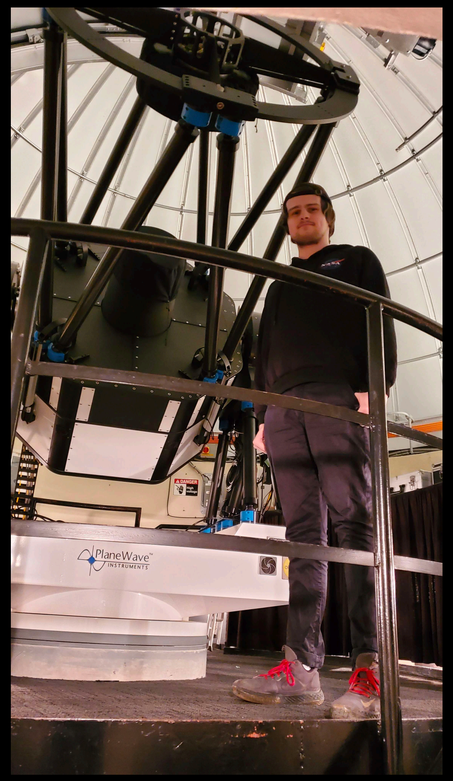
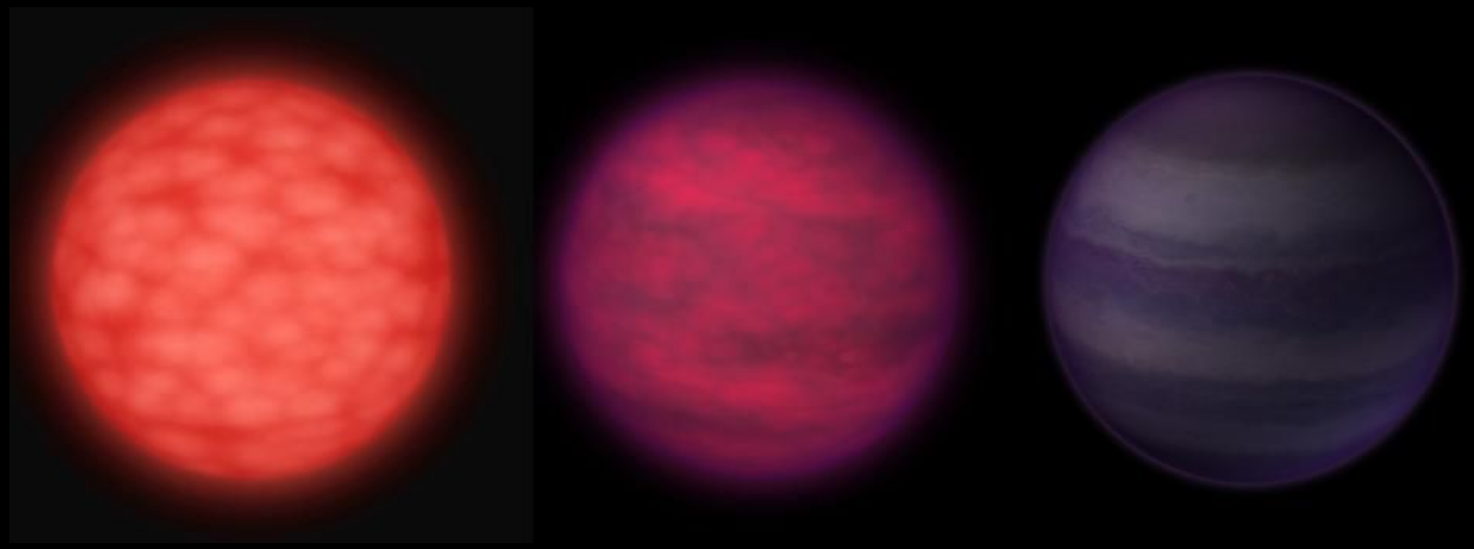
HYPOTHETICAL SPECTRAL FINGERPRINTS OF EARTH-LIKE PLANETS IN BROWN DWARF SYSTEMS

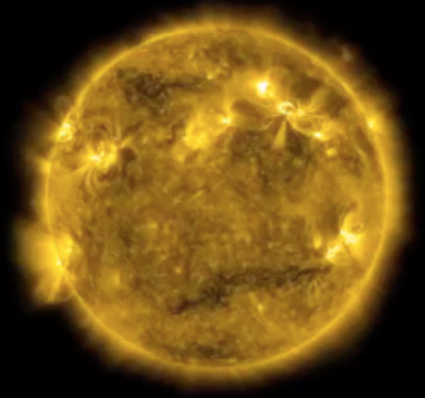
JUNE PARSONS, SARAH RUGHEIMER, NIALL DEACON

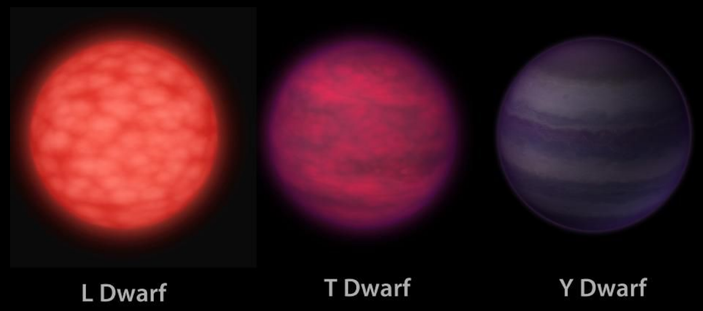




YORK

F G K M Sub-stellar Brown Dwarfs

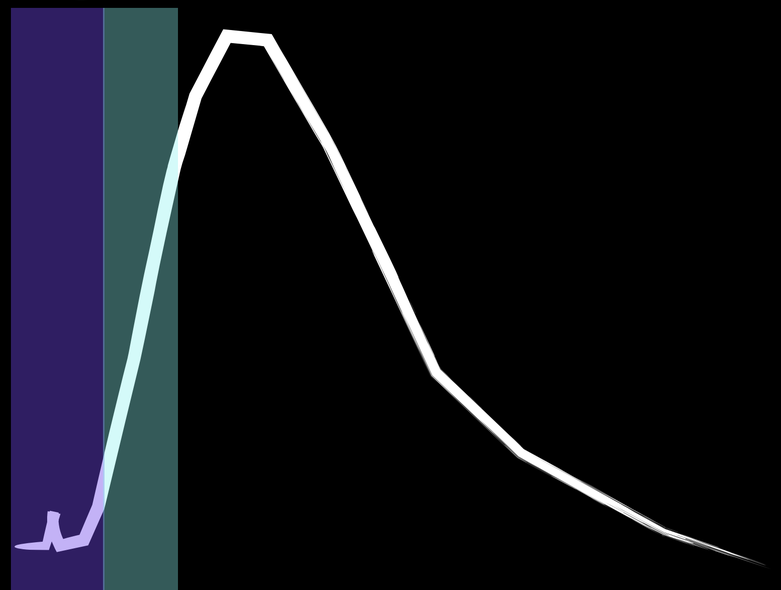


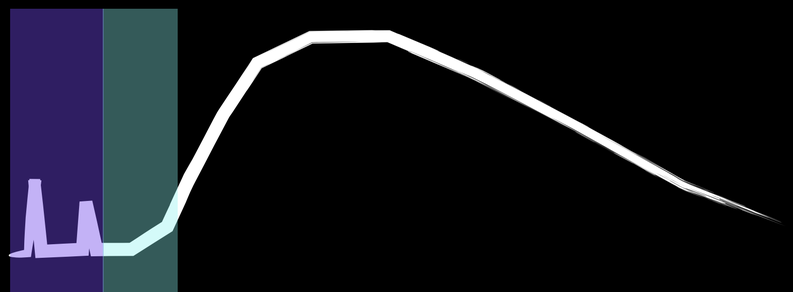


High NUV

Low NUV

High FUV

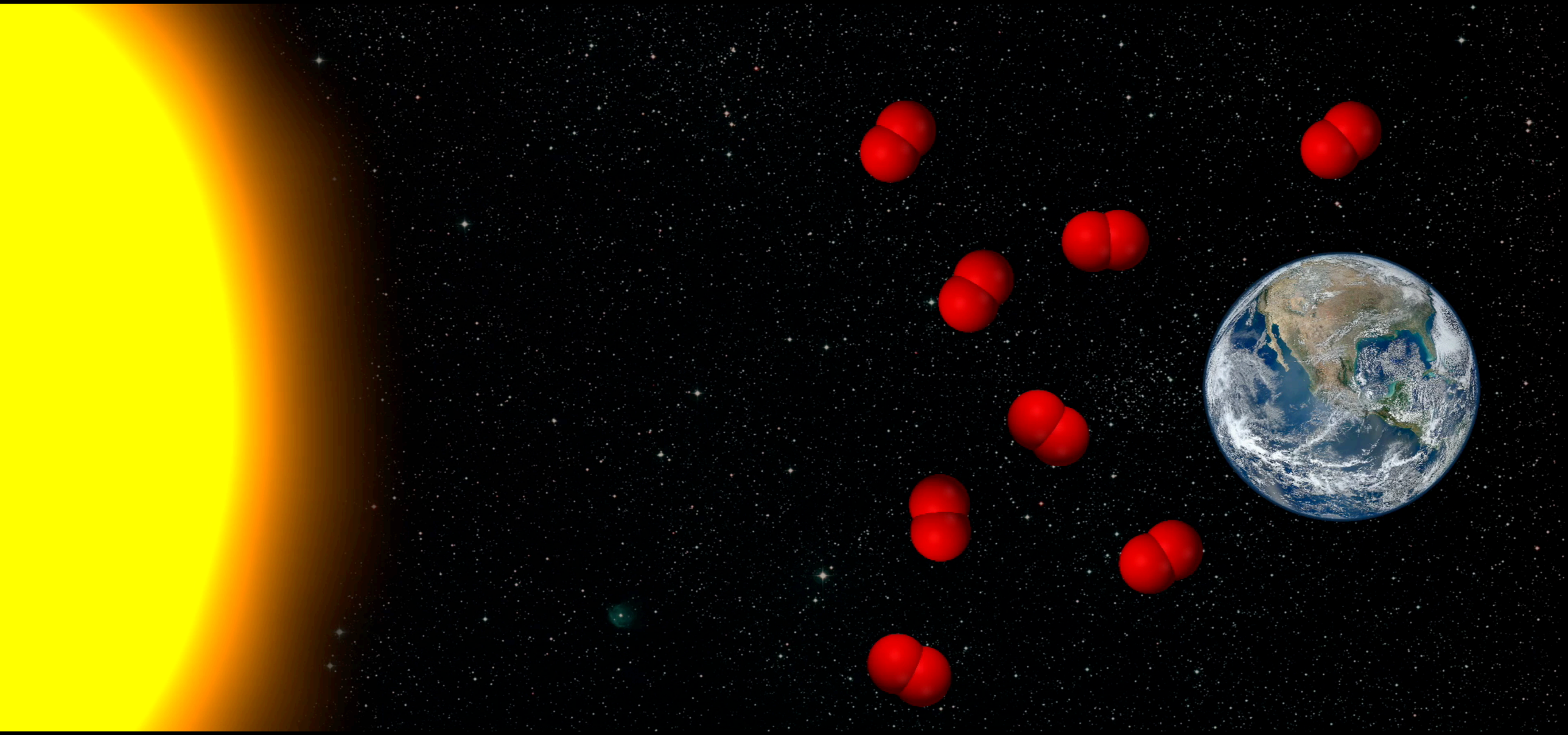




?

