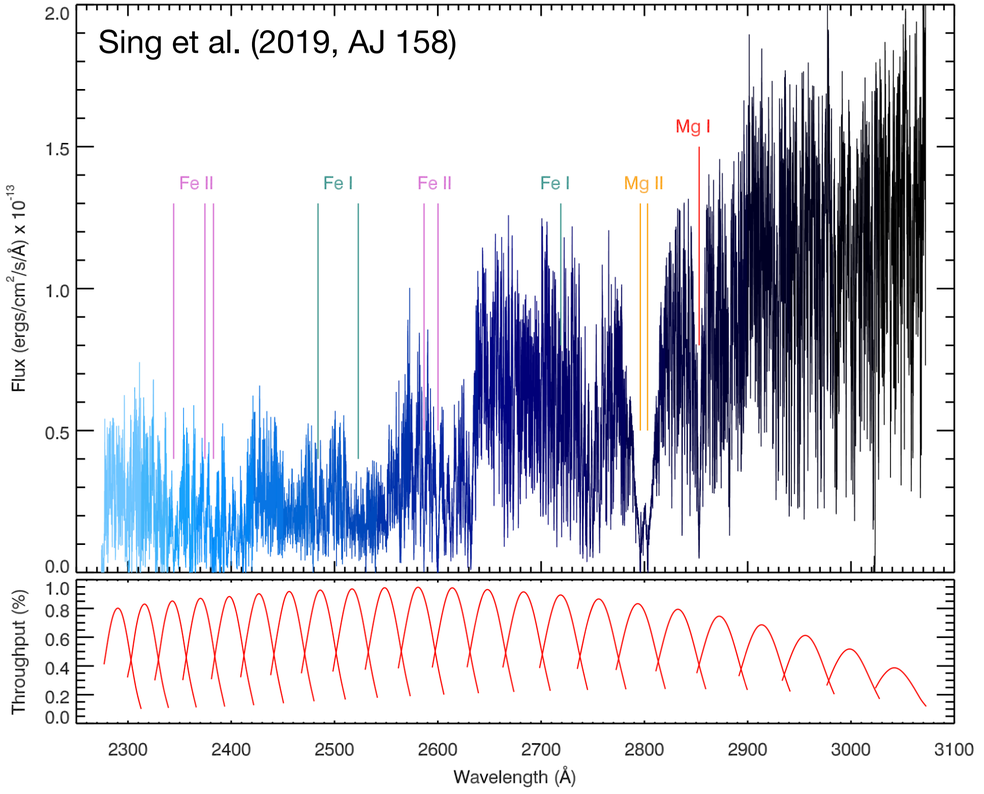
RETRIEVALS: ATMOSPHERIC ESCAPE RATE AND OUTFLOW TEMPERATURE



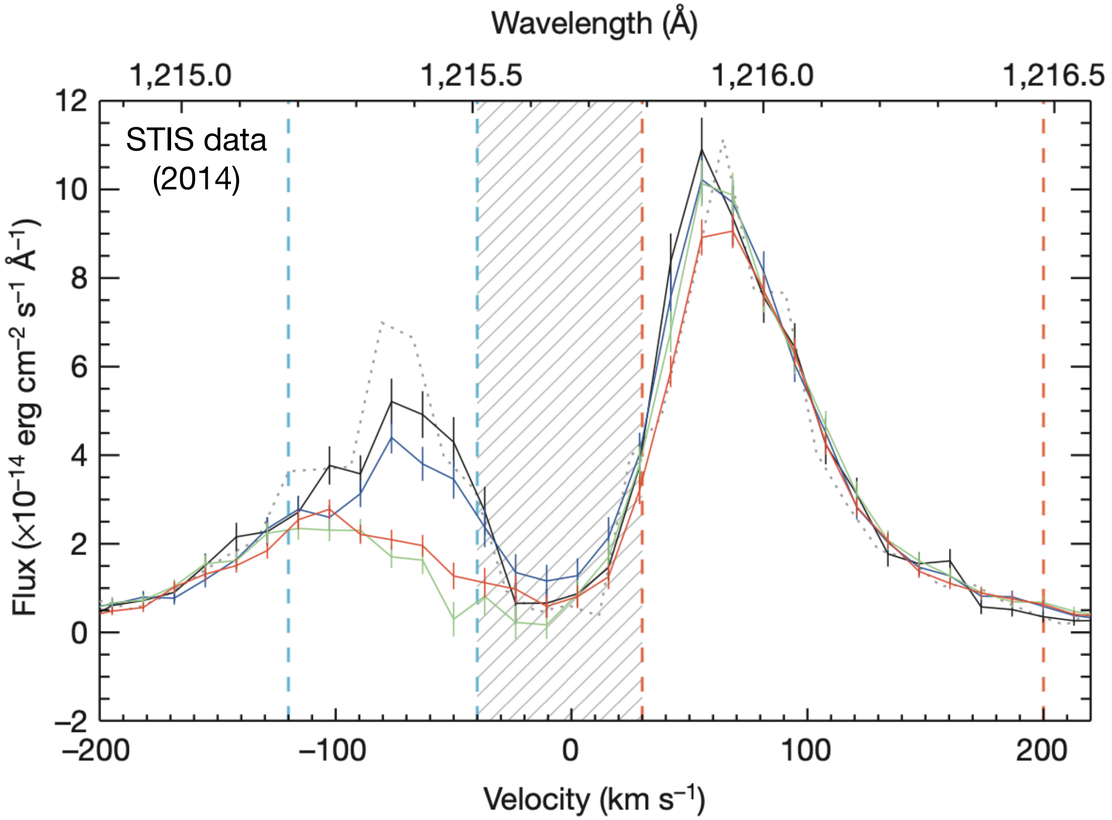
Dos Santos et al. (2022, A&A 659)

