Evidence for a variable hydrogen cloud around the young Neptune DS Tuc Ab

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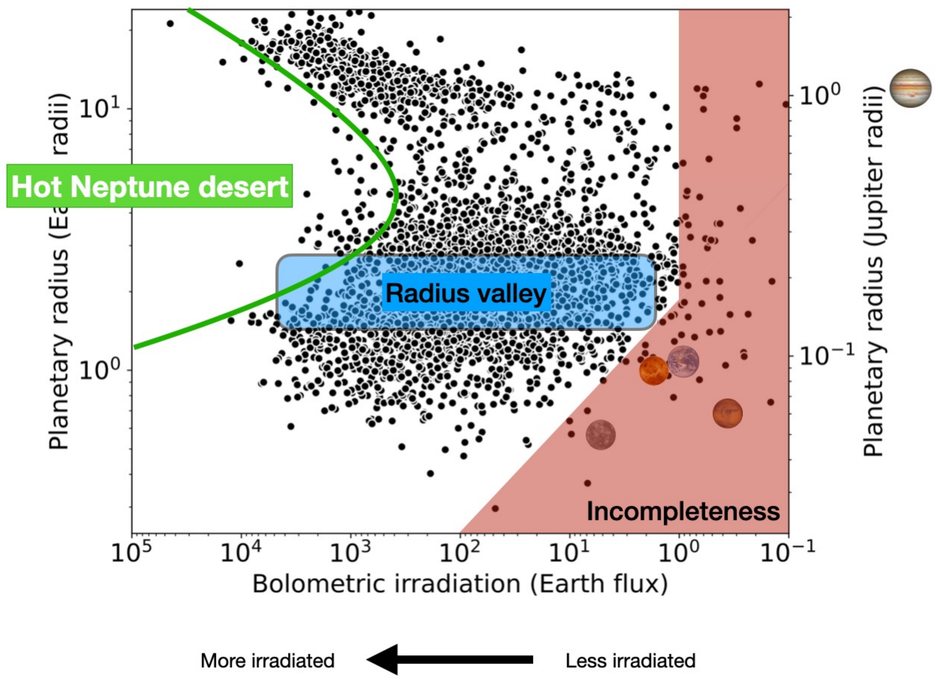
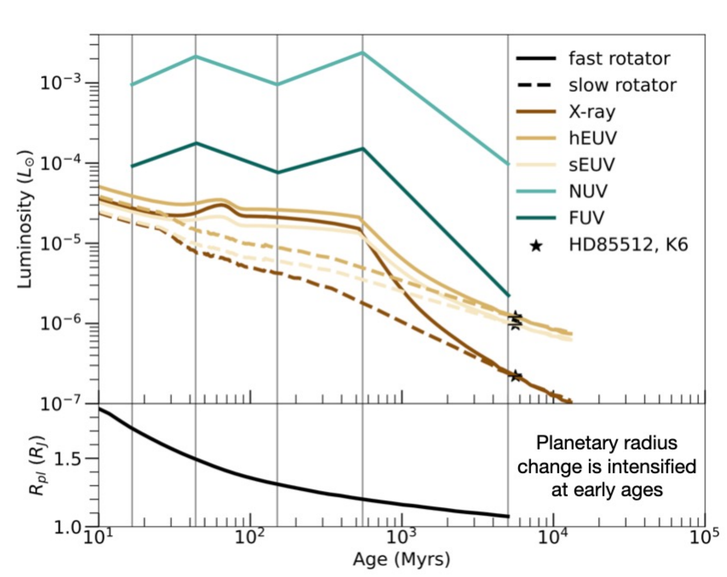
Context: We think that atmospheric escape through photoevaporation driven by high-energy irradiation is a fundamental process that dictates the evolution of exoplanets that orbit close to their host star, particularly those with sub-Jovian masses. It has been posed that most of the photoevaporation happens when planets are young and their host stars more magnetically active. This is observationally backed by exoplanet demographic features, but we lack more direct evidence.