UV DESTROYS SOME BIOSIGNATURES

UV PRODUCES OTHER BIOSIGNATURES



the ratio: $\frac{\text{far UV}}{\text{near UV}}$ matters

Far UV

Ozone Production:

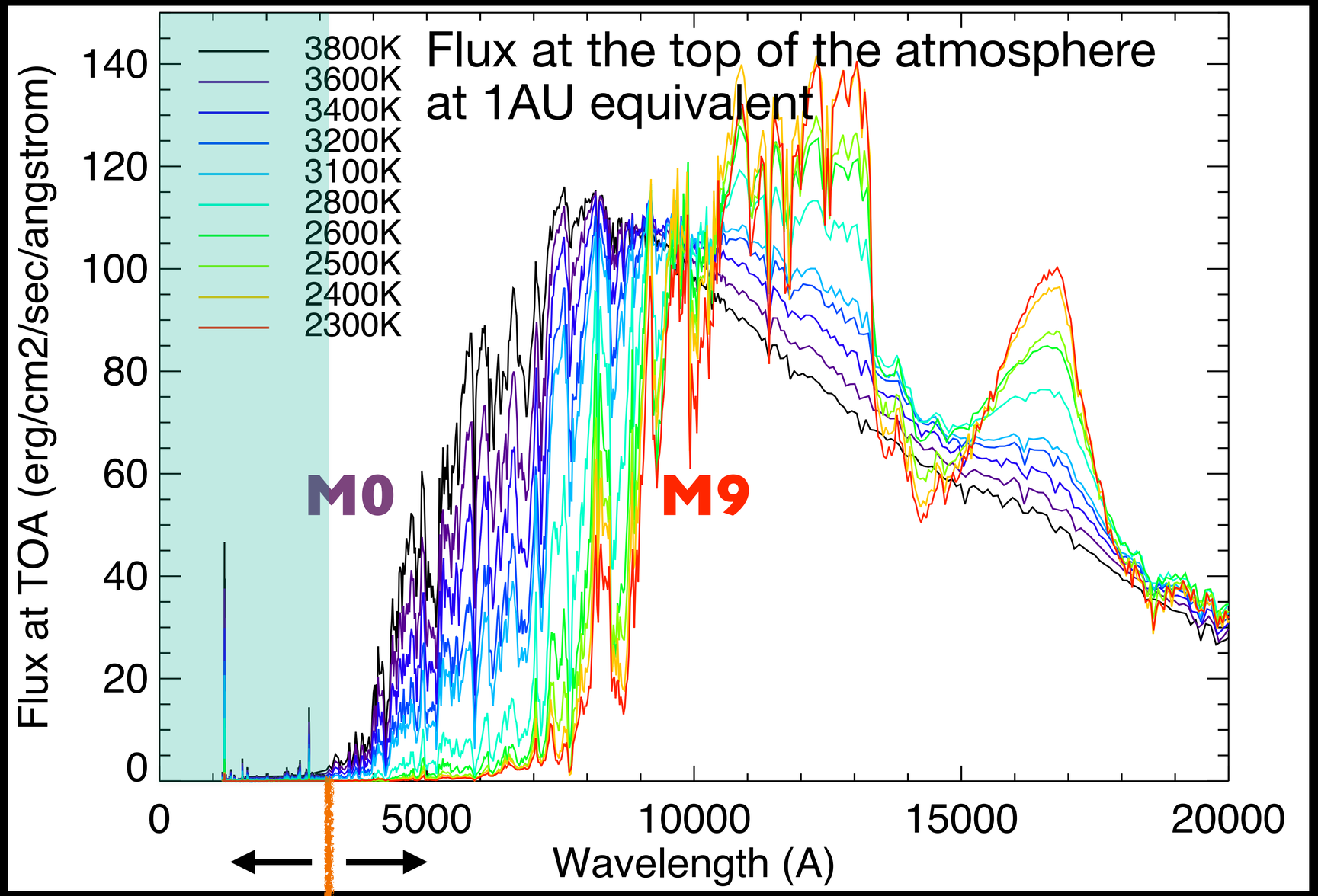
$$O_2 + h\nu \longrightarrow O + O \quad (\lambda < 240\text{nm})$$
$$O + O_2 + M \longrightarrow O_3 + M$$

Ozone Destruction:

$$O_3 + h\nu \longrightarrow O_2 + O \quad (\lambda < 320\text{nm})$$
$$O_3 + O \longrightarrow 2O_2$$

Near UV

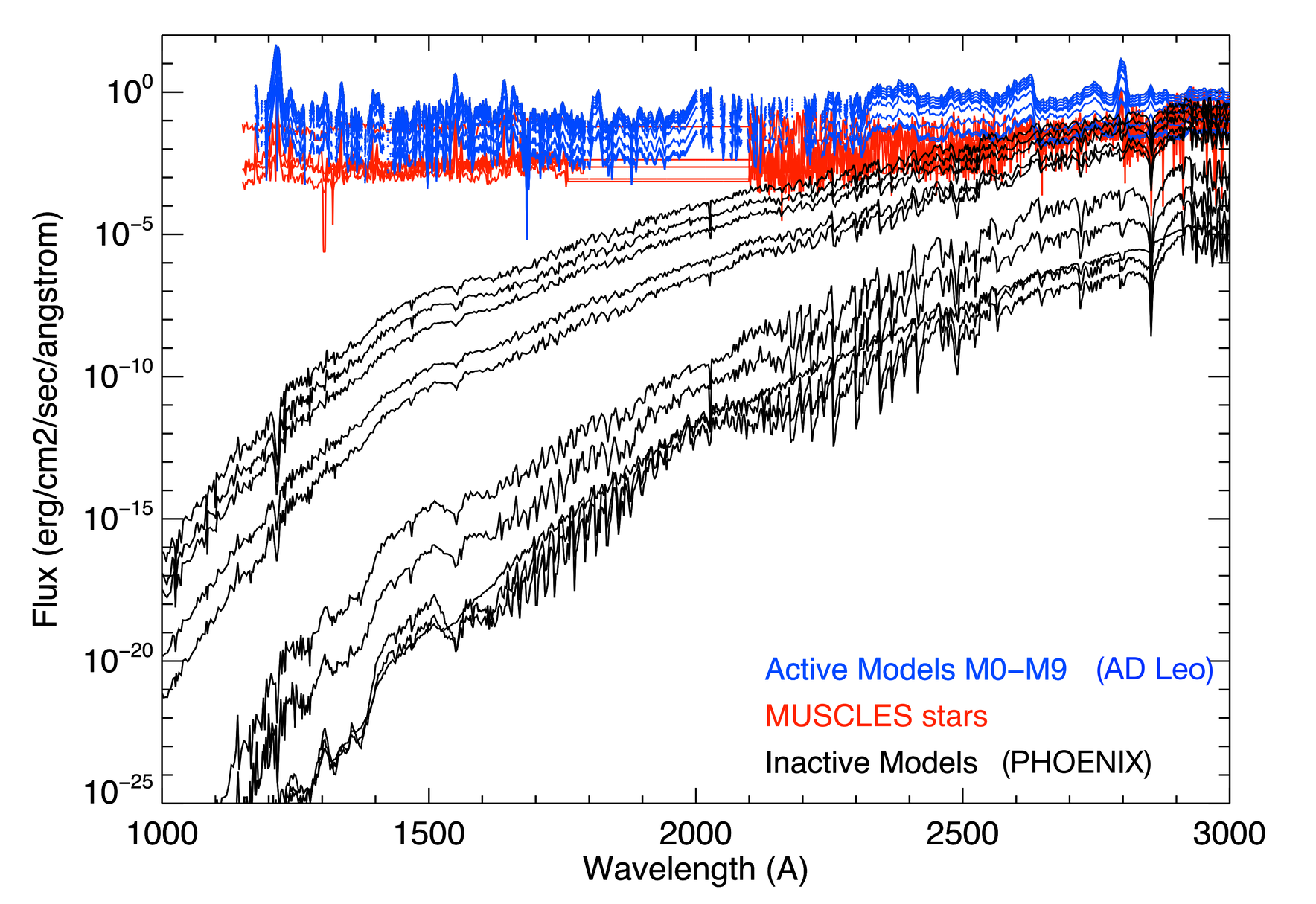
UV: SMALL PART OF FLUX BUT CRUCIAL TO ATM VIA PHOTOCHEMISTRY



MUSCLES Observations **PHOENIX Stellar Models**

Rugheimer *et al.*, 2015

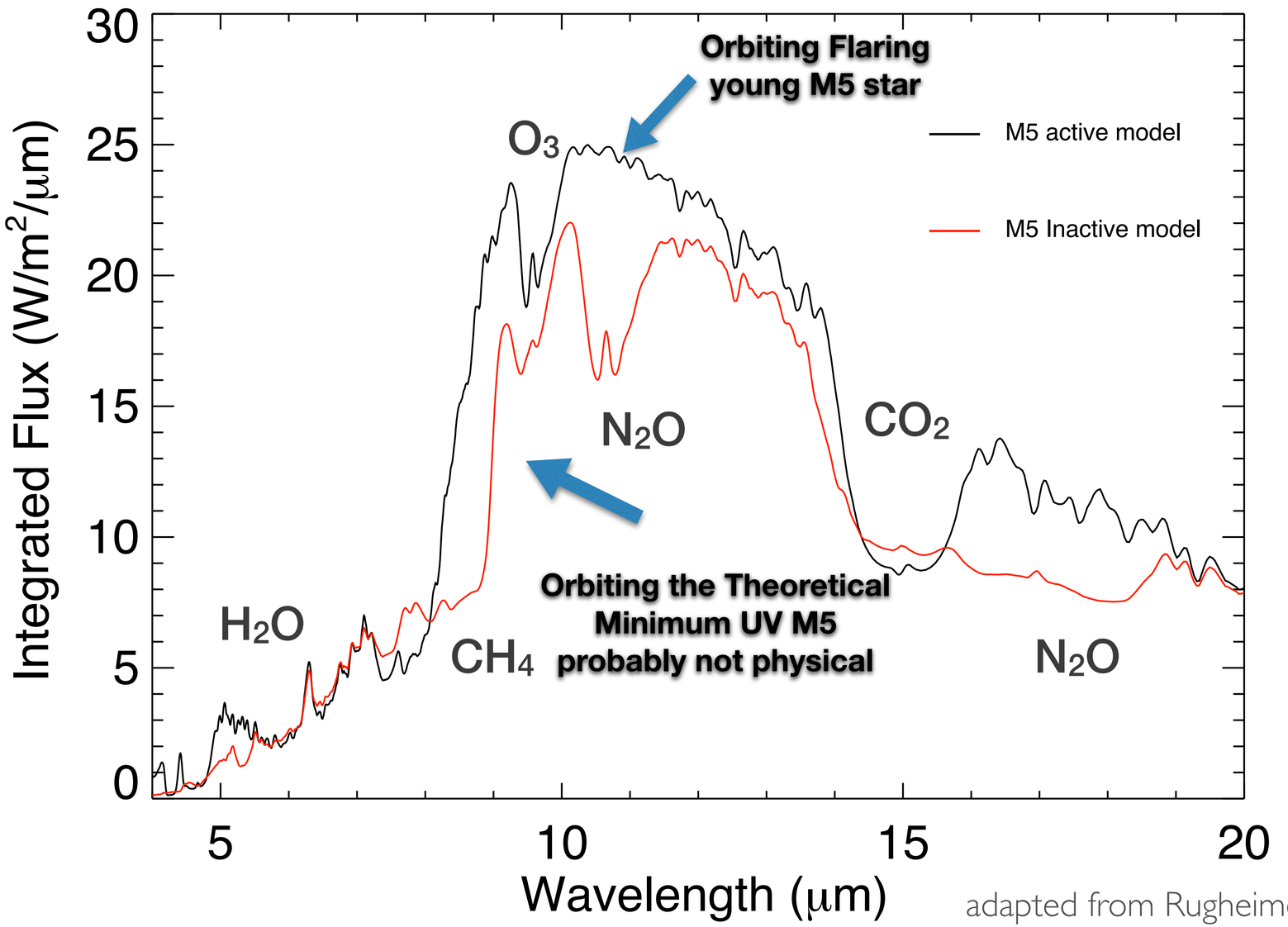
MUSCLES SHOWED QUIESCENT M DWARF UV IS MORE SIMILAR TO FLARE STARS THAN PHOTOSPHERE ONLY EMISSION



