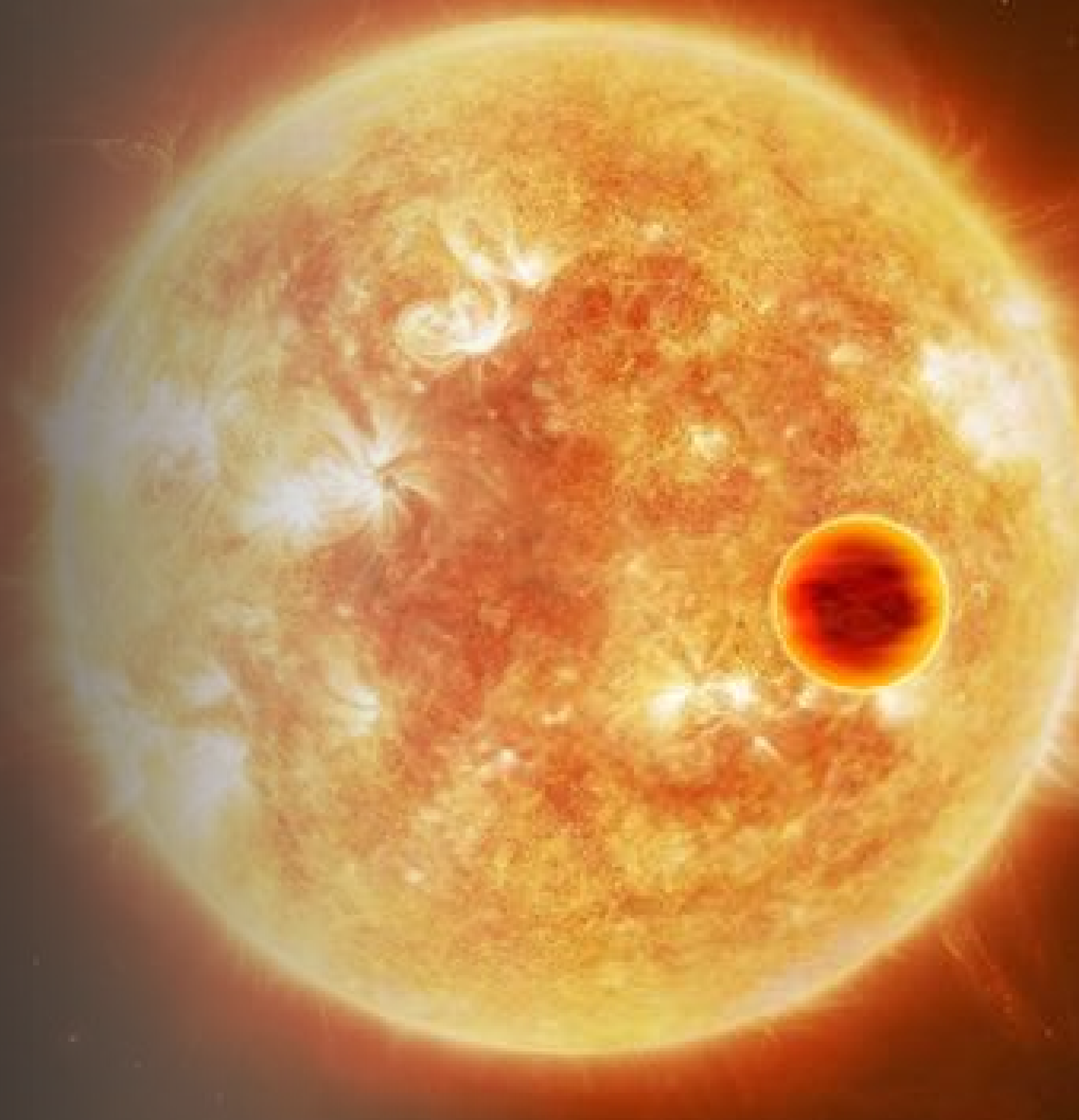
Exploring Rocky Worlds: On the Precipice of a New Frontier