UV has access to many species in the upper atmospheres of evaporating exoplanets

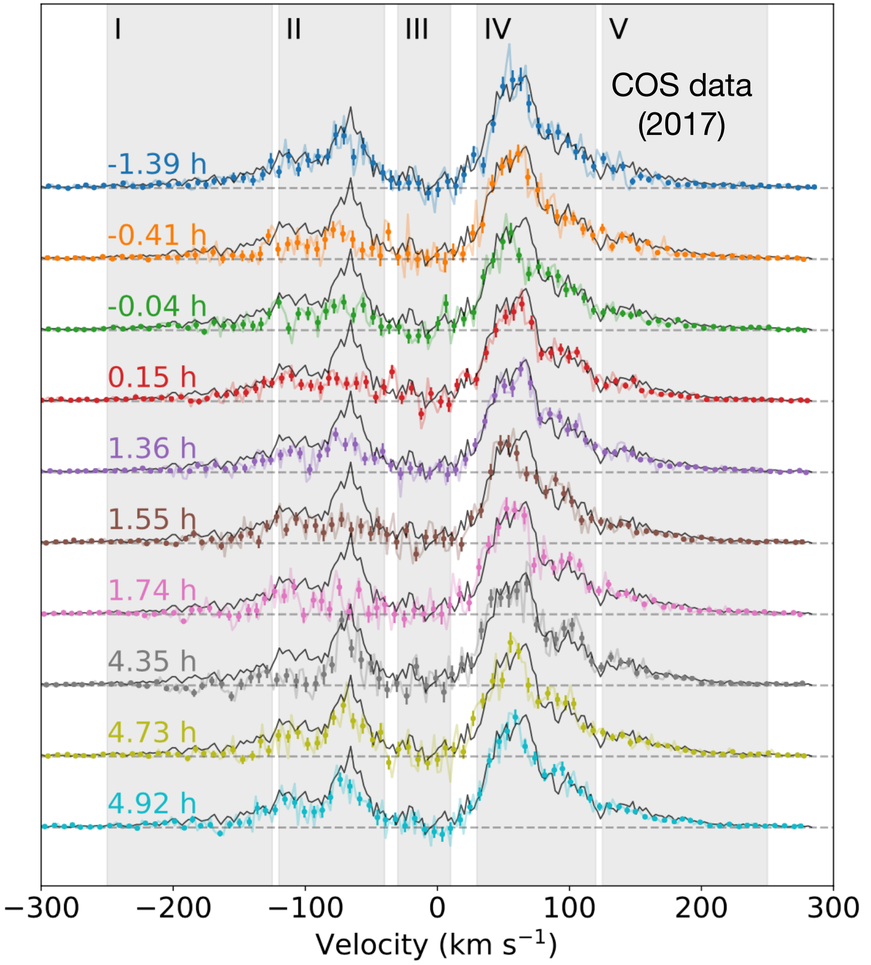




Atmospheric escape of H in GJ 436 b observed with *HST*/STIS and COS



Ehrenreich et al. (2015, Nature 522)



Dos Santos et al. (2019, A&A 629)