France et al. 2016
Rugheimer et al. 2015

Compare two UV extremes of an Earth-like planet orbiting M5 star

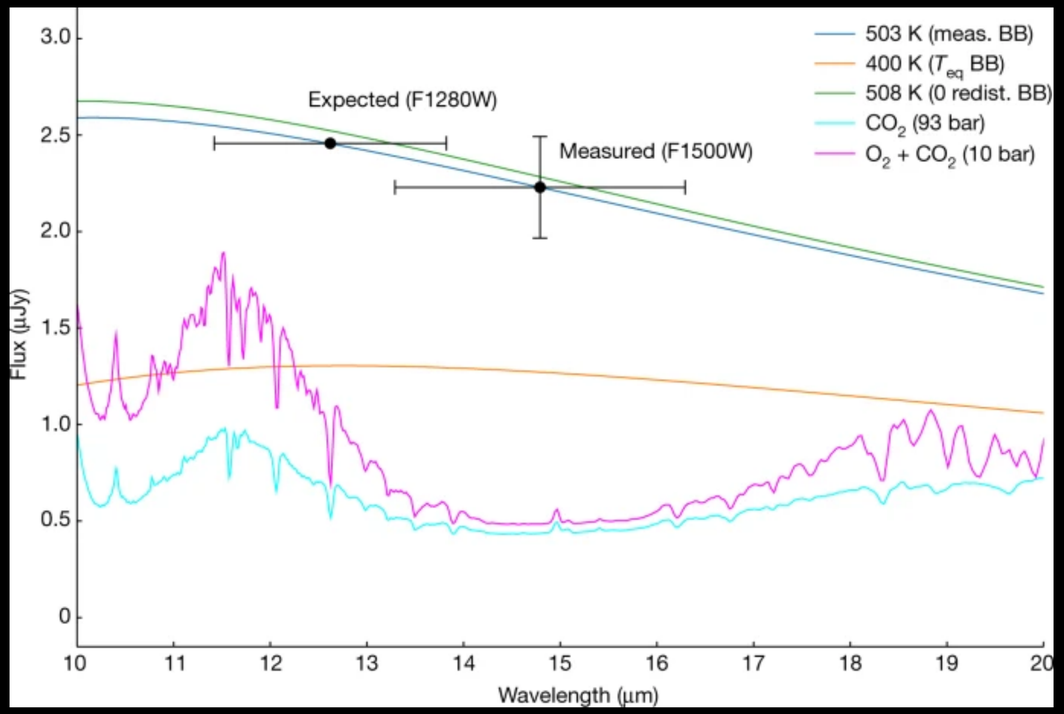
Two UV extremes - otherwise same planet same outgassing



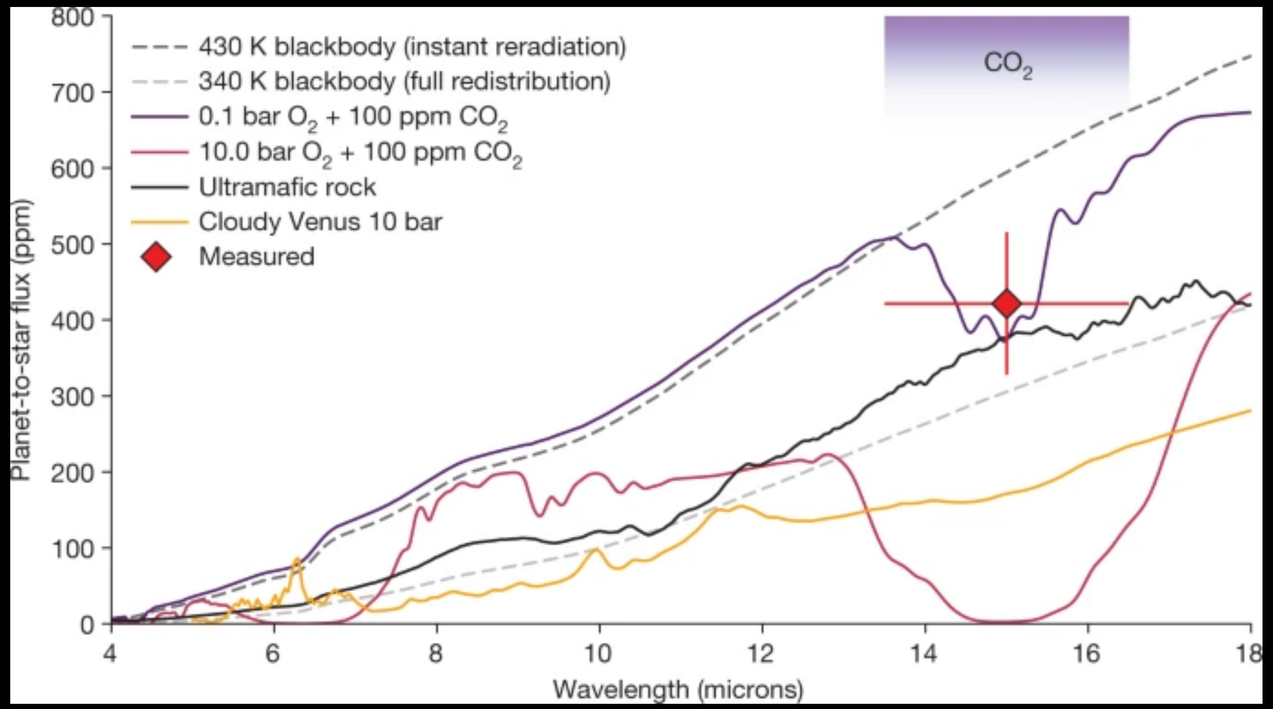
adapted from Rugheimer *et al.*, 2015

M STARS MAY HAVE PROBLEMS RETAINING THIN ATMOSHERES

TRAPPIST-1B (GREENE ET AL. 2023)

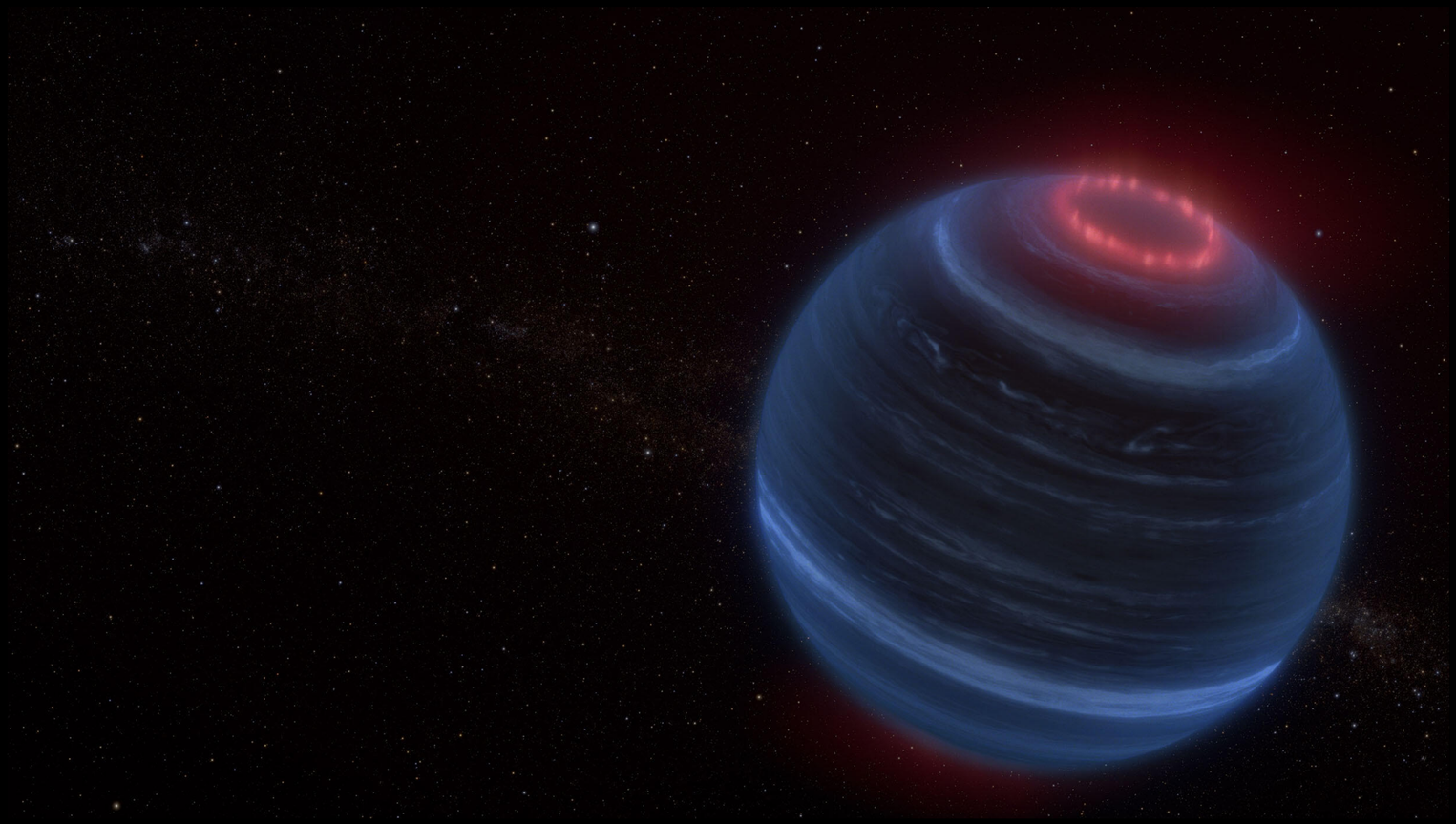


TRAPPIST-1C (ZIEBA ET AL. 2023)