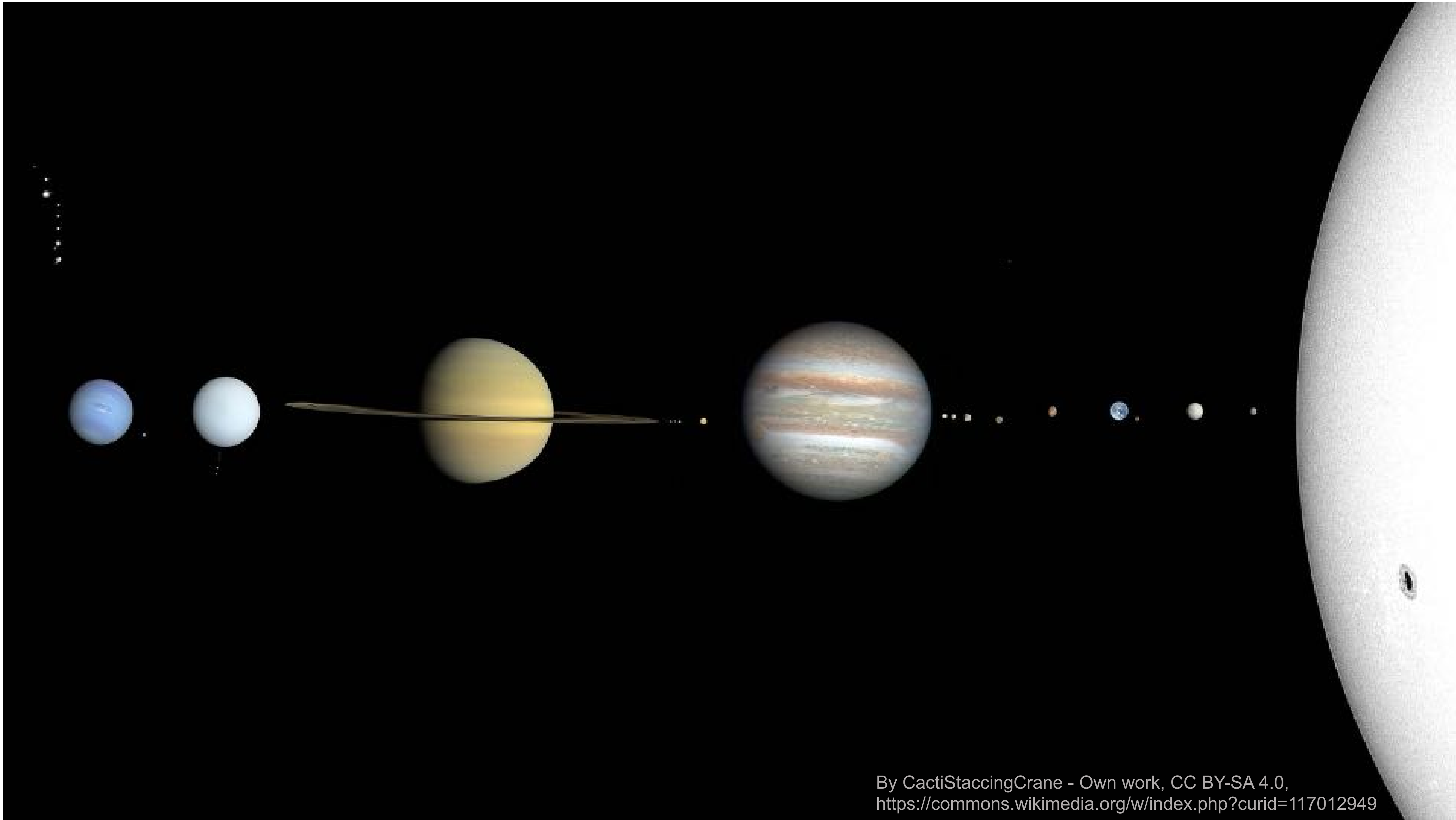
Katie Bennett

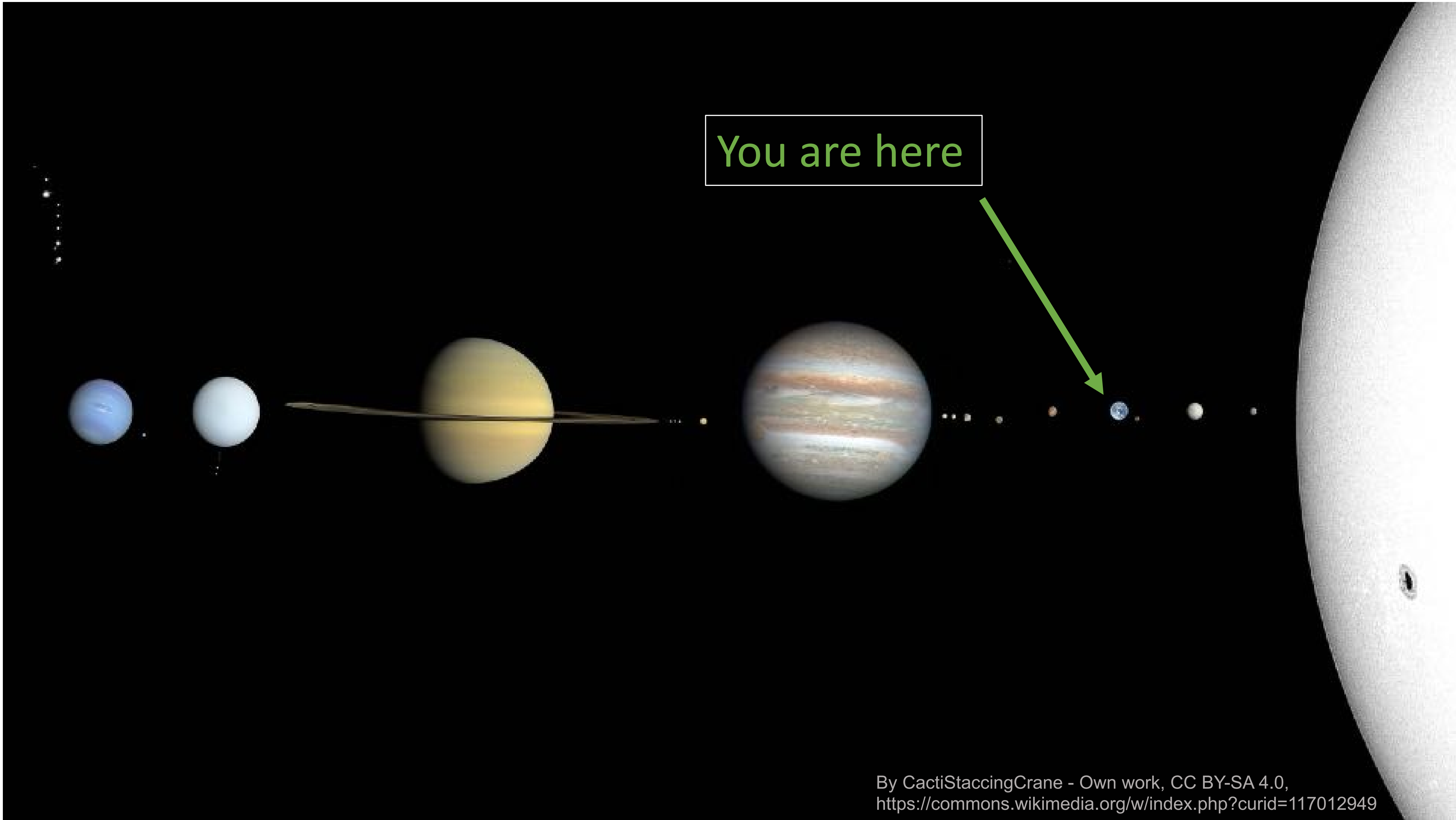
Ph.D. Student

Johns Hopkins University



NASA, ESA, CSA, and STScI

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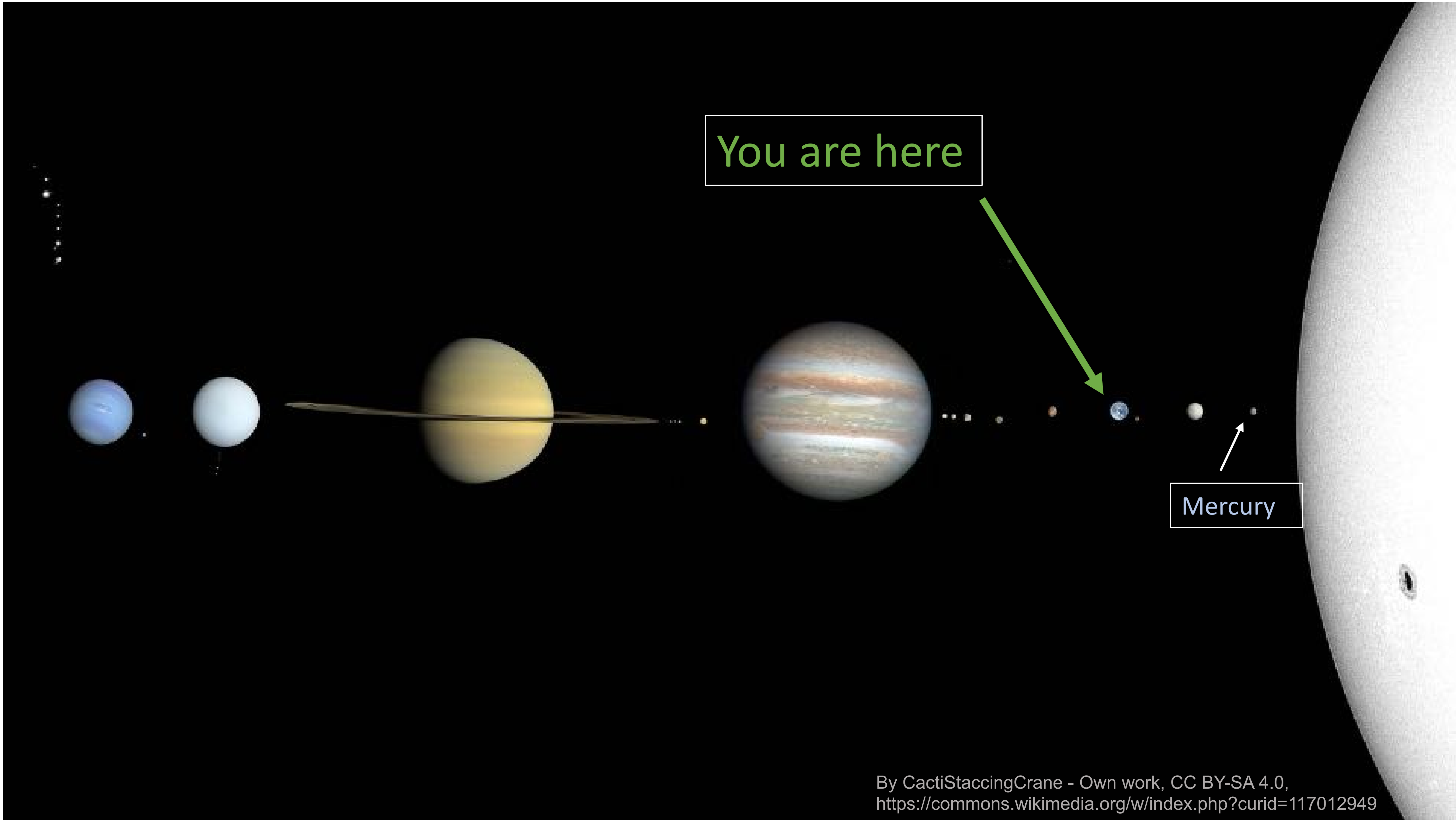
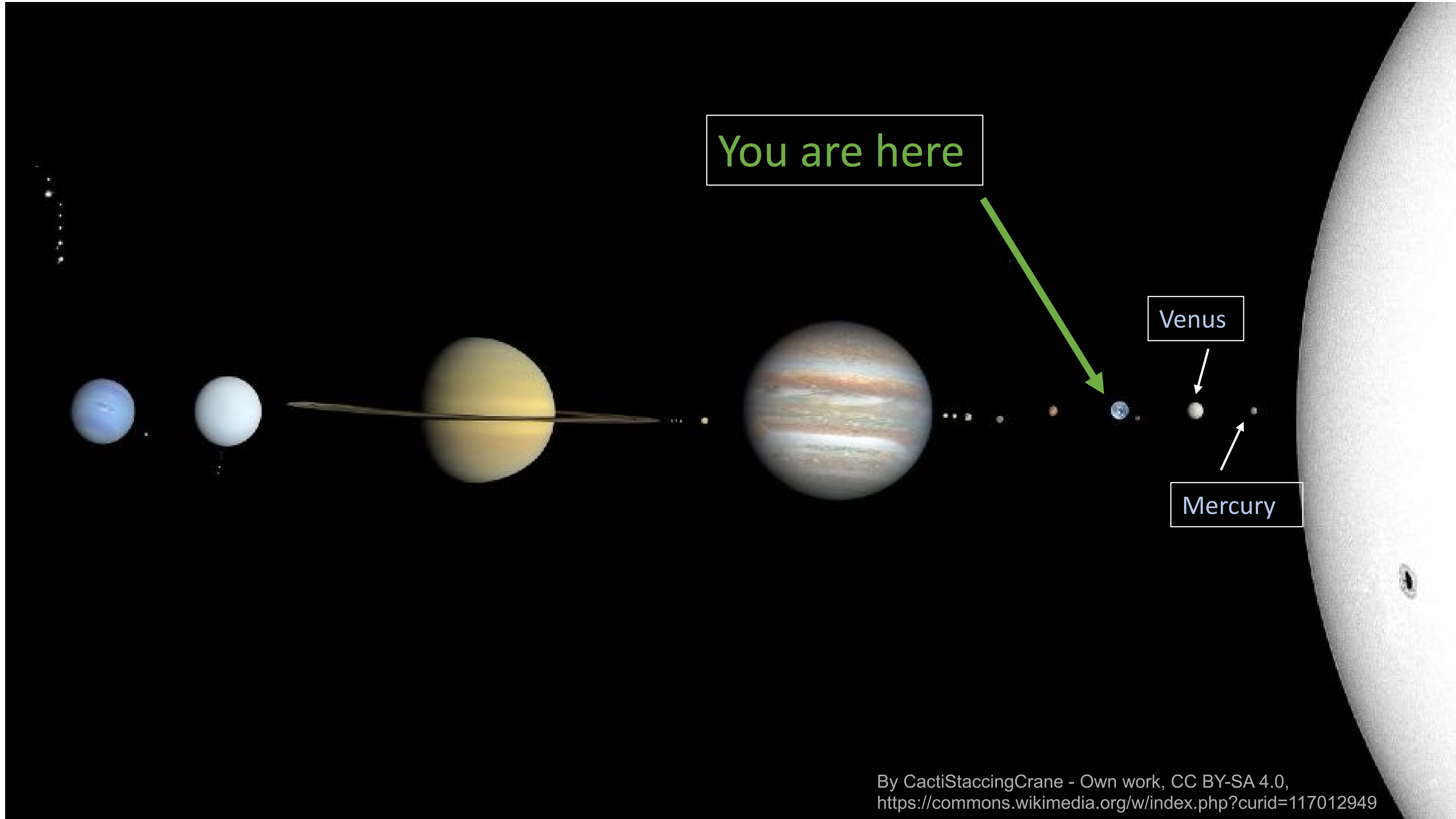
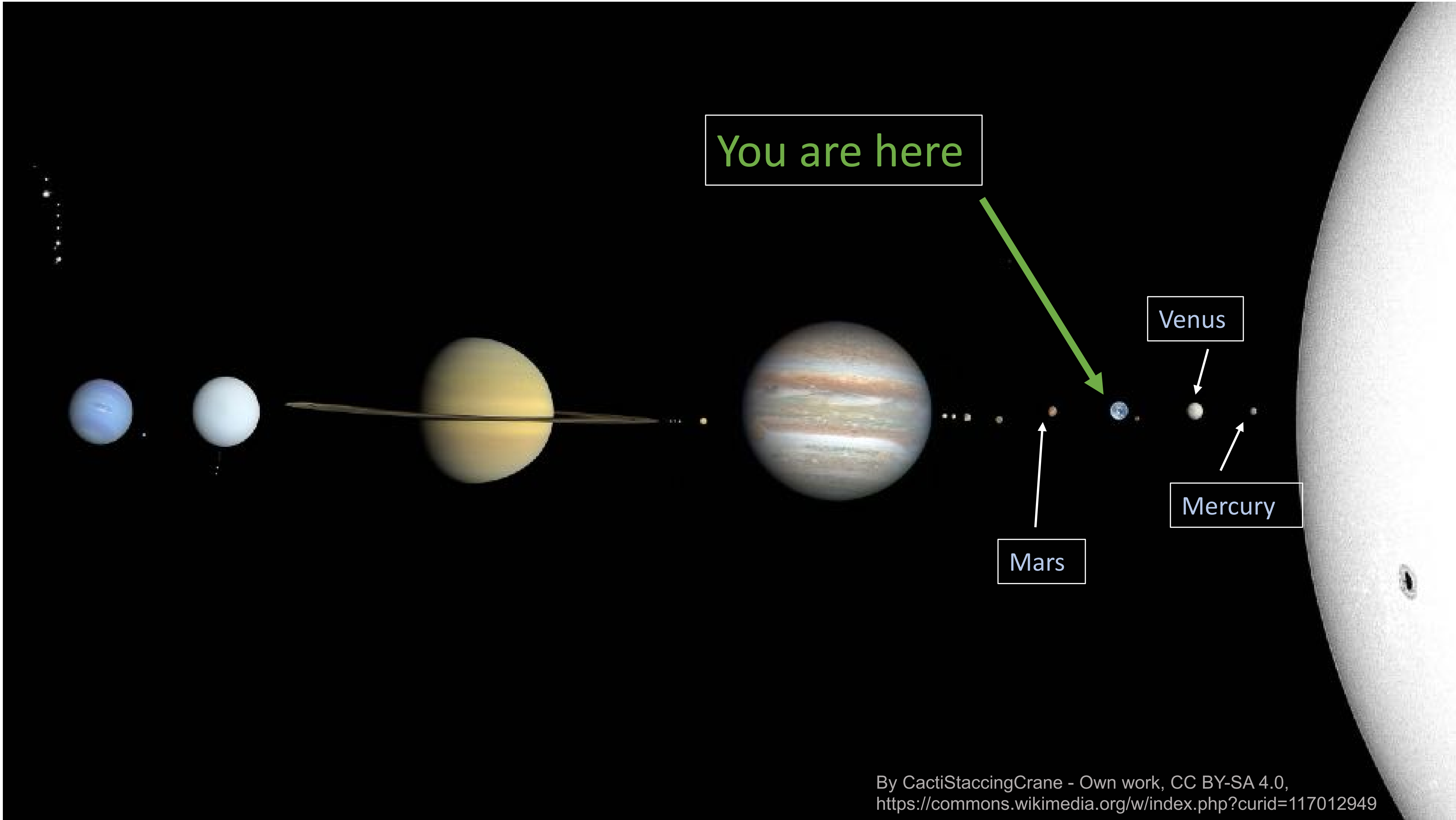