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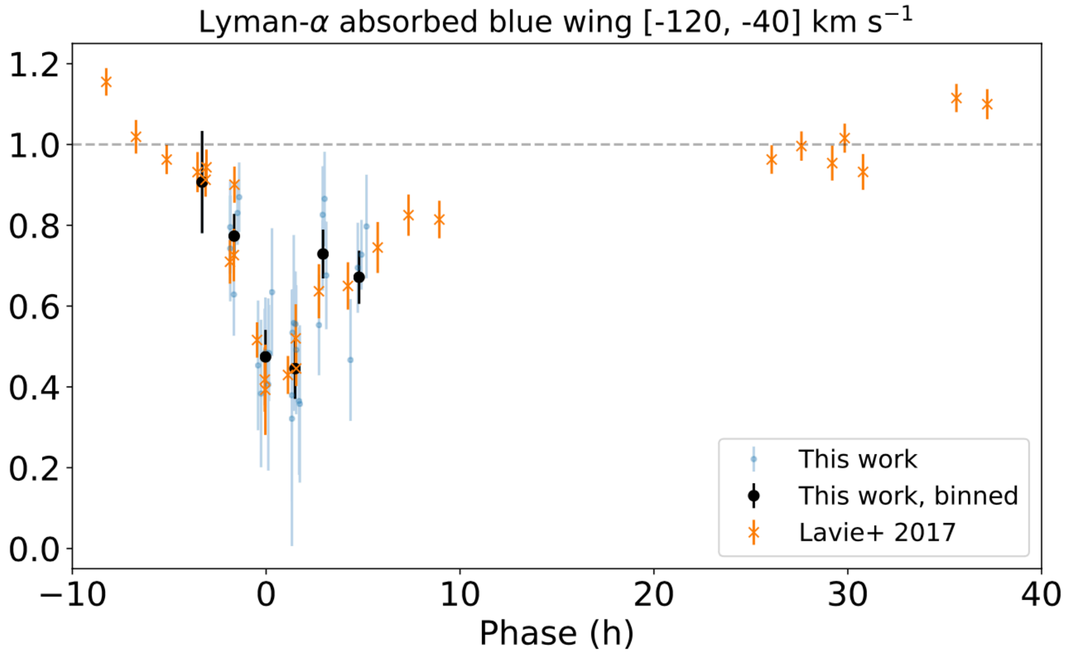
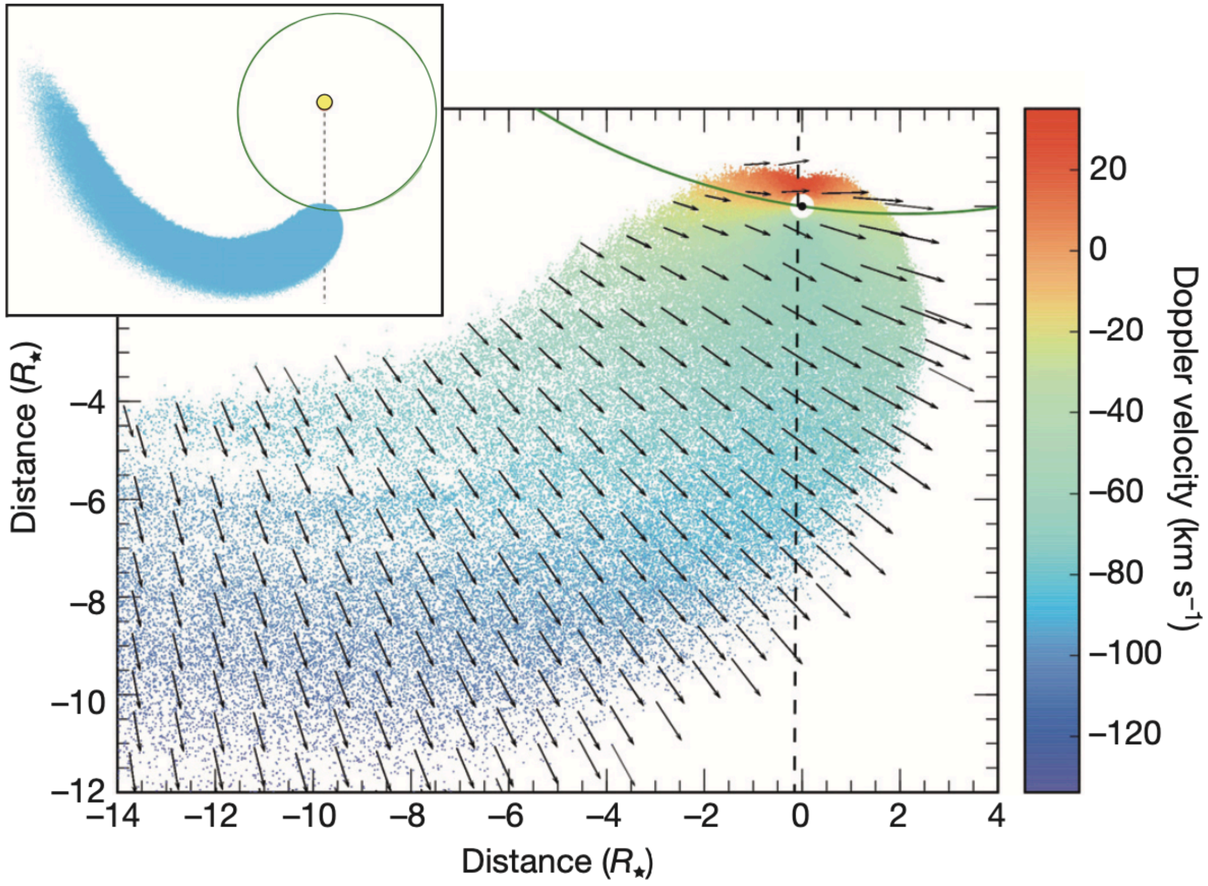