FINGERS CROSSED FOR TRAPPIST-1D,E,F

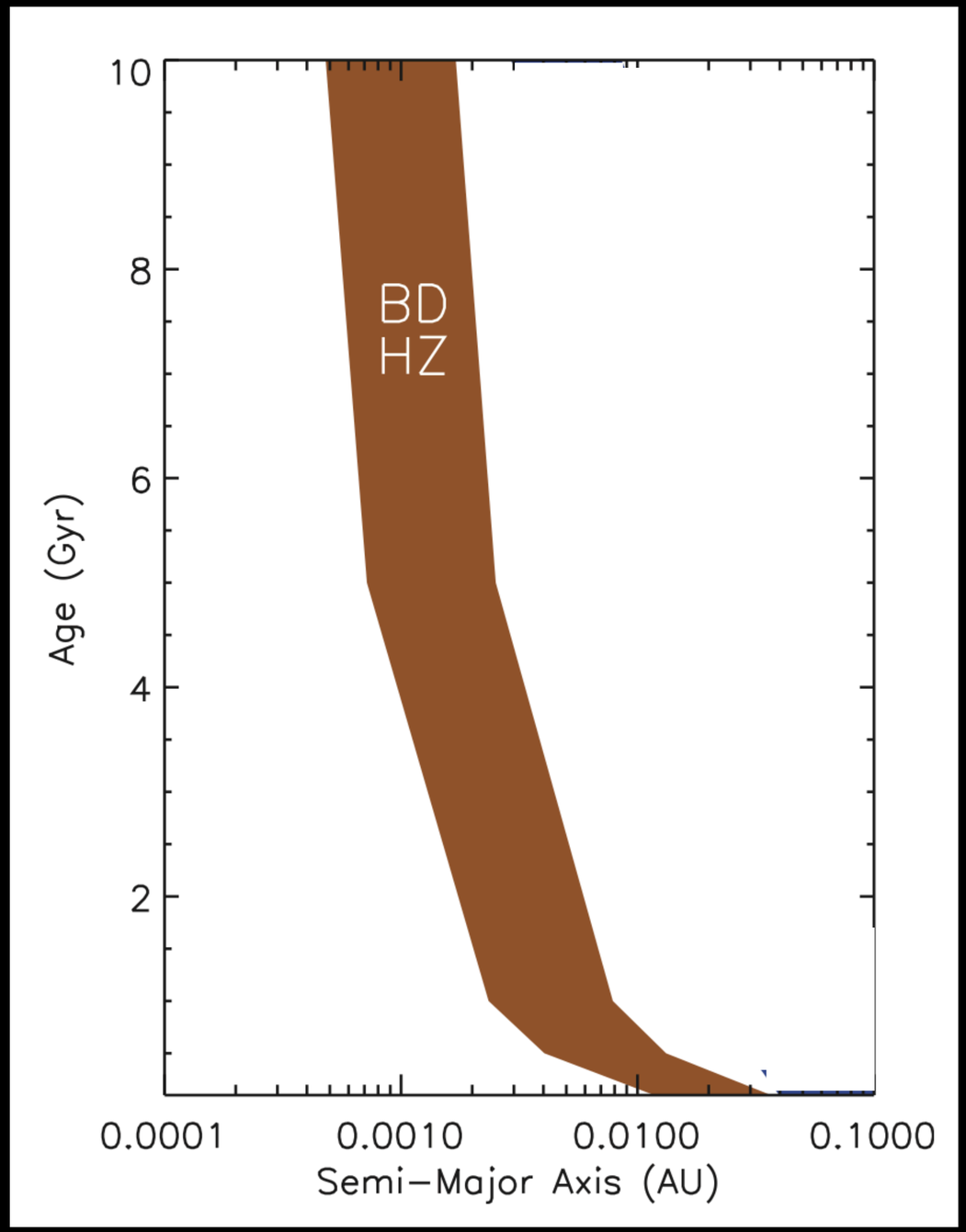
BROWN DWARFS?



BROWN DWARFS FACE SOME CHALLENGES TO HABITABILITY

BROWN DWARFS CONTINUALLY COOL SO THE HABITABLE ZONE MOVES INWARD

WILL H2O BE RETAINED?



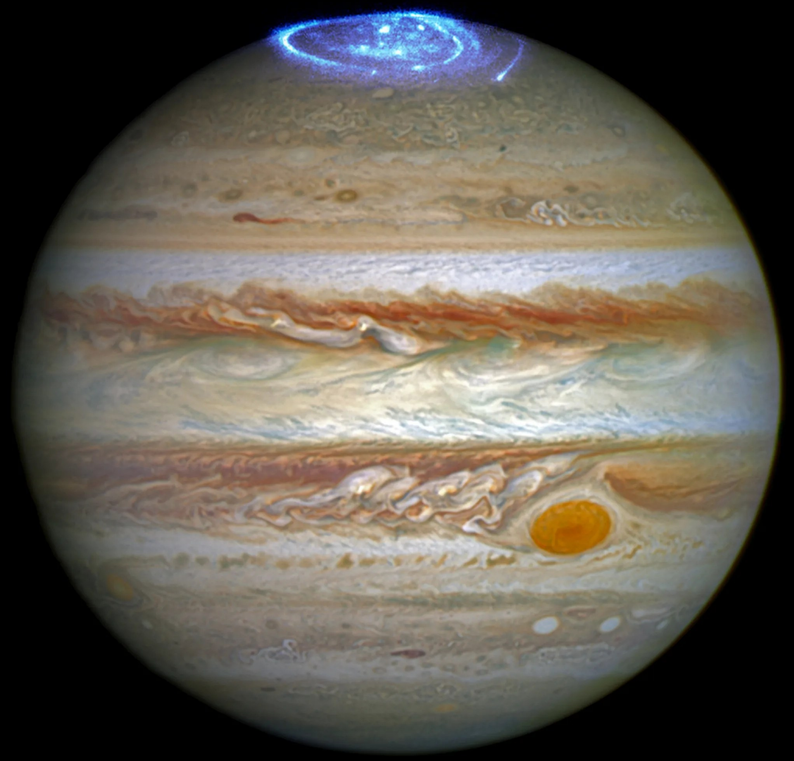
adapted from Barnes & Heller 2013

THREE MODELS FOR UV OF BROWN DWARFS

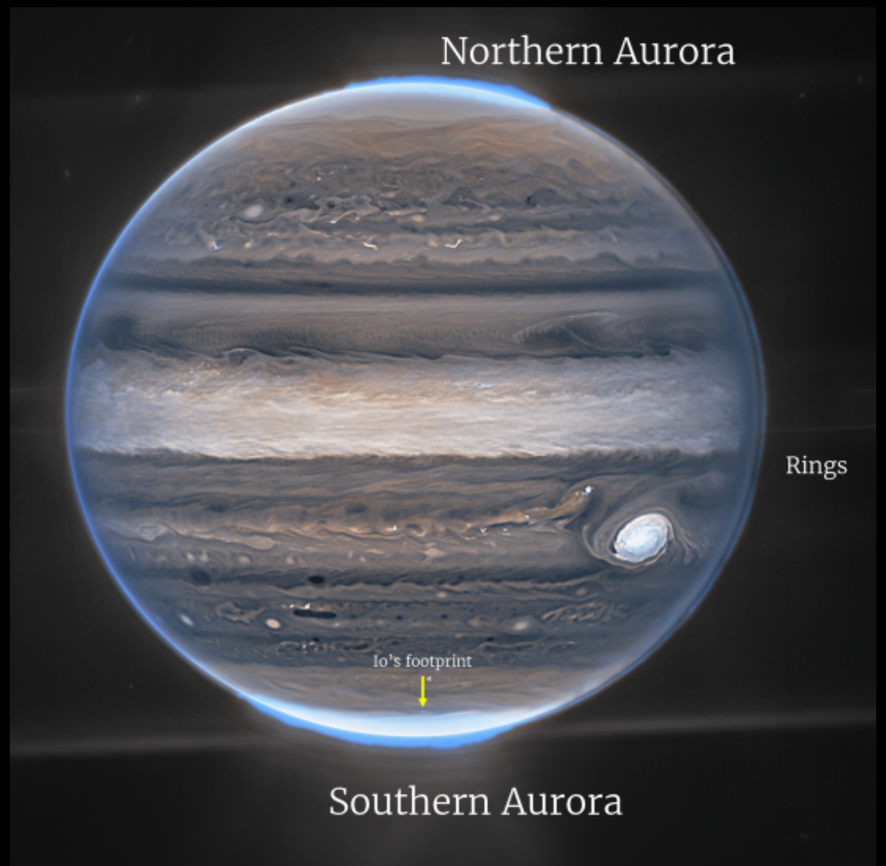
1) PHOENIX PHOTOSPHERE ONLY, NO EXCESS UV