You are here
Mercury


You are here
Venus
Mercury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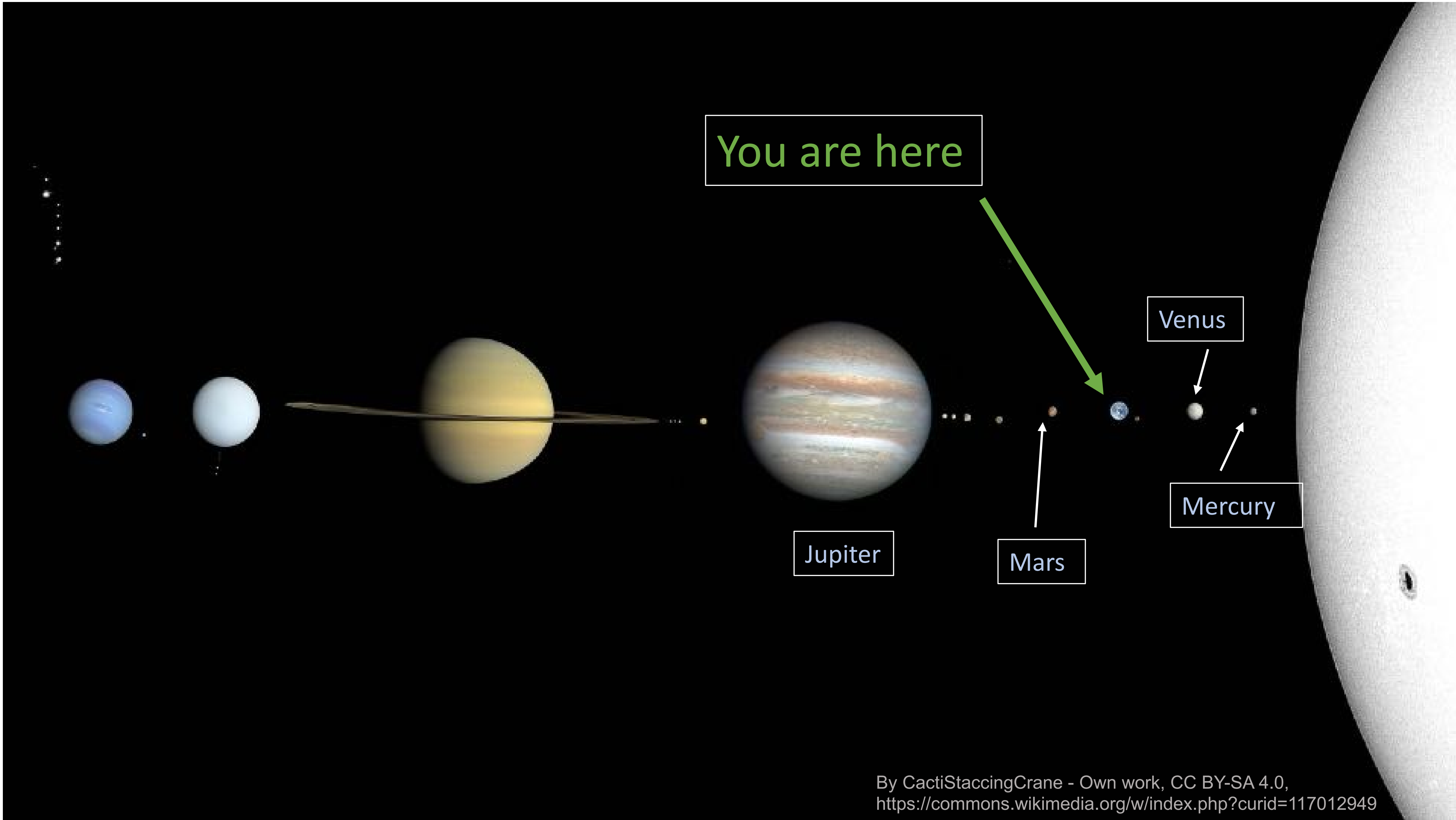