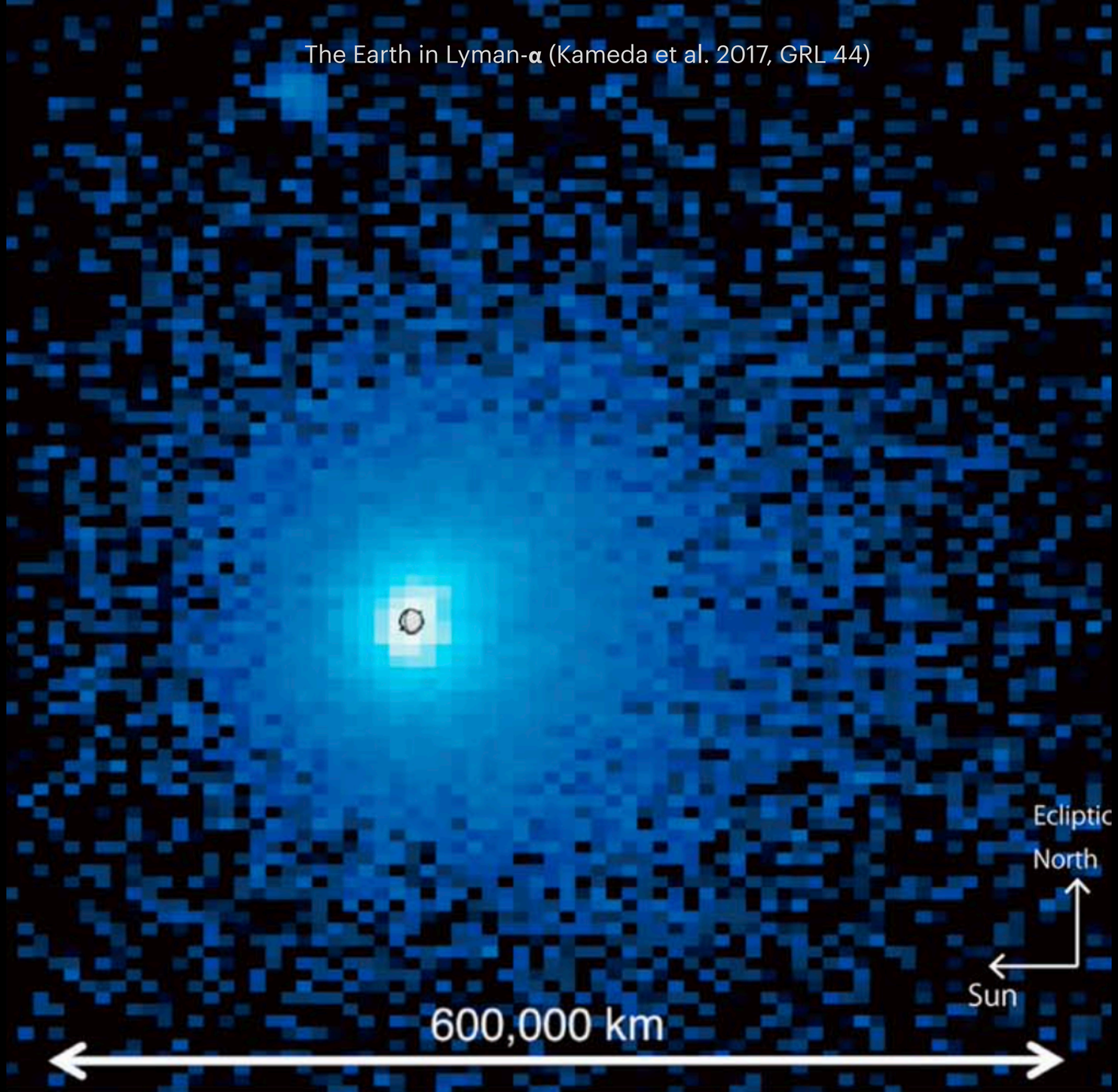