2) JUPITER AURORA UV MODEL FOR BROWN DWARFS

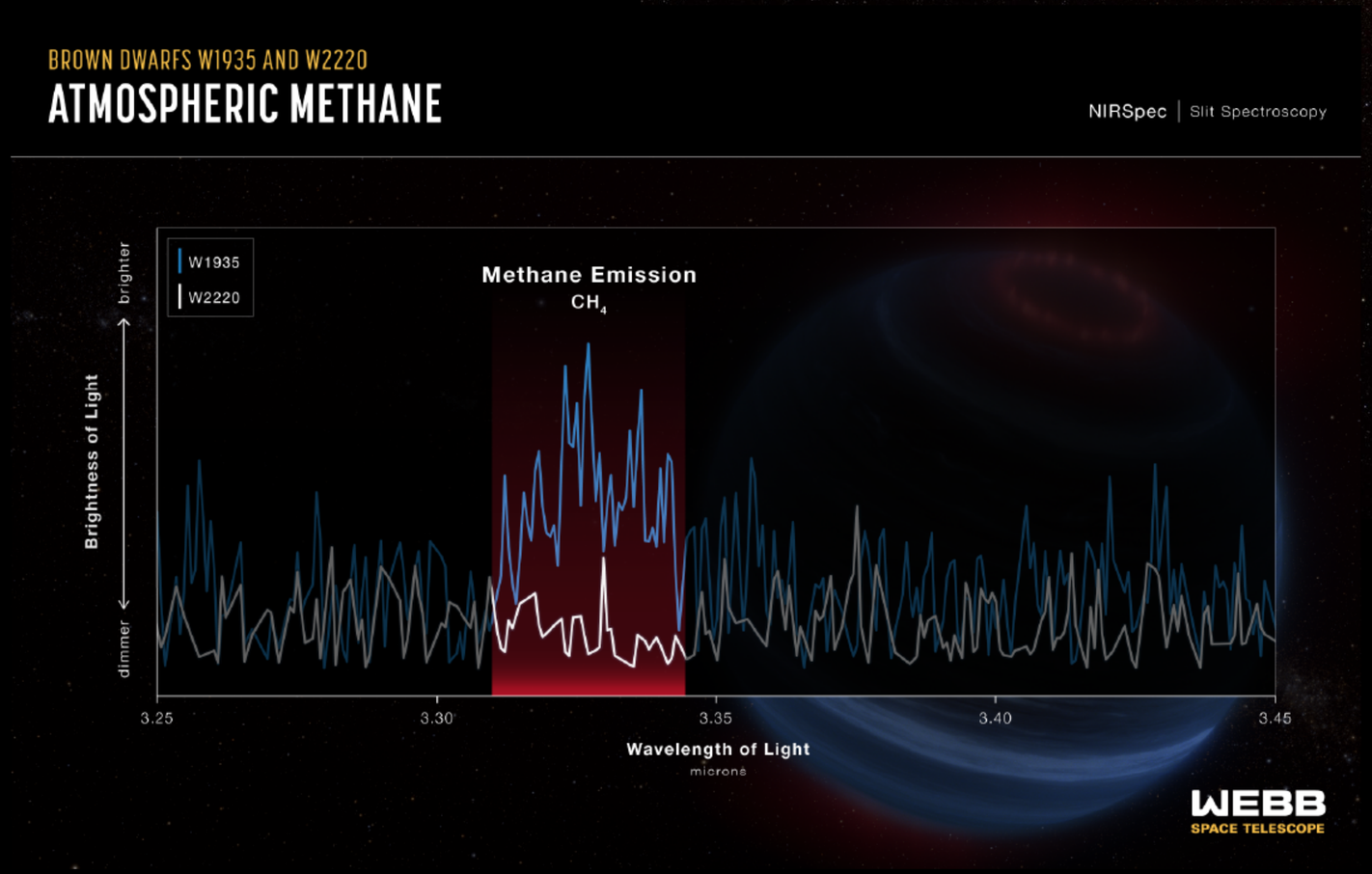
HST JUPITER AURORA

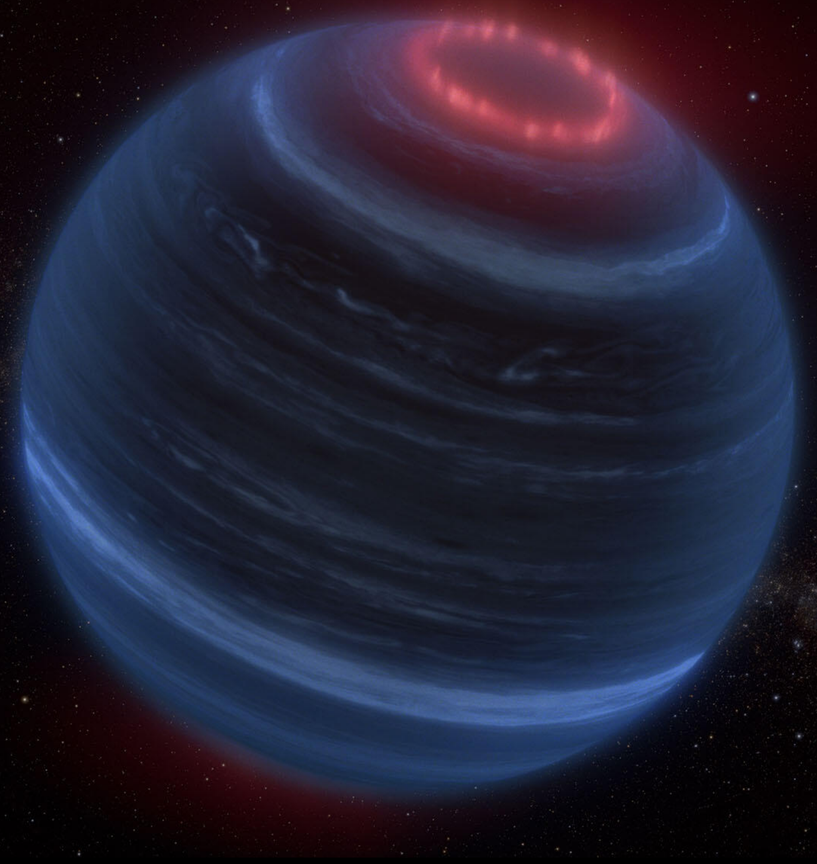


JWST JUPITER AURORA



METHANE EMISSION IN W1935: EVIDENCE OF AURORA ON A COOL BROWN DWARF

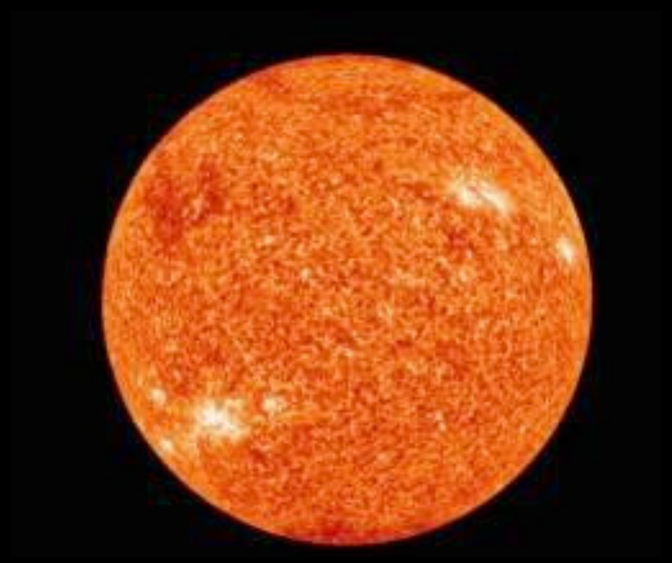




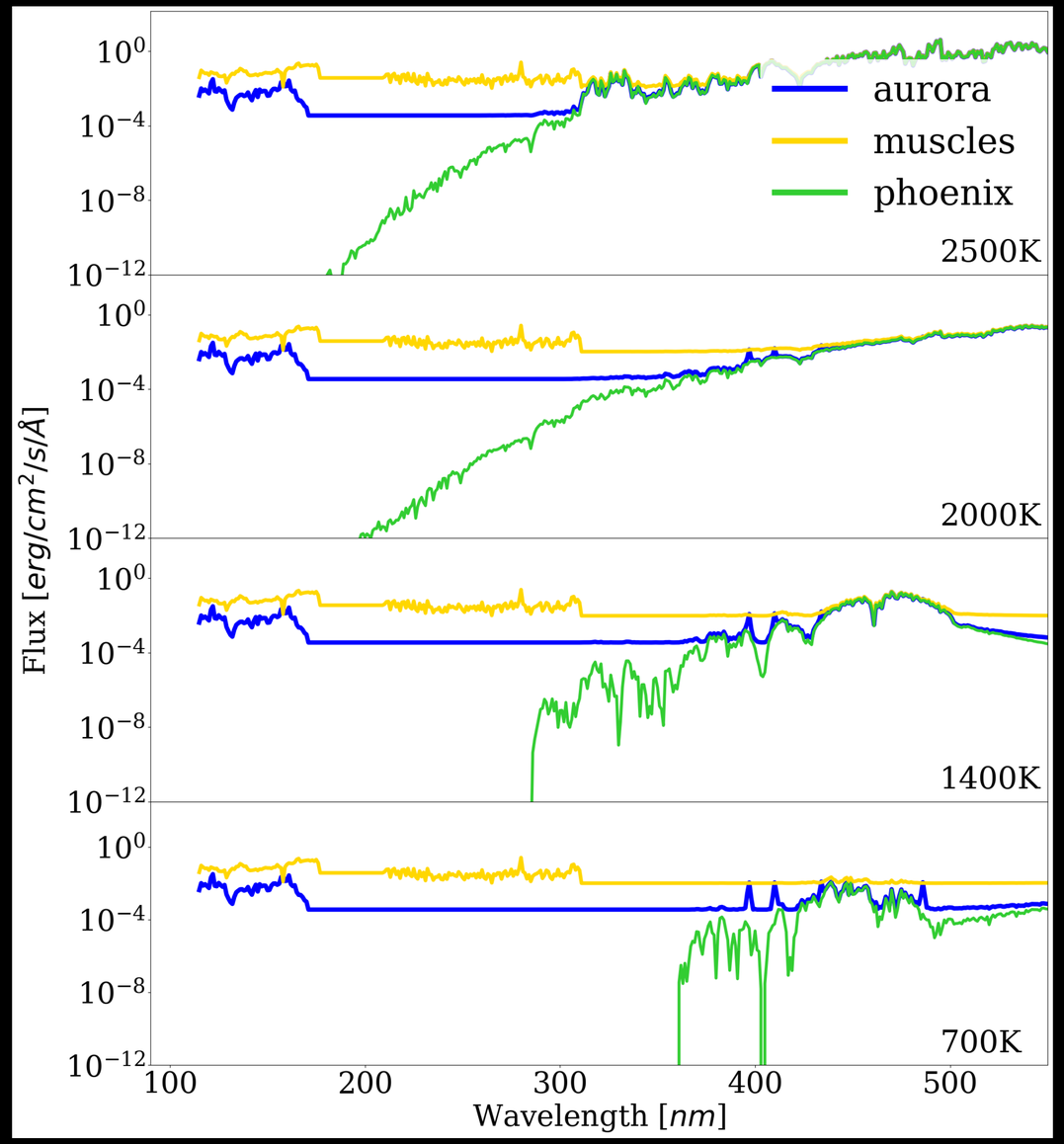
Faherty et al. 2024

Visual: NASA, ESA, CSA, Leah Hustak (STScI)

3) EXTRAPOLATING UV FROM MUSCLES QUIESCENT M DWARF (GJ 1214)