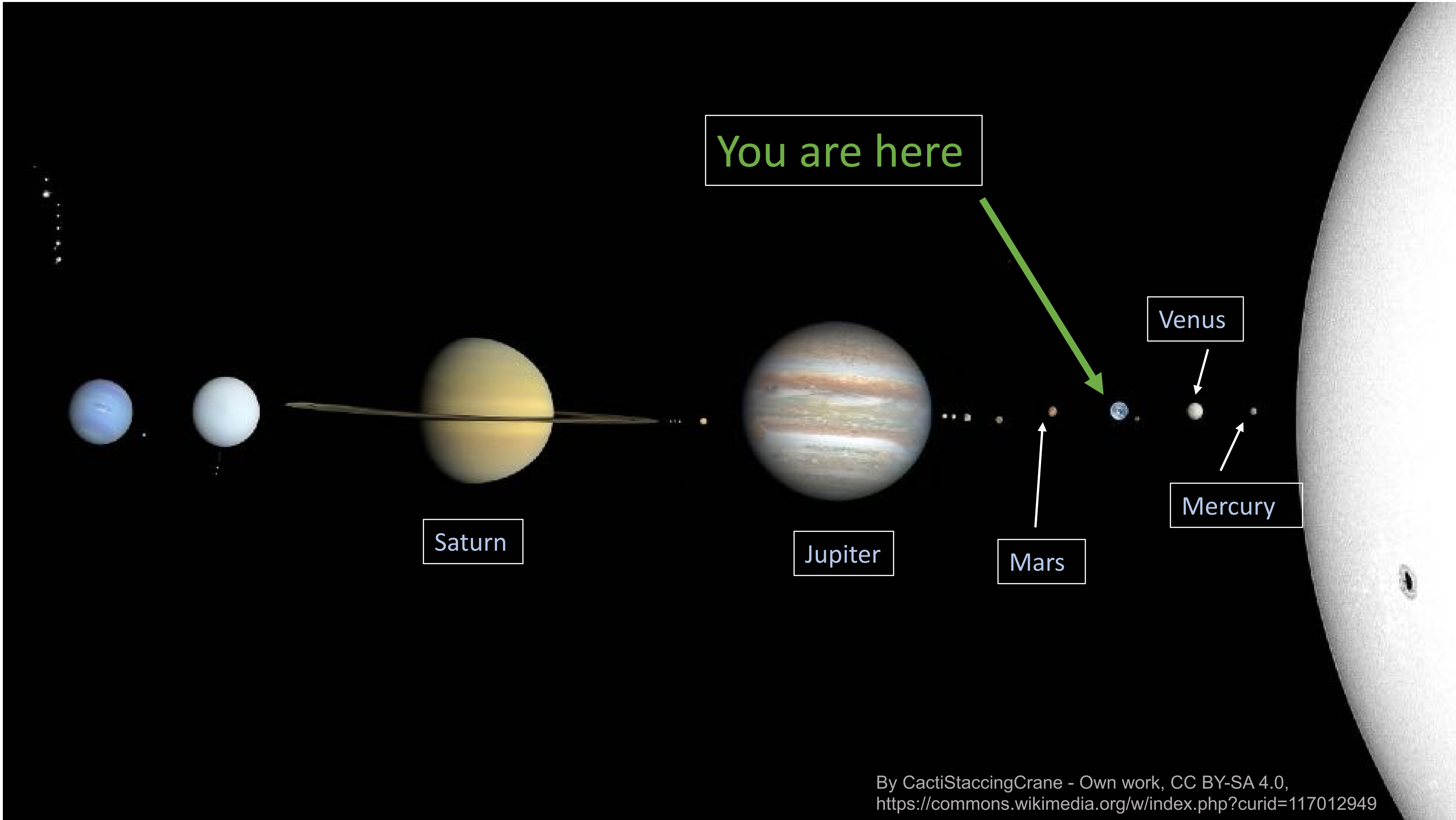
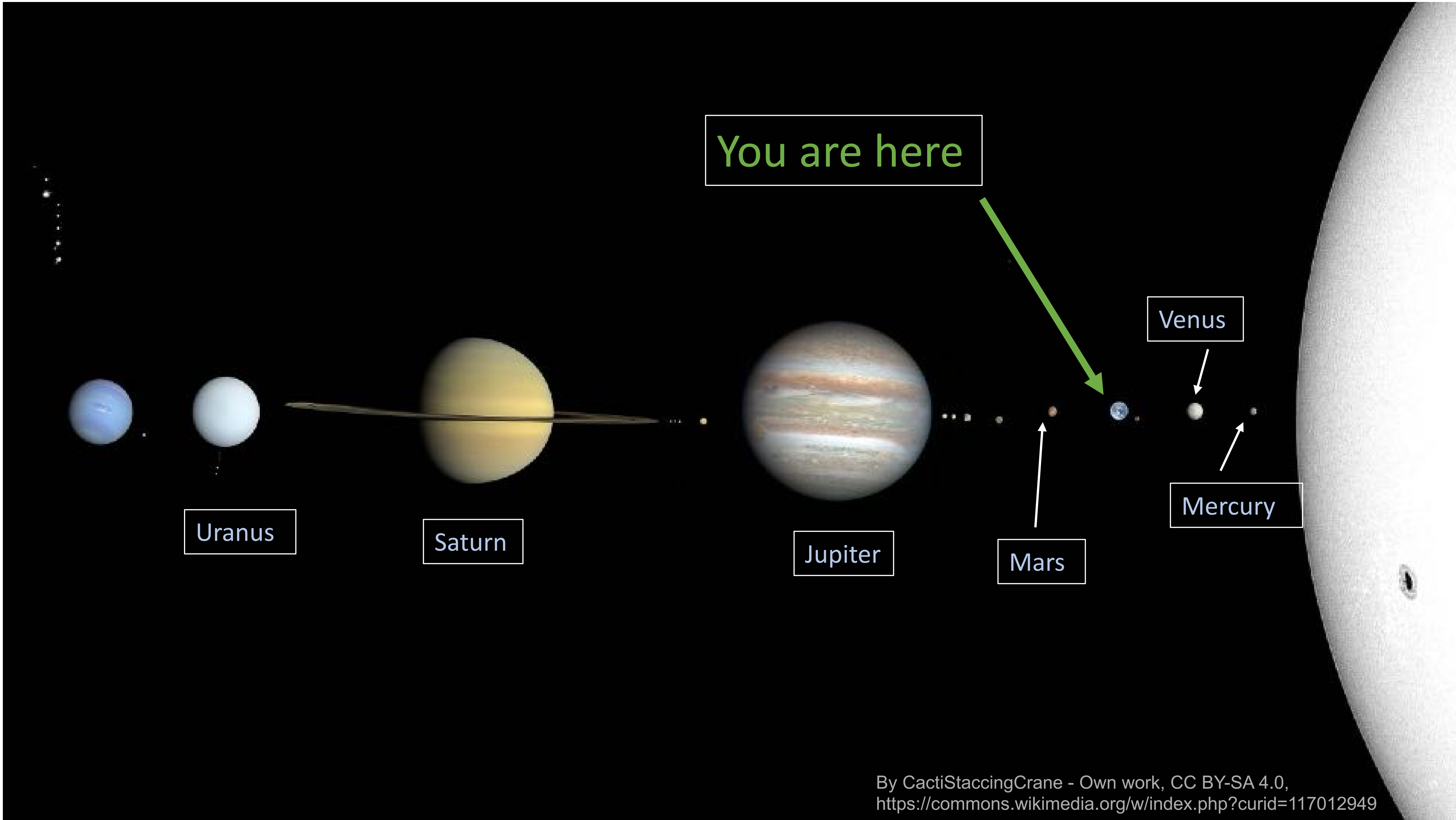
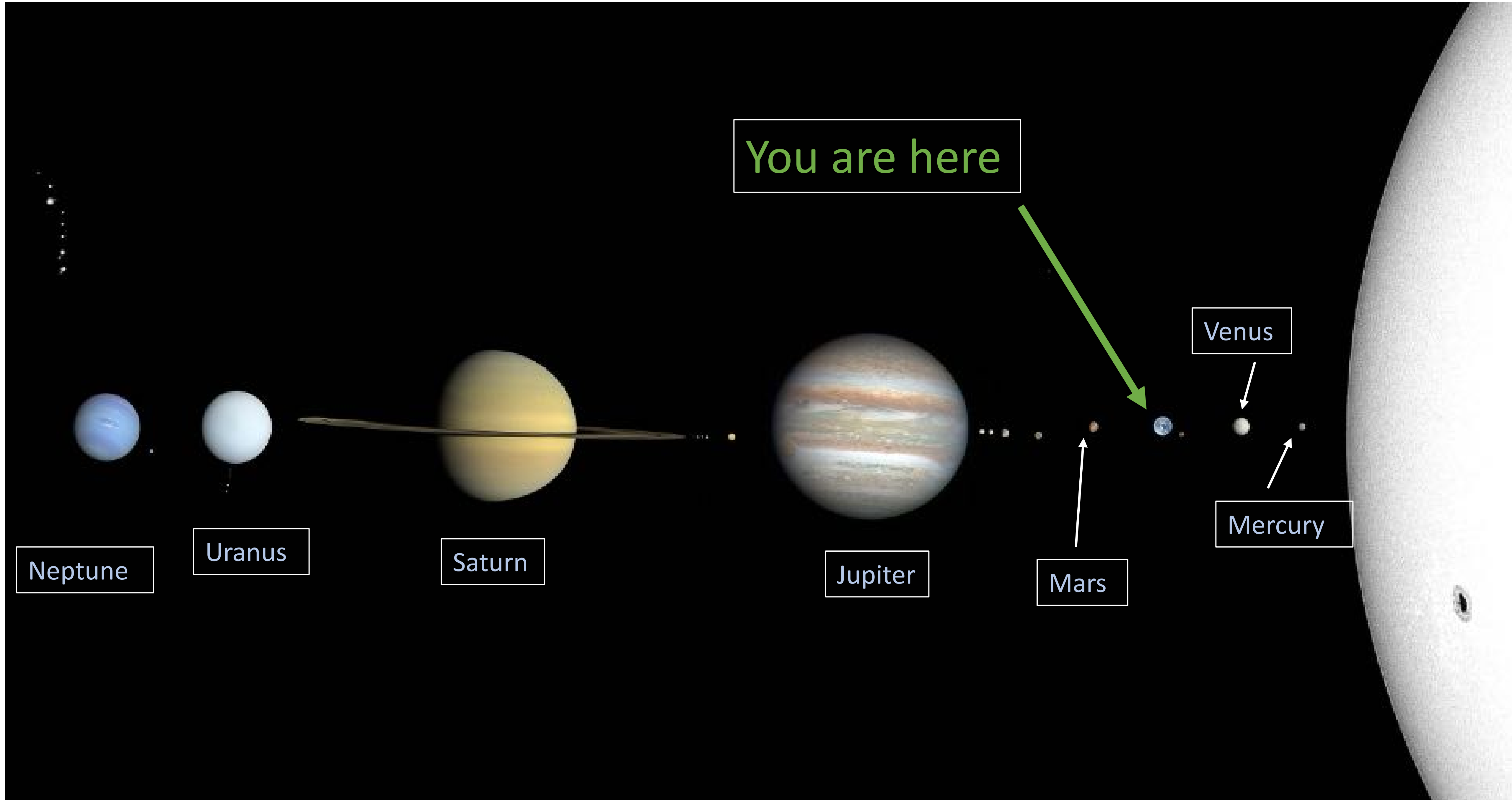
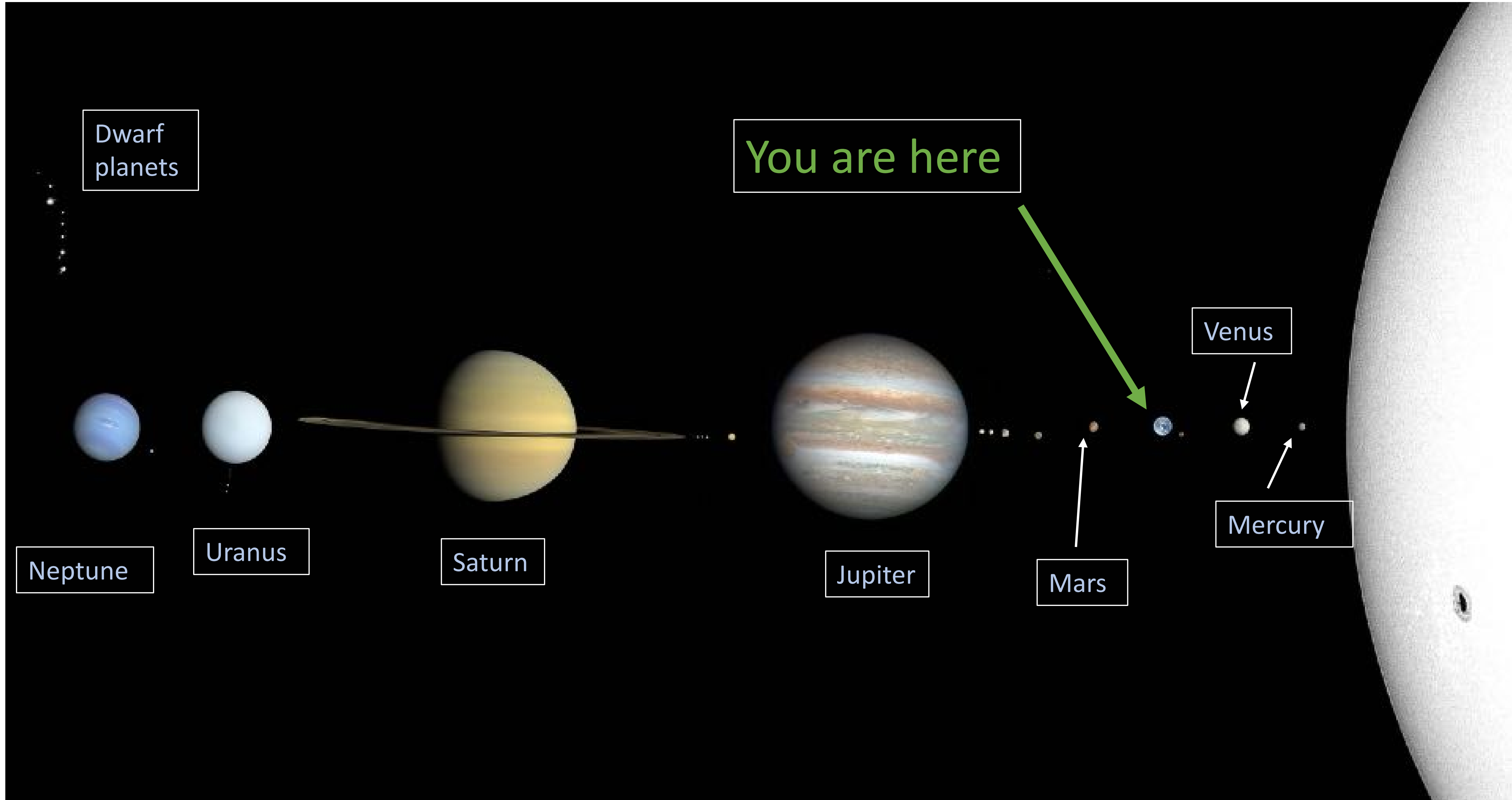
Venus
Mercury
Mars