Dos Santos et al. (2019, A&A 629)

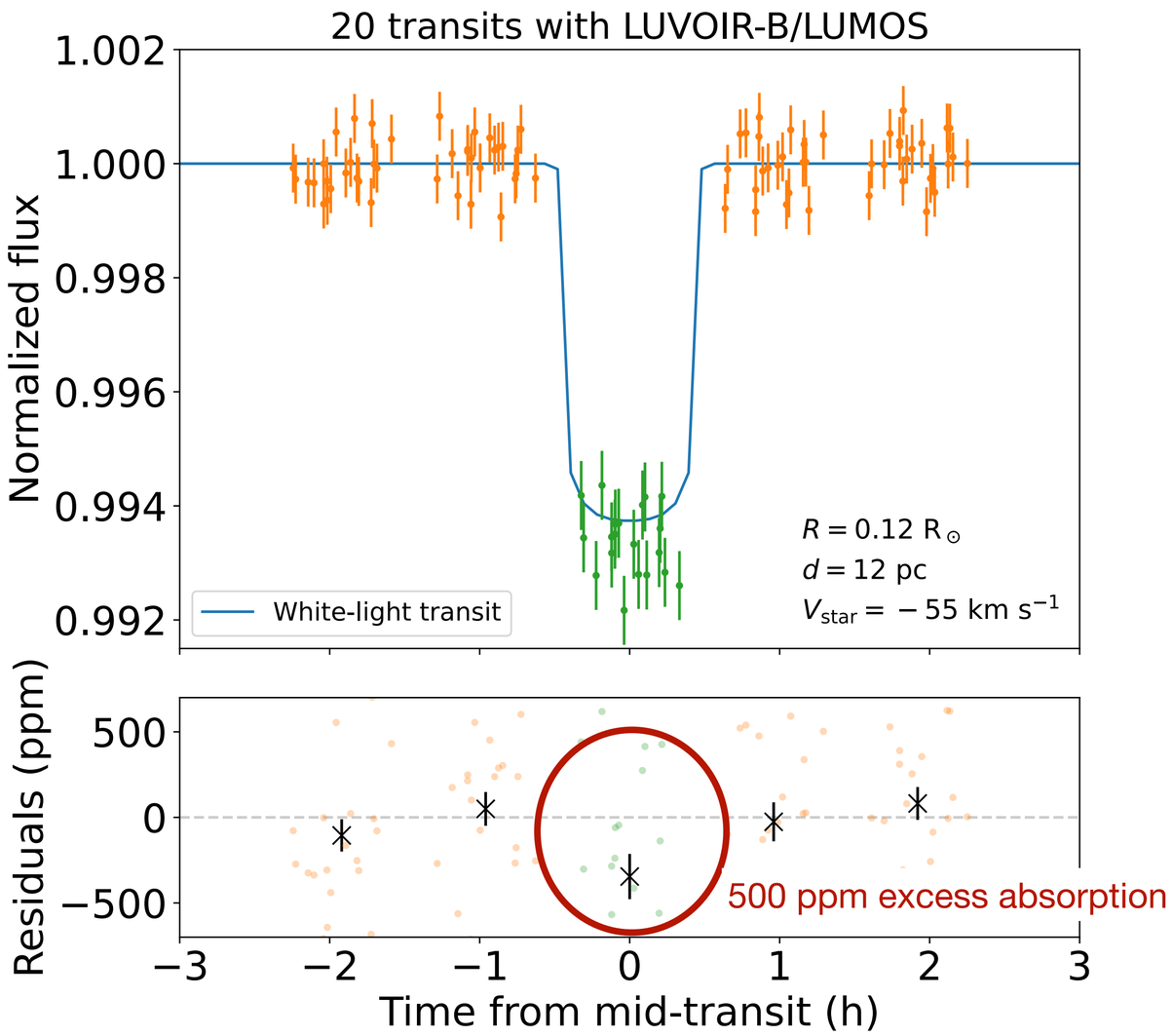


Ehrenreich et al. (2015, Nature 522)

The Earth in Lyman-α (Kameda et al. 2017, GRL 44)



Lyman-α light curve of an Earth-like planet around TRAPPIST-1 planet using *LUVOIR*-B/LUMOS (Dos Santos et al. 2019, A&A 622)



My wishlist for a UV spectrograph on HWO

1. Medium- to high-resolution modes (think STIS and COS)
2. Detectors resilient to high count rates
3. High temporal stability (think *JWST*)
4. At least 10x more effective area than *HST*/COS 🙏