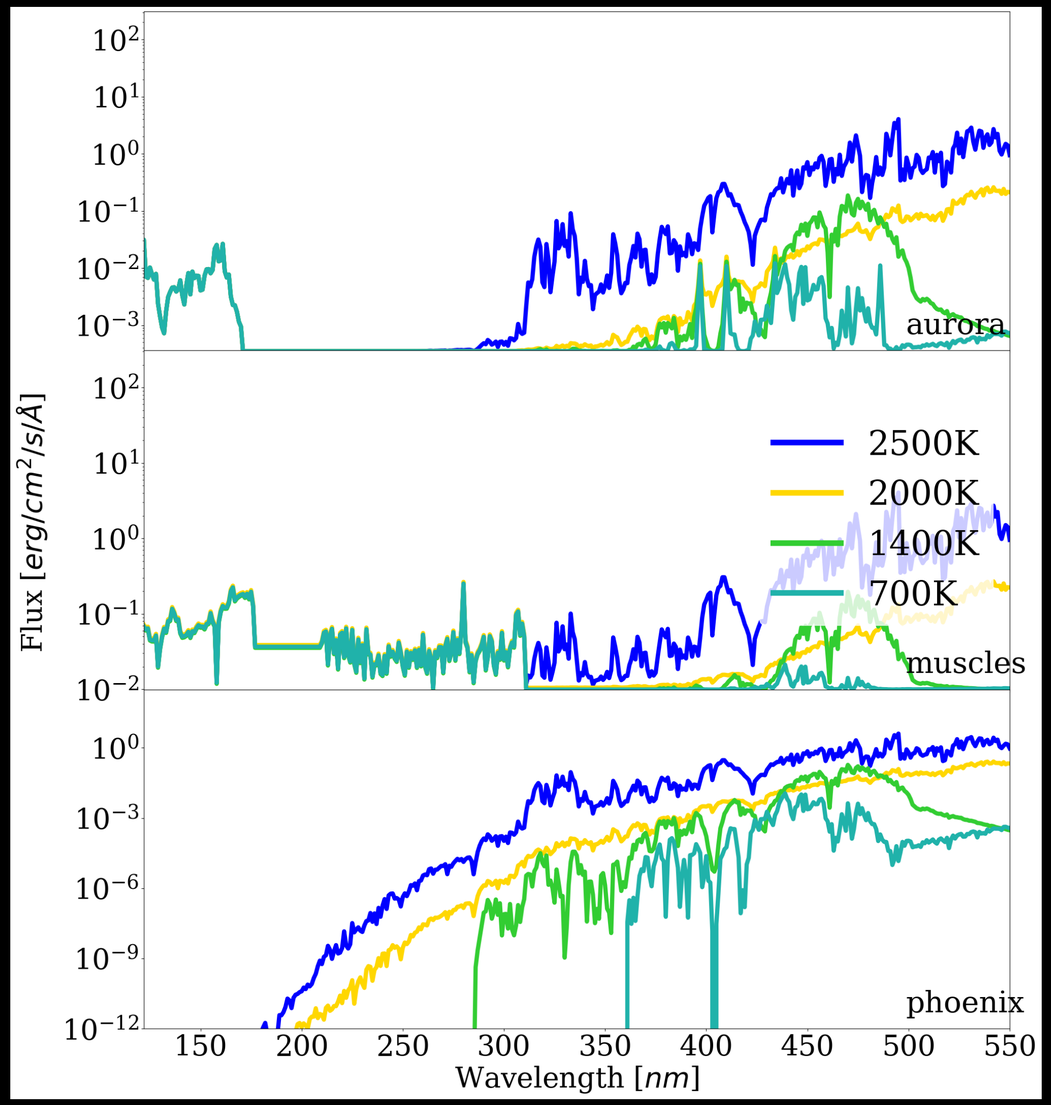


THREE UV MODELS WITH 4 BROWN DWARF TEMPURATURES



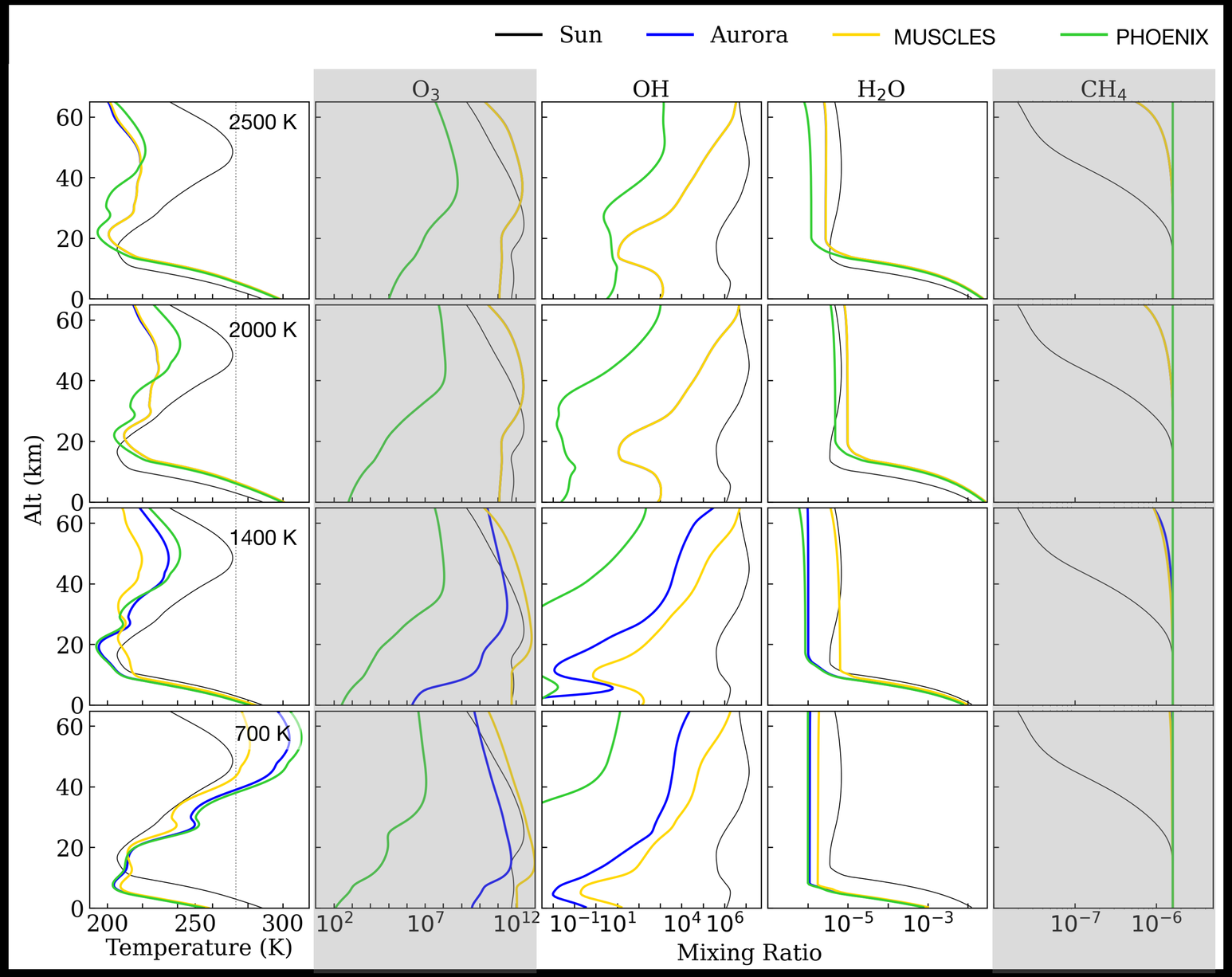
Parsons, Rugheimer et al in prep

BROWN DWARFS STEADILY COOL AS THEY AGE
PROGRESSION OF UV FOR EACH MODEL



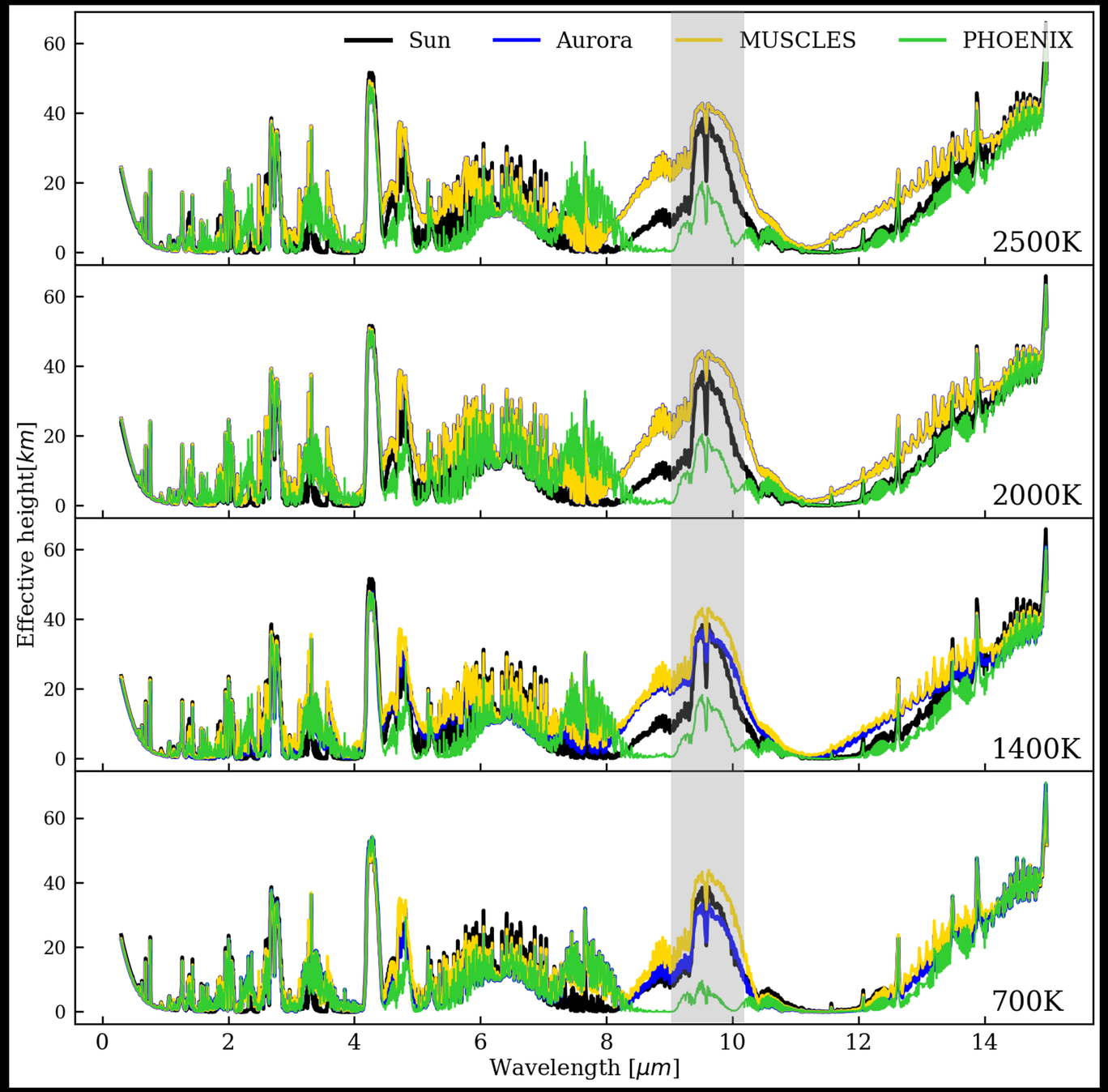
Parsons, Rugheimer et al in prep

*PRELIMINARY EARTH-LIKE ATMOSPHERE RESULTS



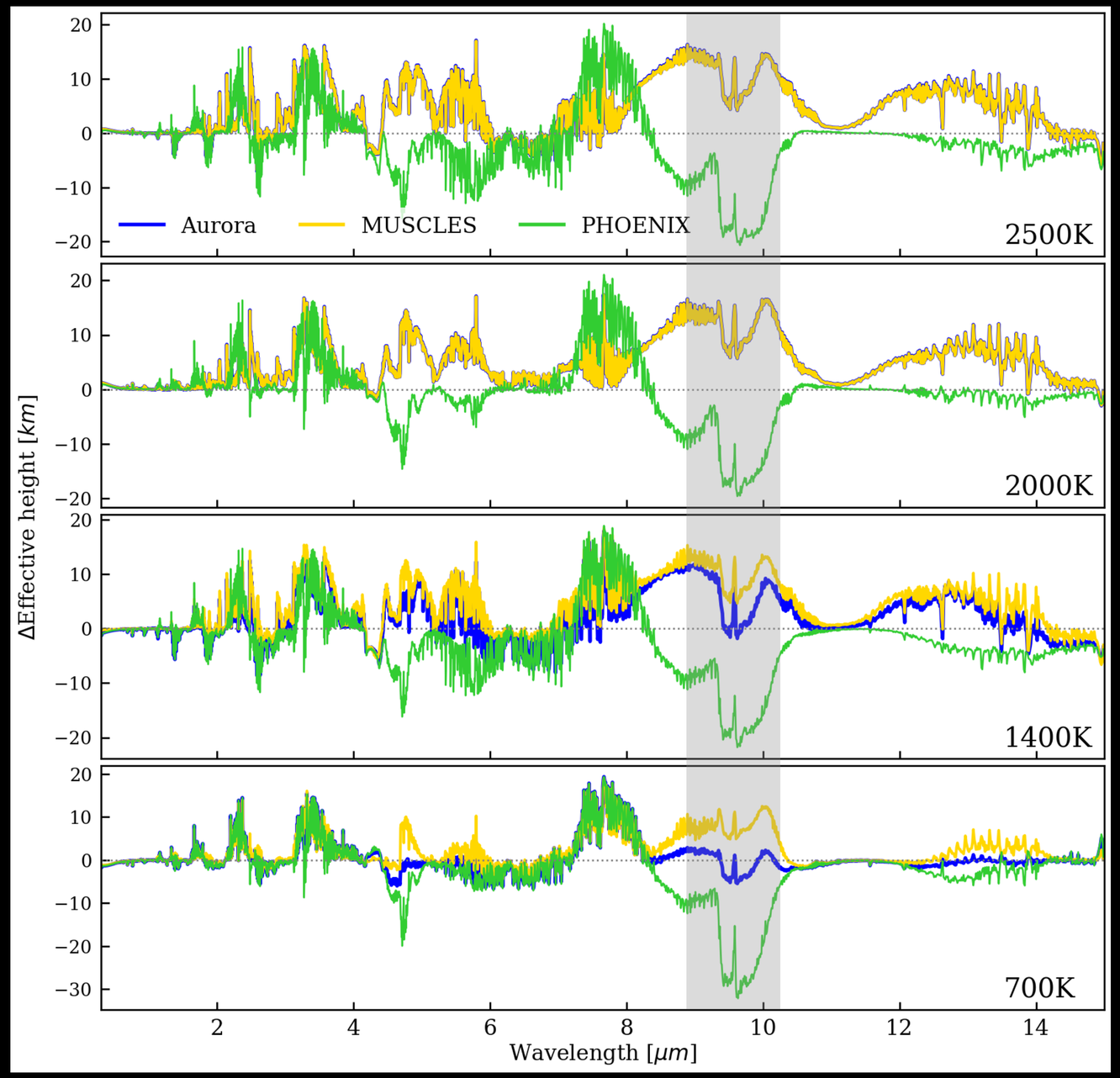
Parsons, Rugheimer et al in prep

HYPOTHETICAL TRANSMISSION SPECTRA FOR AN EARTH ORBITING A BROWN DWARF AND THE SUN



Parsons, Rugheimer et al in prep

DIFFERENCE IN TRANSMISSION EFFECTIVE HEIGHT COMPARED TO THE SUN