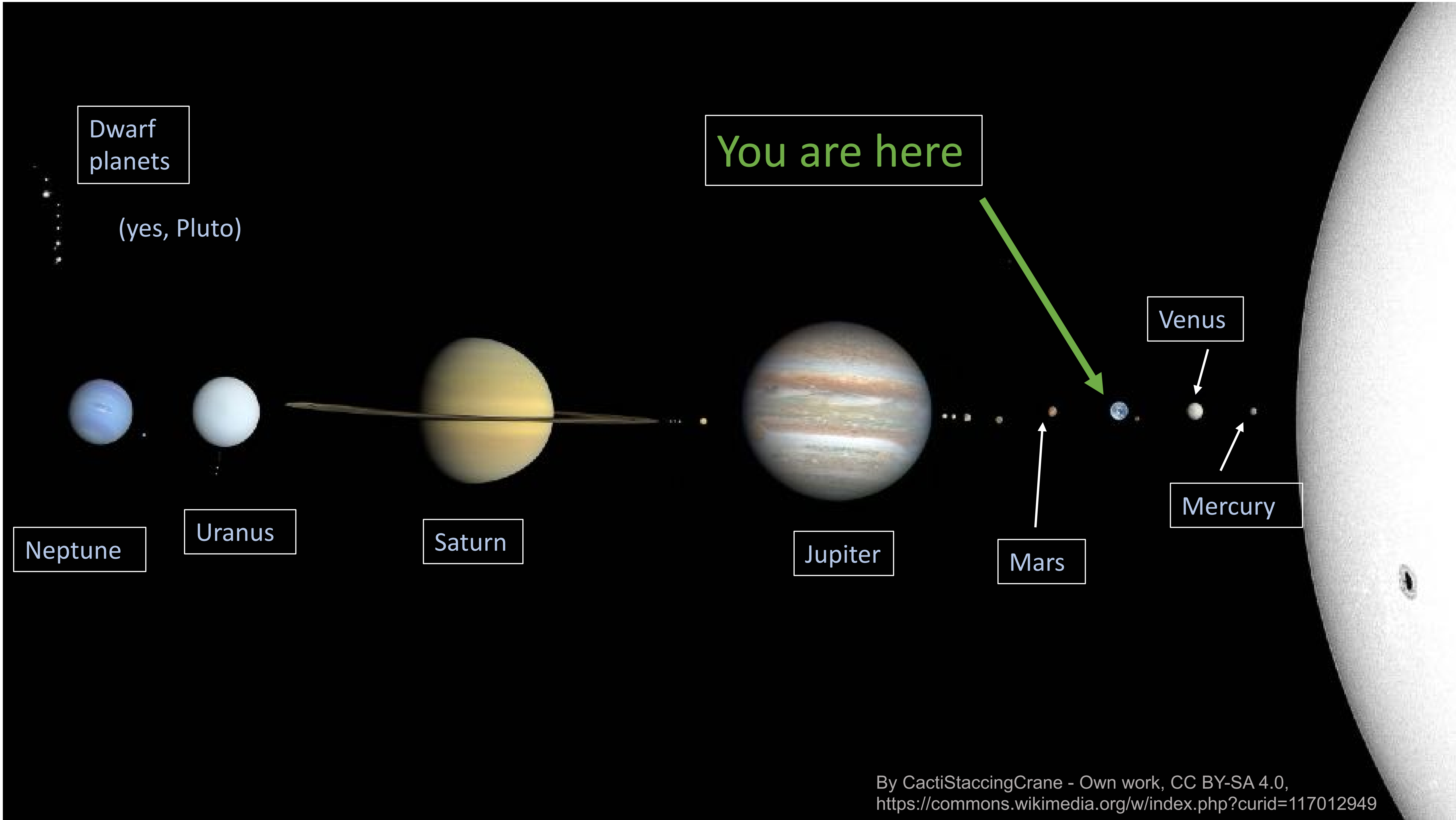

You are here
Venus
Jupiter
Mars
Mercury


You are here
Venus
Saturn
Jupiter
Mars
Mercury


You are here
Venus
Uranus
Saturn
Jupiter
Mars
Mercury

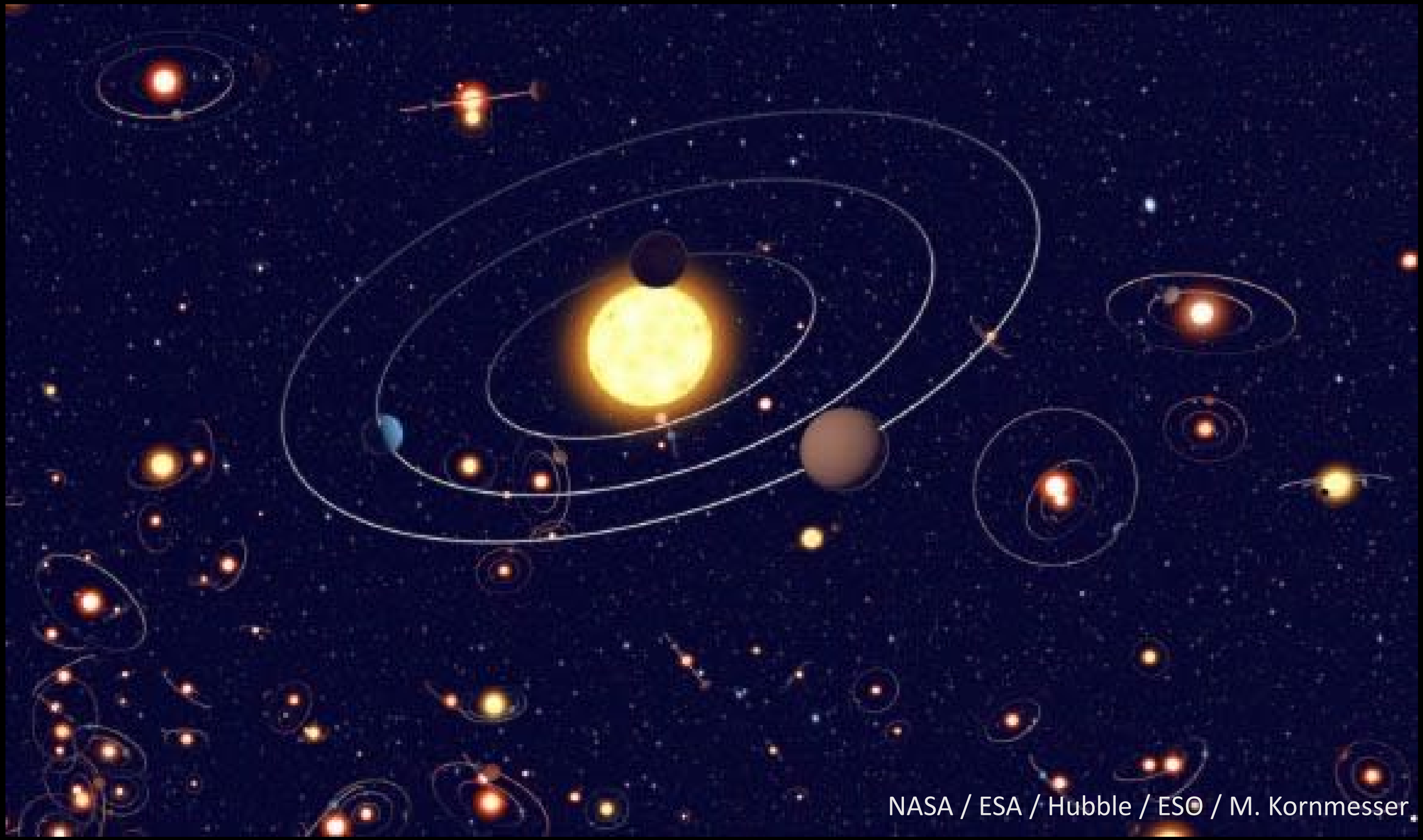

You are here
Venus
Mercury
Mars
Jupiter
Saturn
Uranus
Neptune


Dwarf planets
You are here
Venus
Mercury
Neptune
Uranus
Saturn
Jupiter
Mars

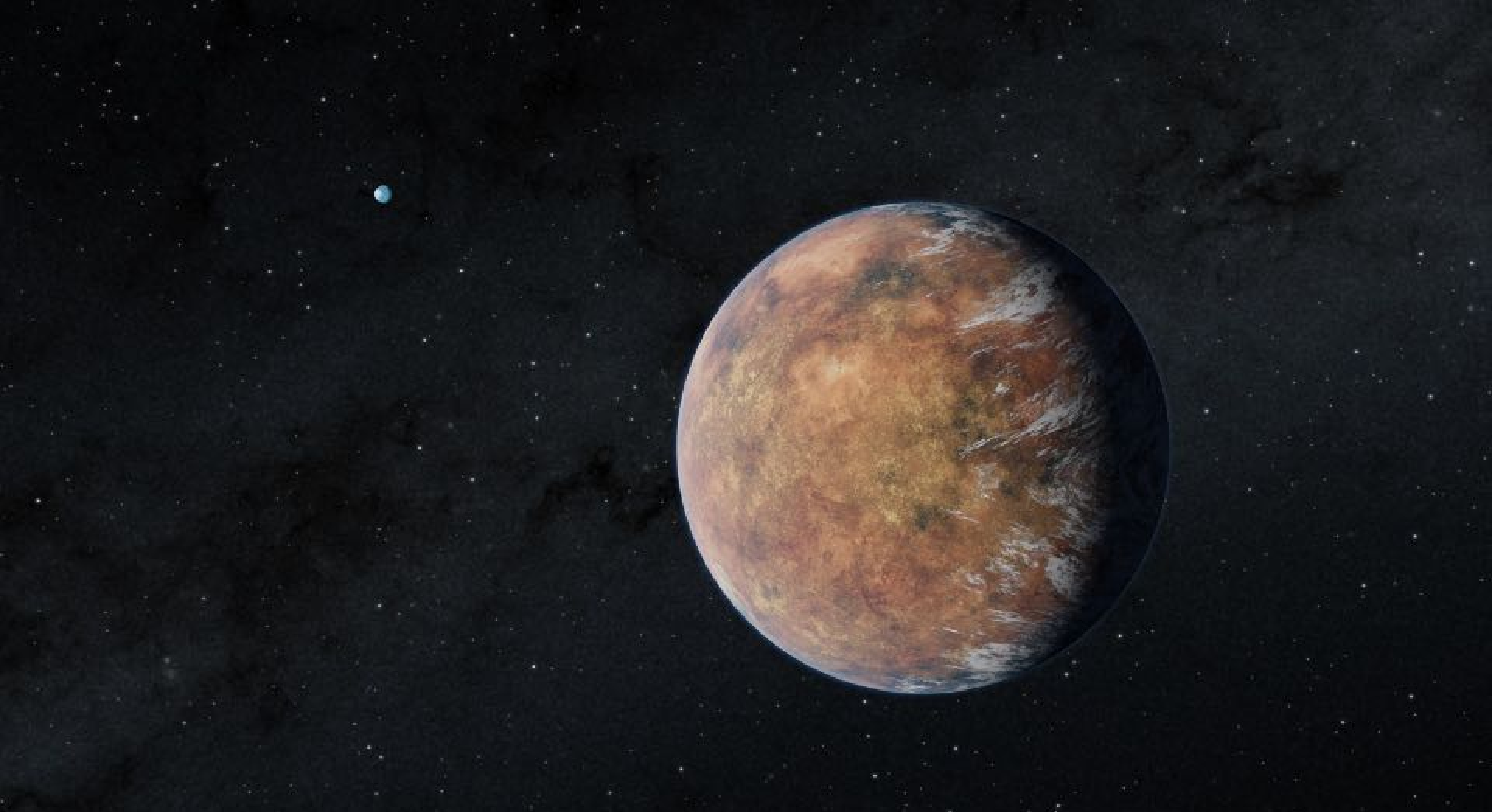

Dwarf
planets
(yes, Pluto)
You are here
Venus
Mercury
Neptune
Uranus
Saturn
Jupiter
Mars

Amazon, Poster Foundry


NASA, ESA, CSA, and STScI

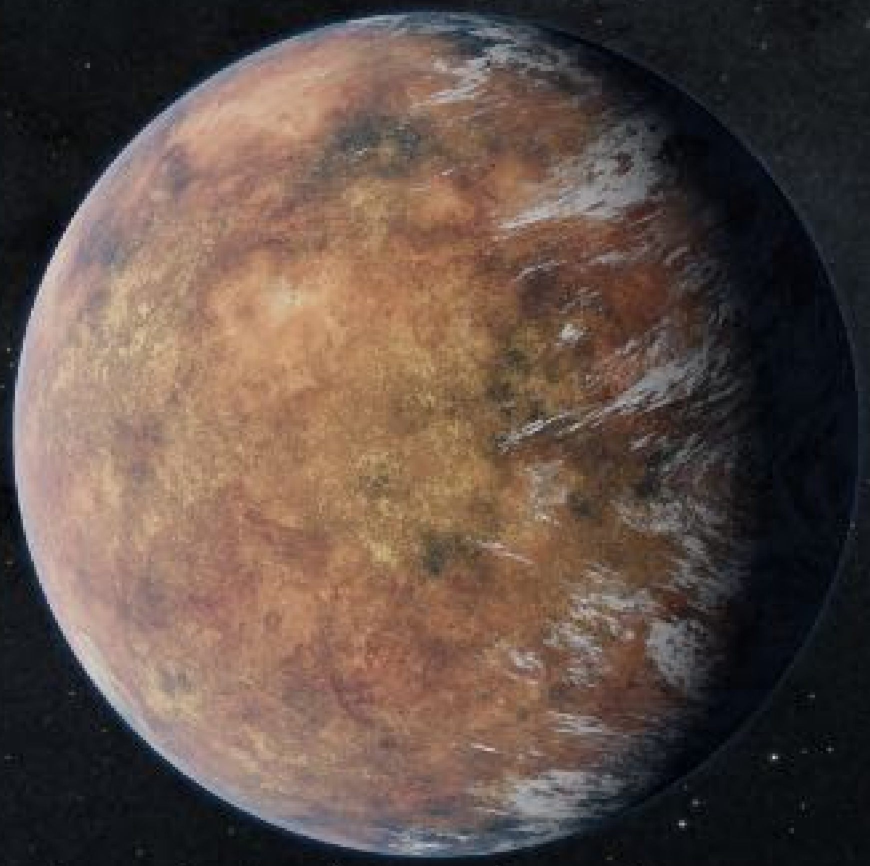


There are MANY other solar systems out there!