The hot-Neptune desert and the radius valley are demographic features carved by atmospheric escape



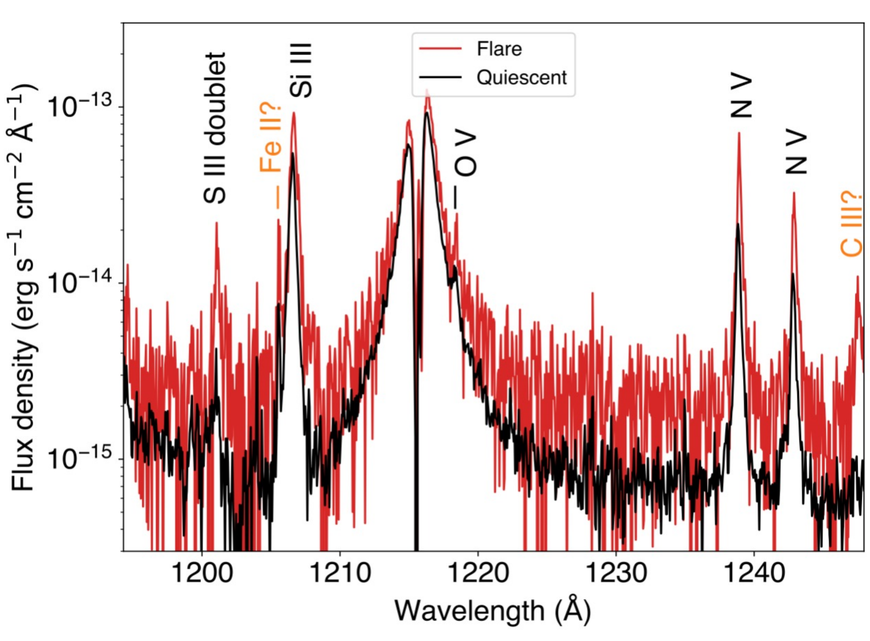
The high-energy output of cool stars is the strongest when they are young, and atmospheric escape follows suit



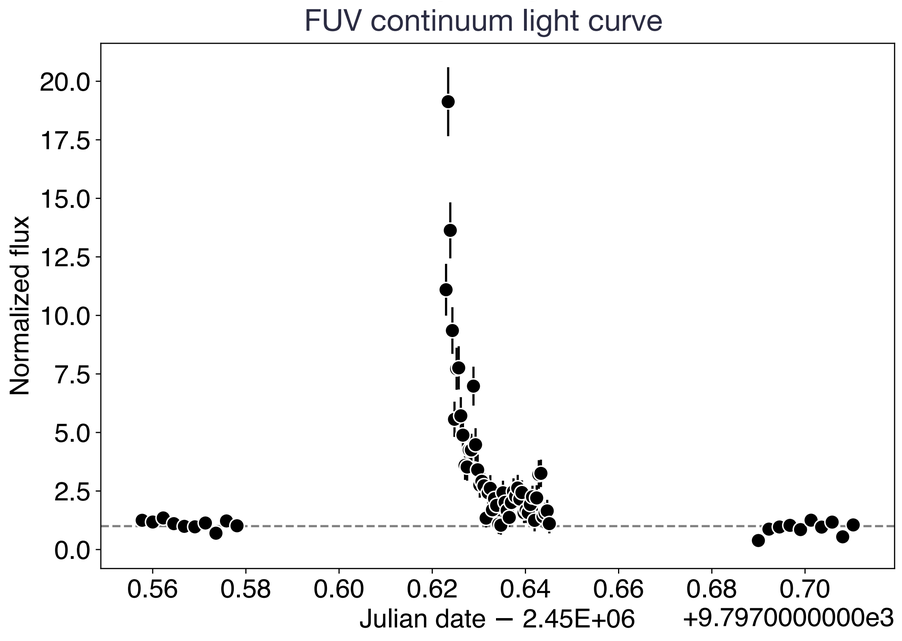
Allan et al. (2024, MNRAS 527)

Experiment: Given this context, we observed the young (45 Myr) Neptune DS Tuc Ab with the Hubble Space Telescope (HST) to look for signals of ongoing atmospheric escape using transmission spectroscopy of the Lyman-α line.