Parsons, Rugheimer et al in prep

LIFE

LARGE INTERFEROMETER FOR EXOPLANETS

LIFE shall obtain **thermal emission spectra** with sufficient spectral resolution, wavelength coverage and sensitivity to investigate **at least 30 (requirement) / 50 (goal) extrasolar planets** with r*adii between 0.5 and 1.5 Earth radii and receiving between 0.35 and 1.7 times the insolation of the Earth* in order to assess **their diversity, habitability and search for biomarkers.**

LIFE Project Steering Board

PI

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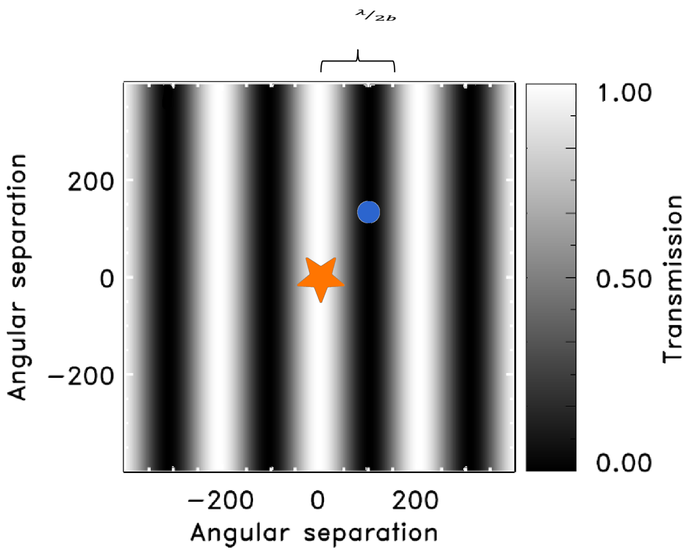
Hendrik Linz