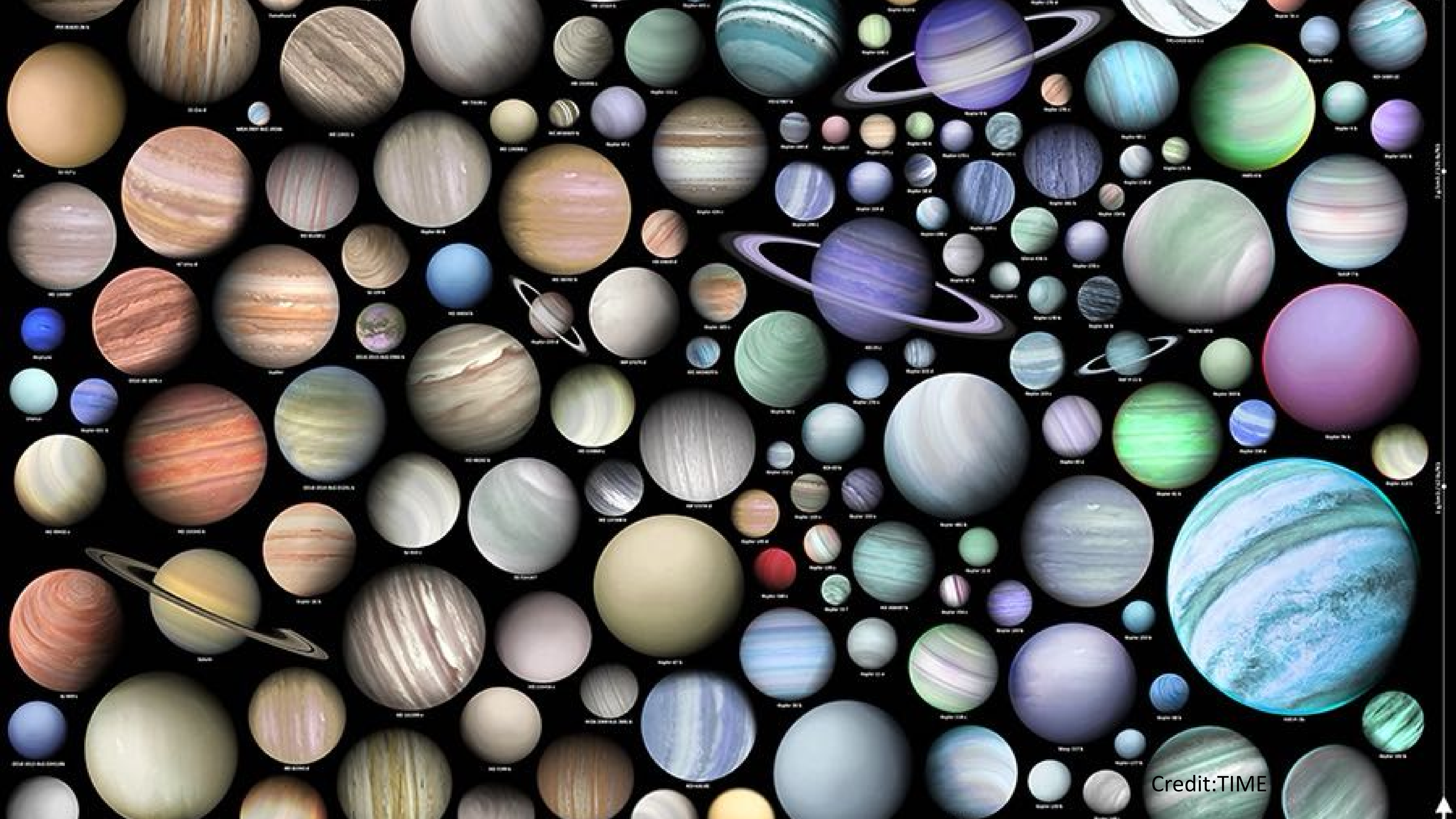


https://exoplanets.nasa.gov

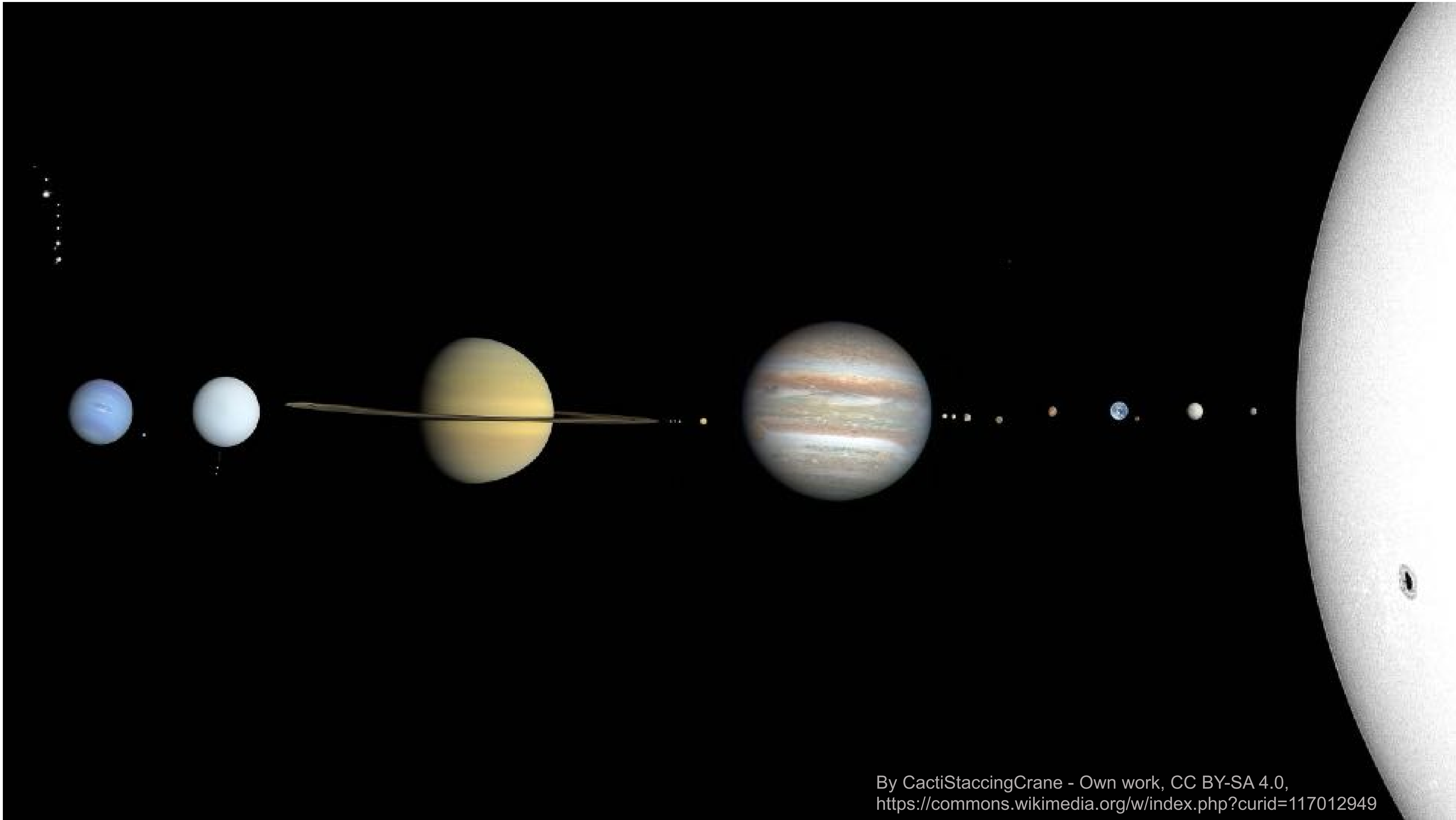
Exoplanet: a planet orbiting a star other than the Sun