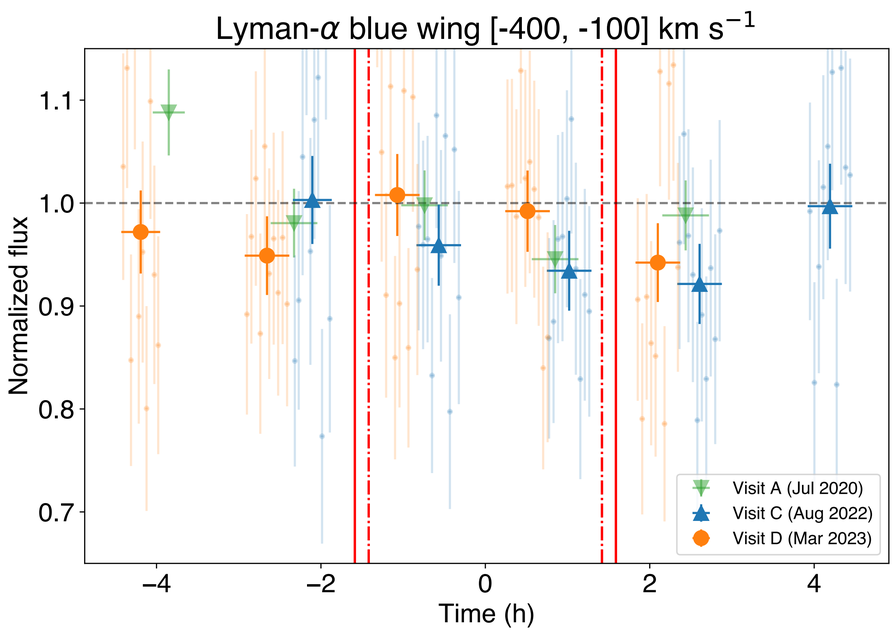
Three transit visits with HST/STIS/G140M. One out of transit visit (flare). PI: Dos Santos, GO programs 16085 and 16723

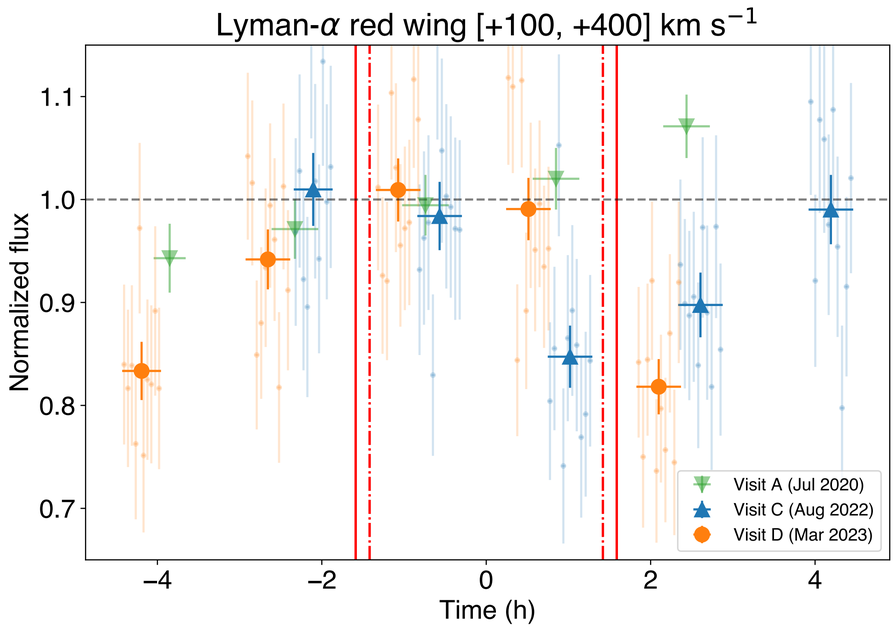


We observed one large flare during an out-of-transit visit. Flares like this occur a few times per day in stars like DS Tuc A



Results: When we analyzed the Lyman- light curves, we found that the blue wing remains relatively quiet on all visits. On the other hand, the red wing exhibits large absorption (~20%) during pre-transit and during egress in the visits between 2022 and 2023. The red wing light curve is quiet in the visit occurred in 2020.





Conclusion: Our explanation for the pre-transit and egress absorption observed during the transits of DS Tuc Ab in 2022-2023 is that the planet could be surrounded by a cloud of neutral H fed by atmospheric escape. This cloud infalls into the host star at high velocities, producing red-shifted, asymmetric absorption during the transit of DS Tuc Ab. This feature is variable in time, as it is not observed in the epoch of 2020.