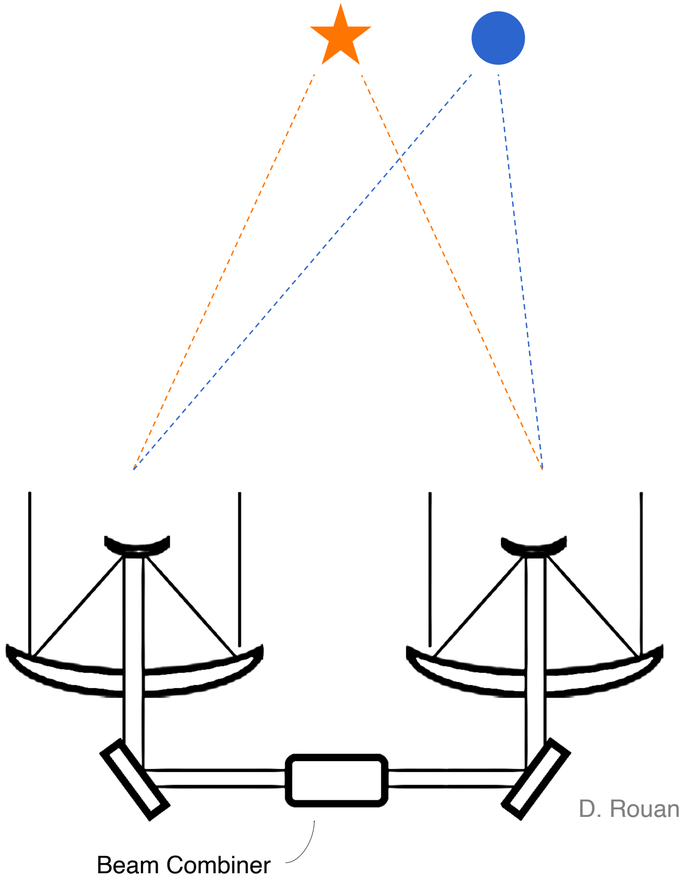
Denis Defrere

Nulling Interferometry

in a Nutshell



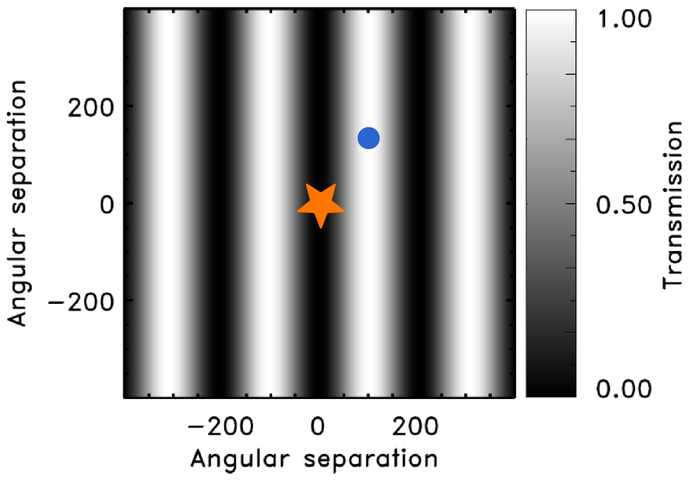
Imaging
Interferometer



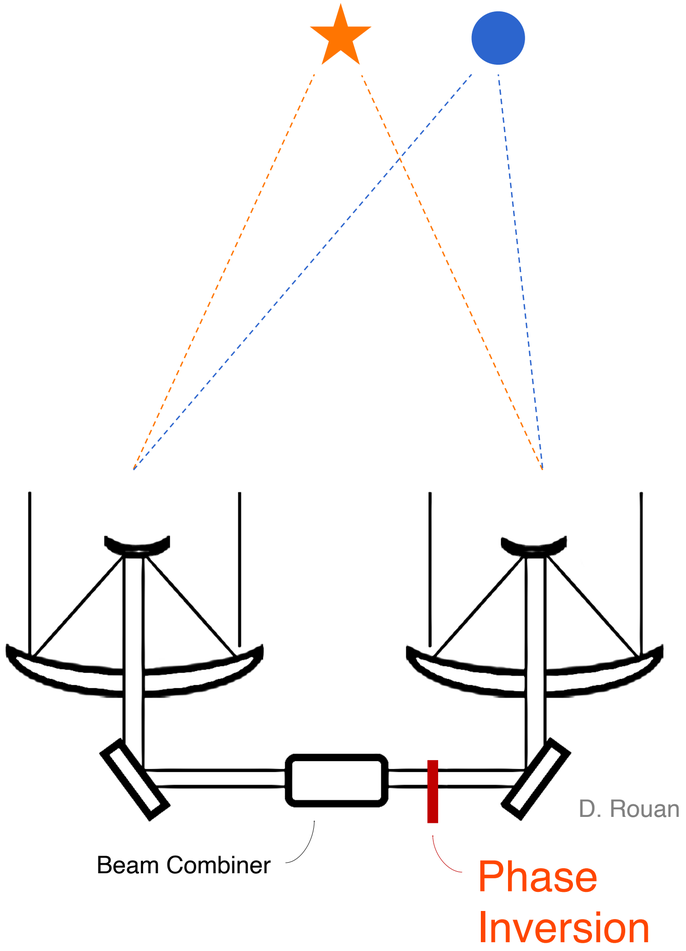
D. Rouan

Nulling Interferometry

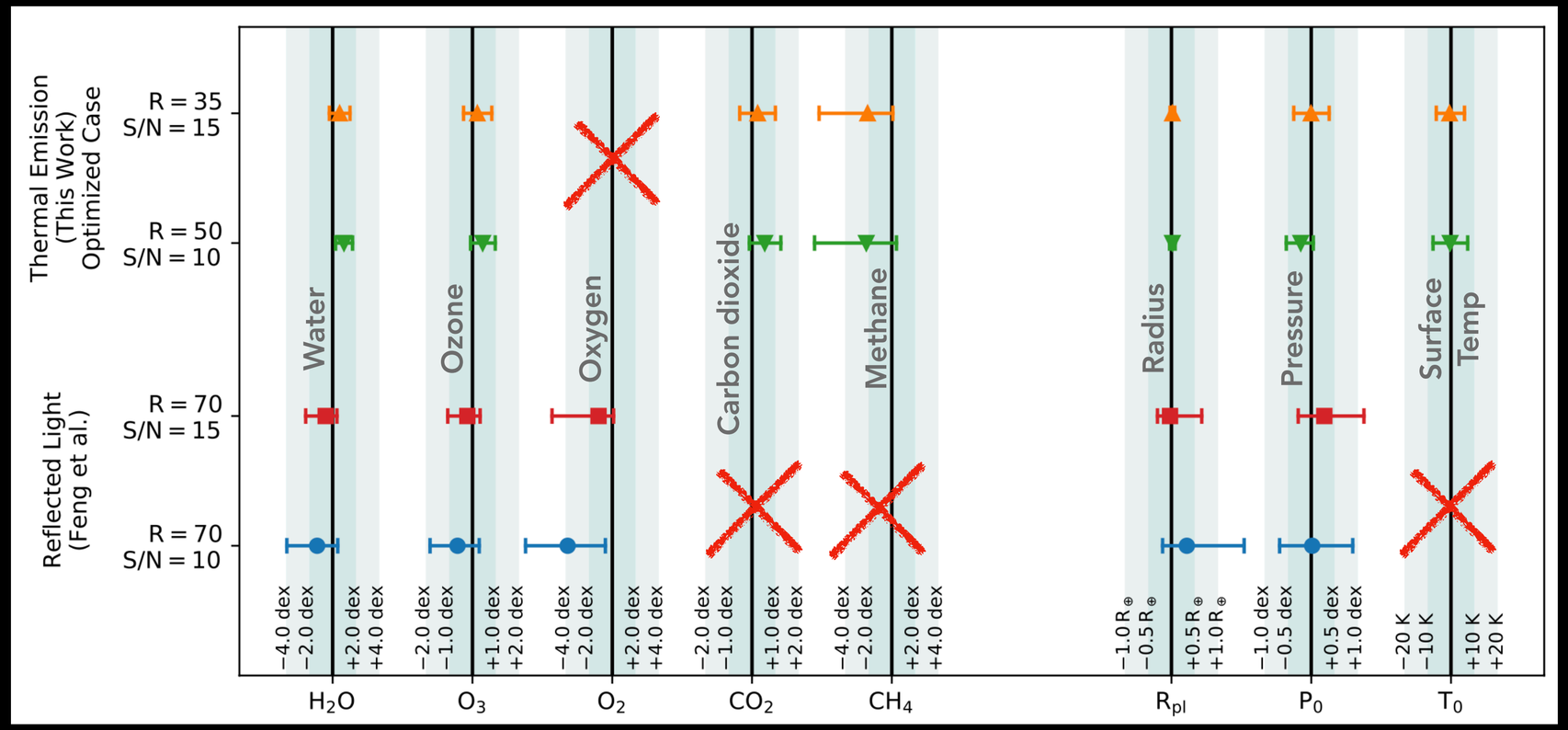
in a Nutshell

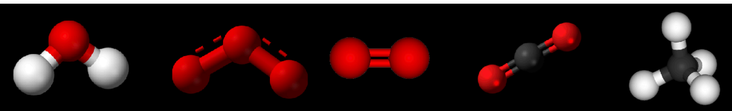


Nulling
Interferometer



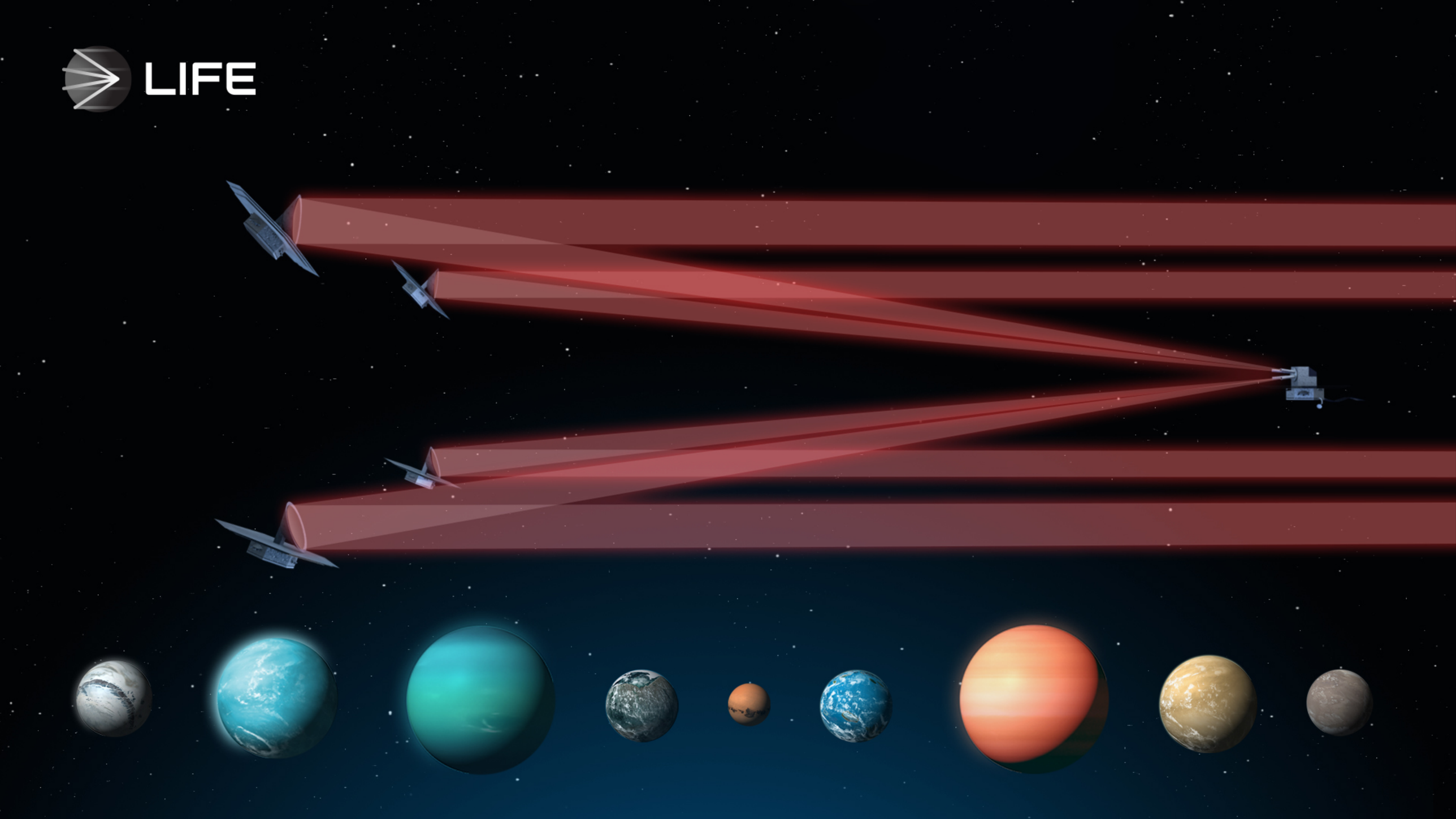
Complementary Missions:





LIFE needs a minimum S/N of 10 and R = 35 or ideally 50, 4 - 17.5 μm (3-20μm ideally)
And compared to HWO get CO_2, CH_4 and T_{surf} but can't get O_2

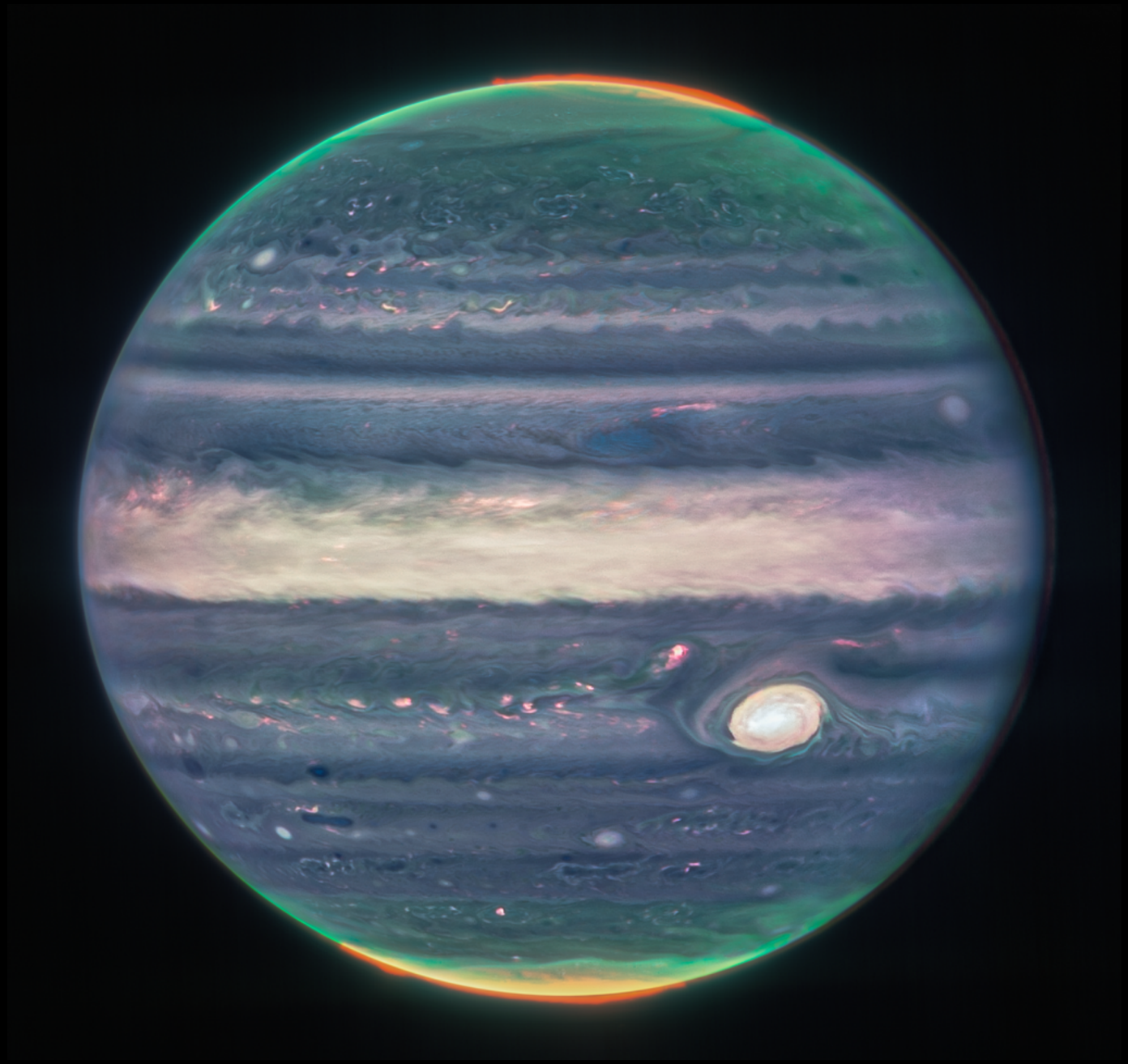
Konrad et al. 2022


LIFE

BROWN DWARFS MIGHT HAVE HABITABLE PLANETS

THEIR UV ENVIRONMENTS MAY VARY SUBSTANTIALLY

KNOW THEY UV, KNOW THY PLANET

LIFE IS A COOL MISSION CONCEPT YOU SHOULD FOLLOW

QUESTIONS?