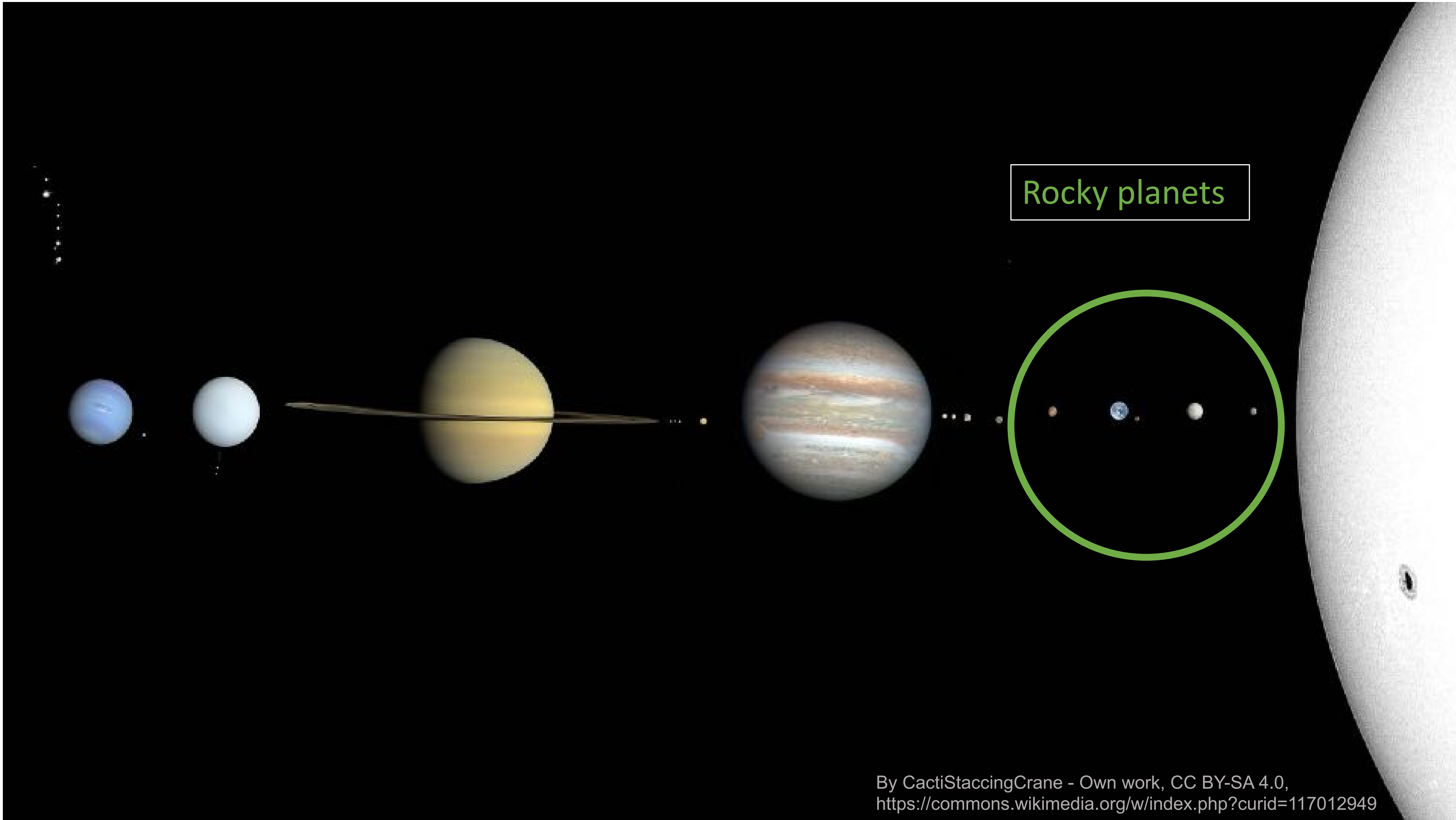


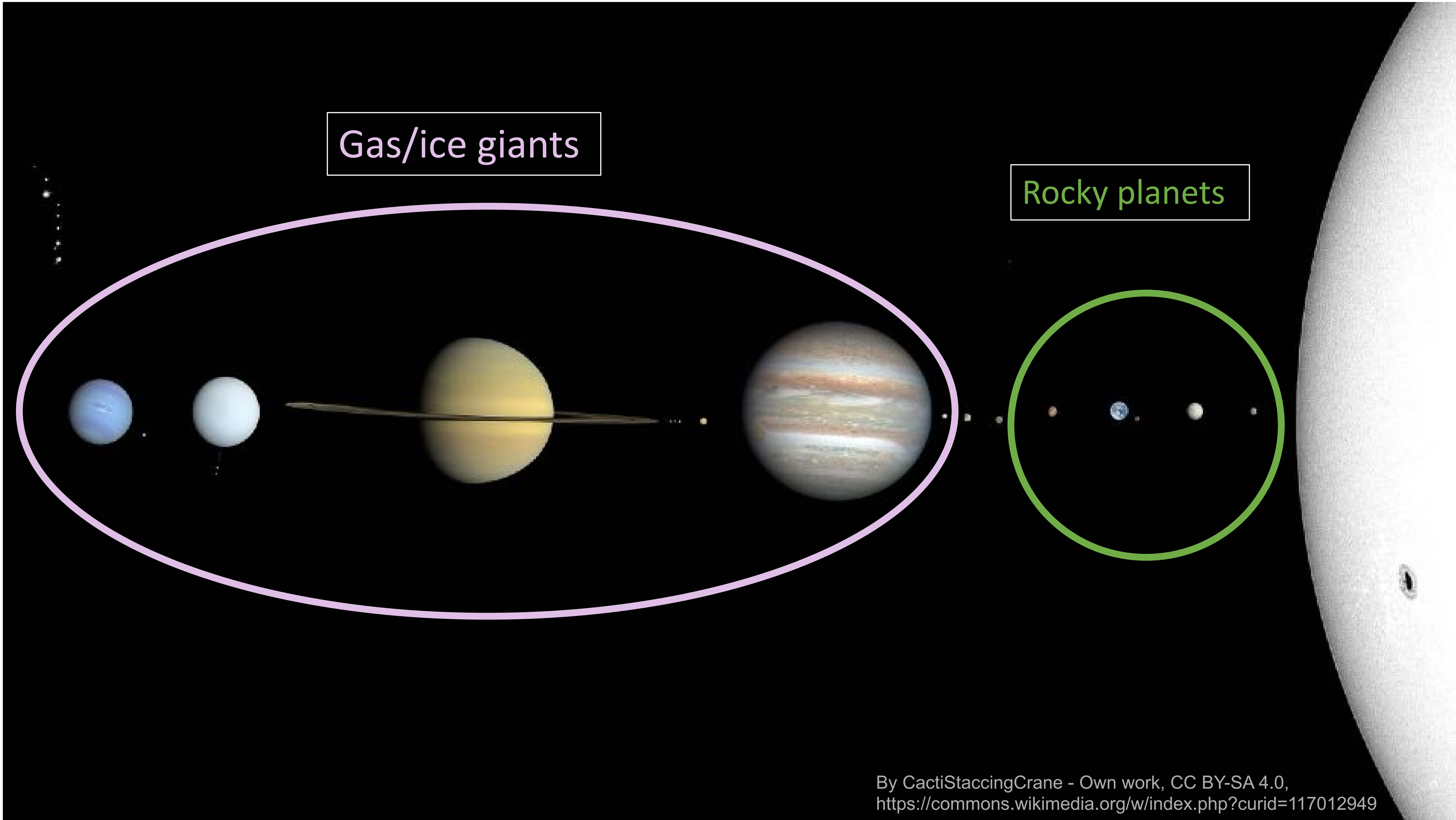
https://exoplanets.nasa.gov

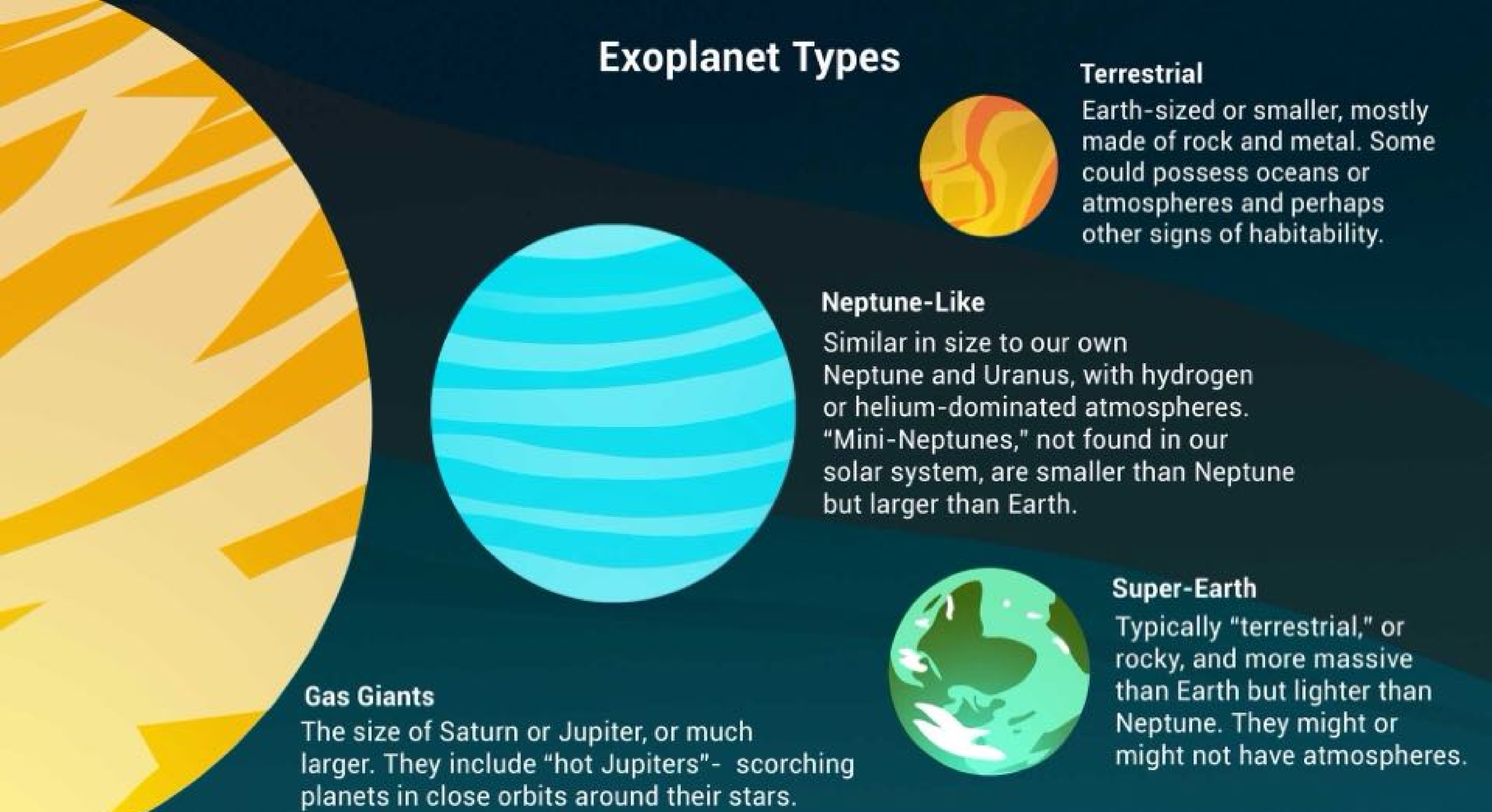


Credit:TIME



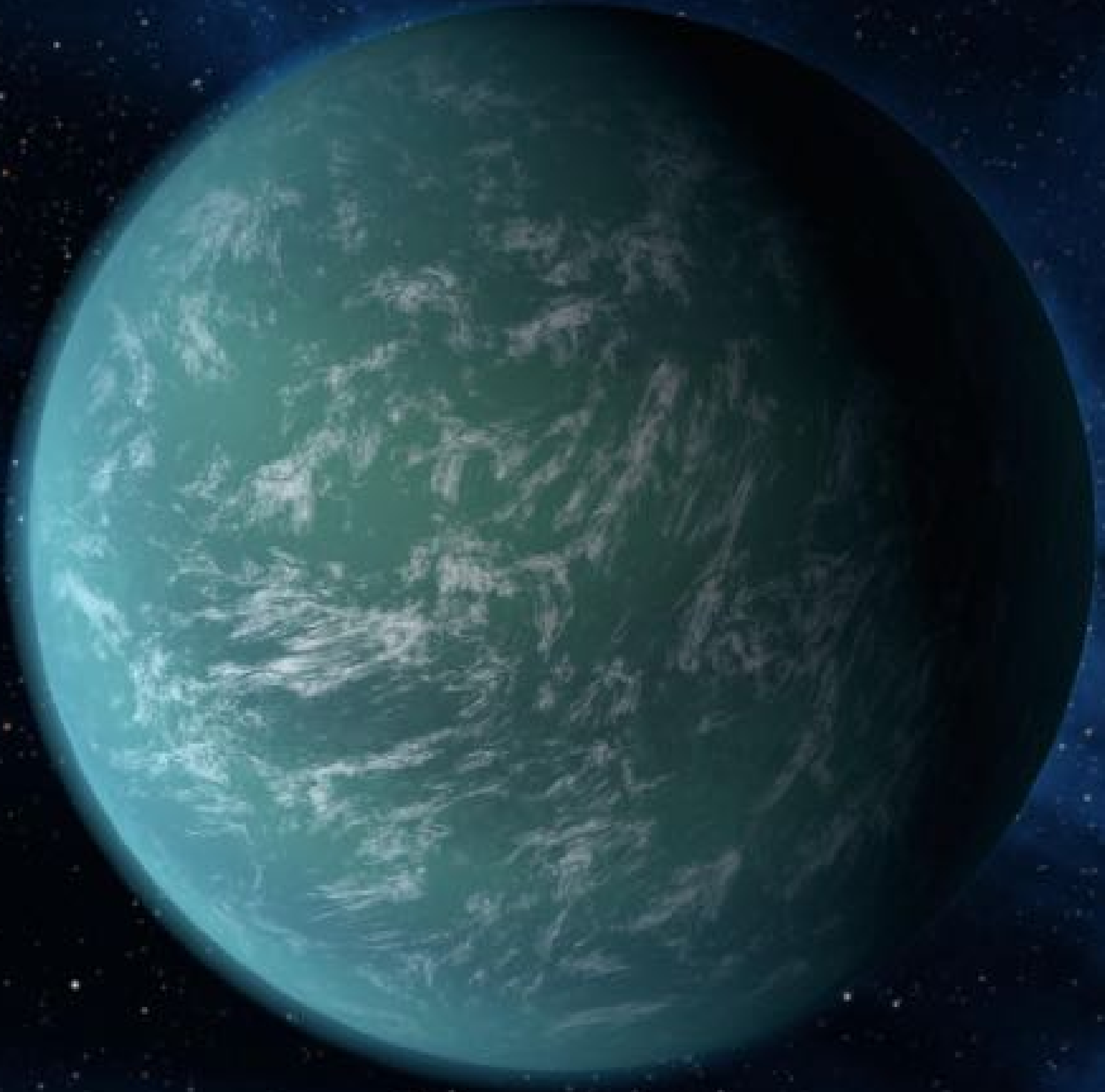

Rocky planets


Gas/ice giants
Rocky planets



Credit: NASA/JPL-Caltech/Lizbeth B. De La Torre

Are there exoplanets that are like Earth?

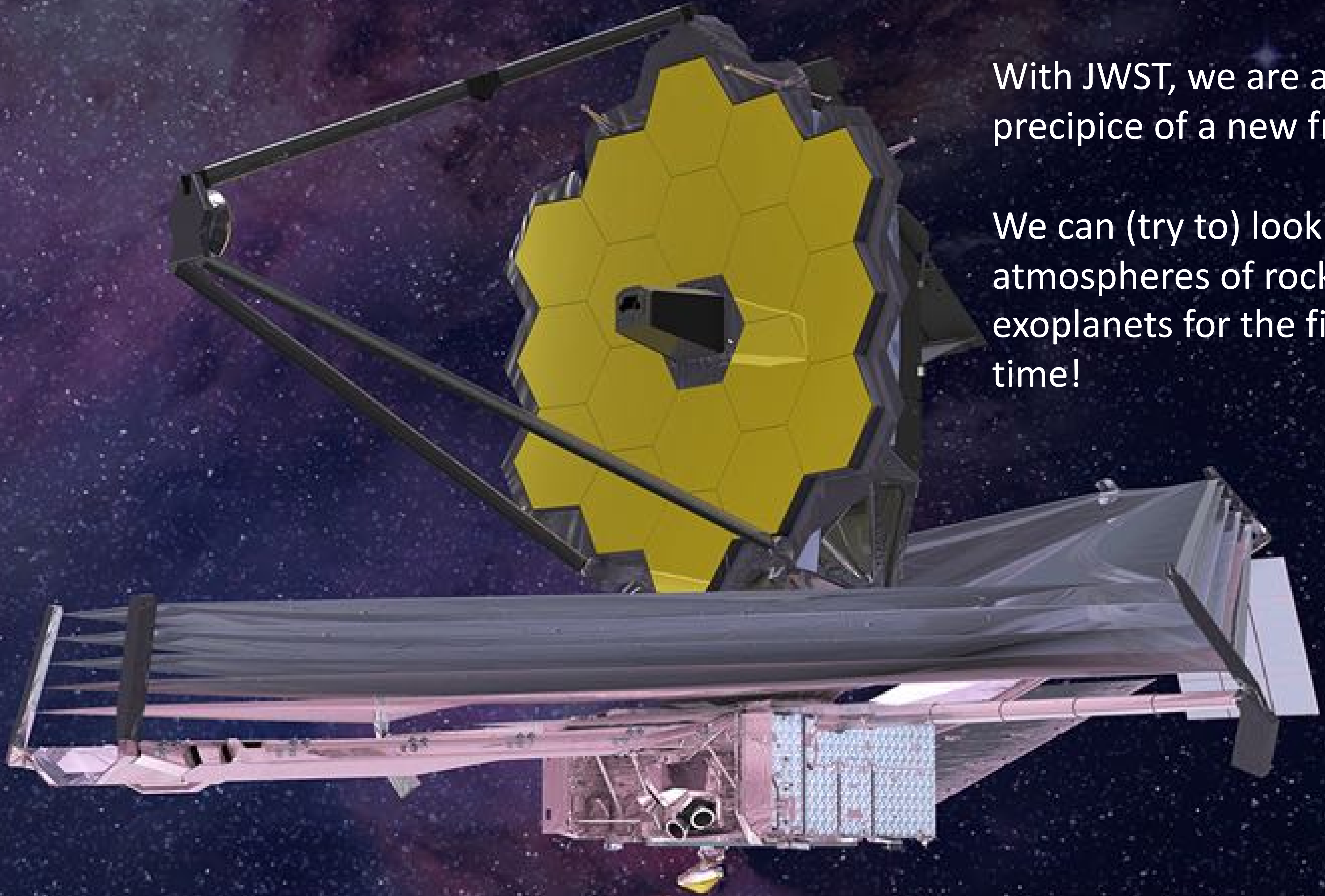


WAMU

C&EN

With JWST, we are at the precipice of a new frontier.

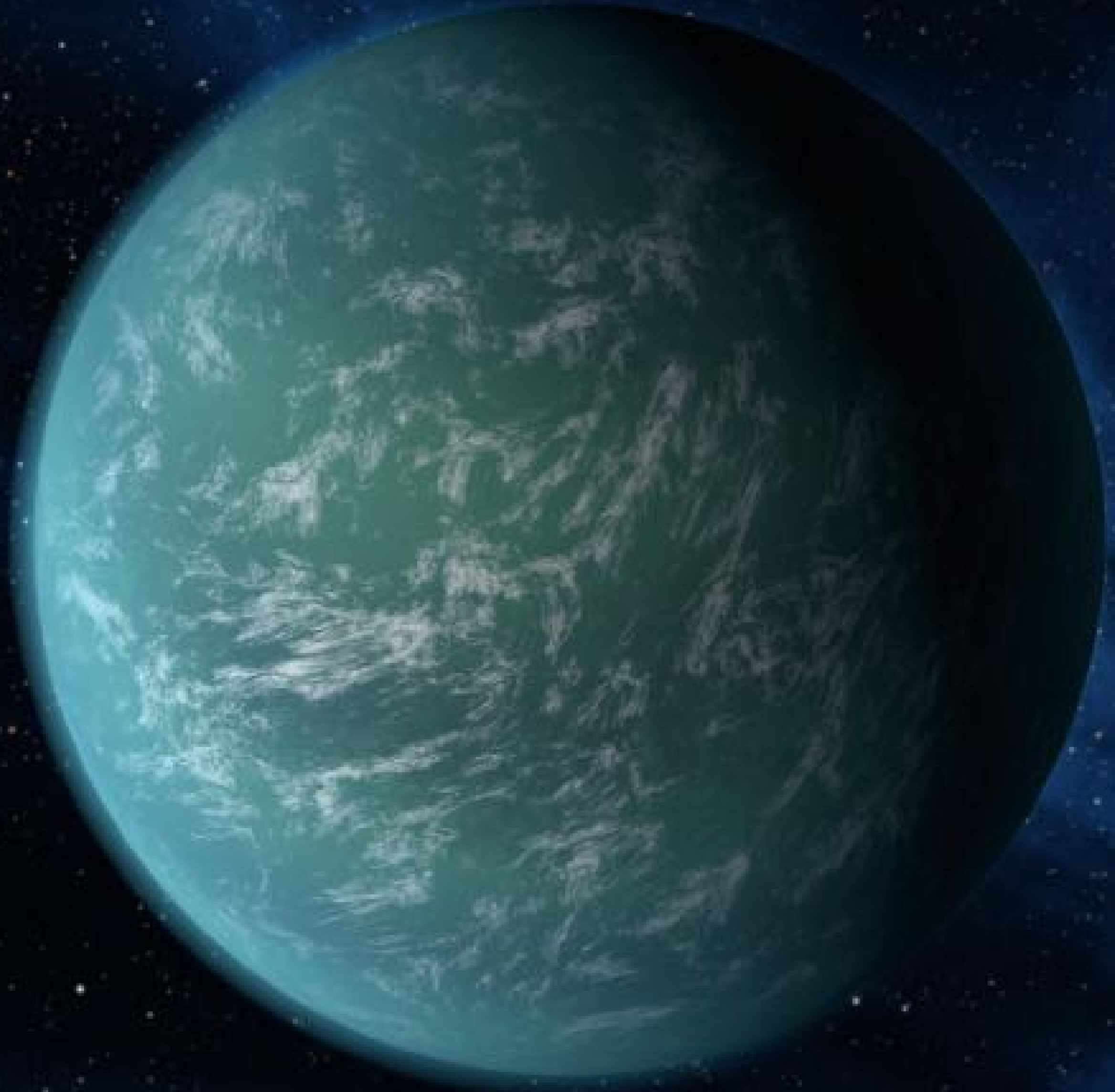
We can (try to) look at the atmospheres of rocky exoplanets for the first time!



CSA

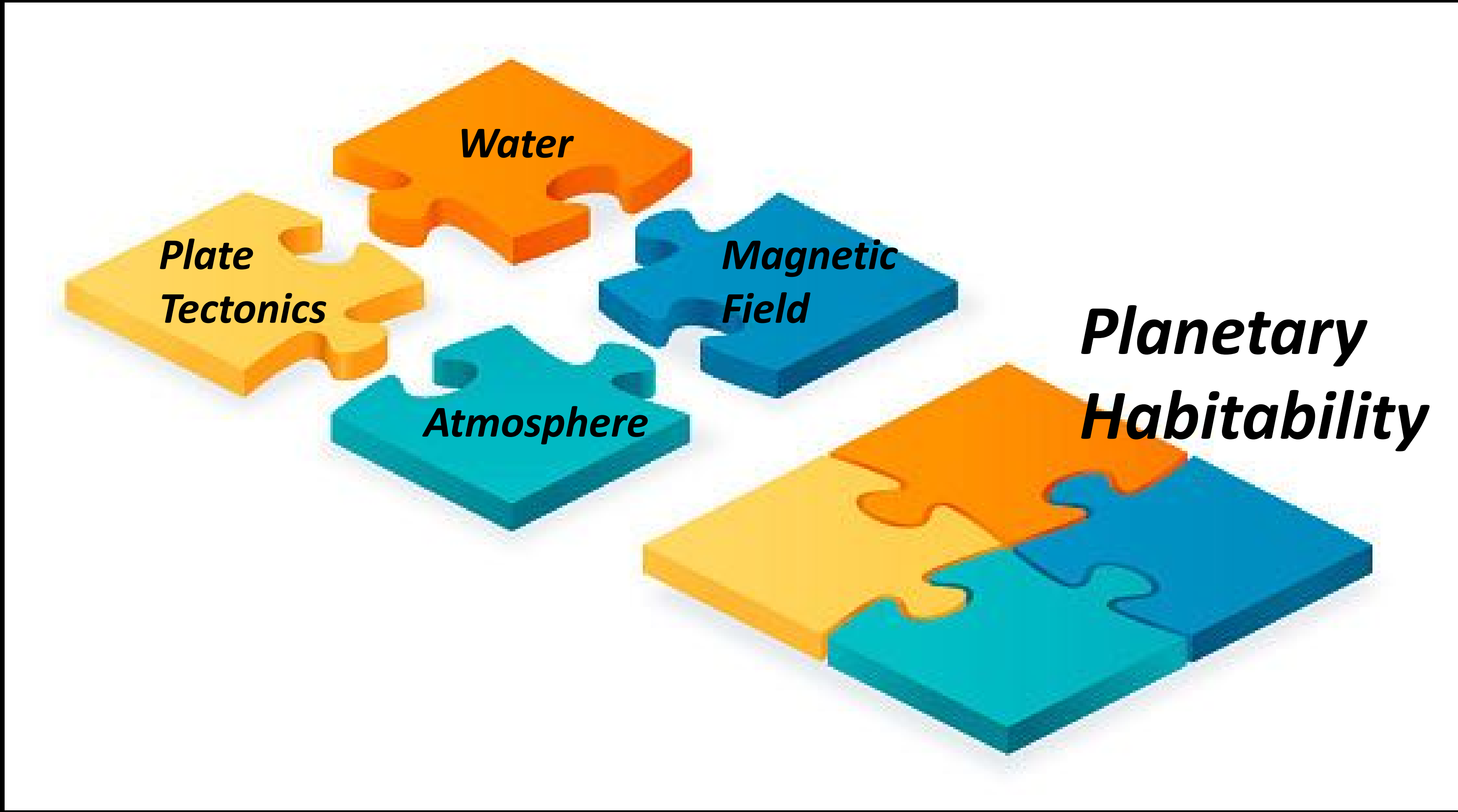
Why do we care about planet atmospheres?

Are there exoplanets that are like Earth?

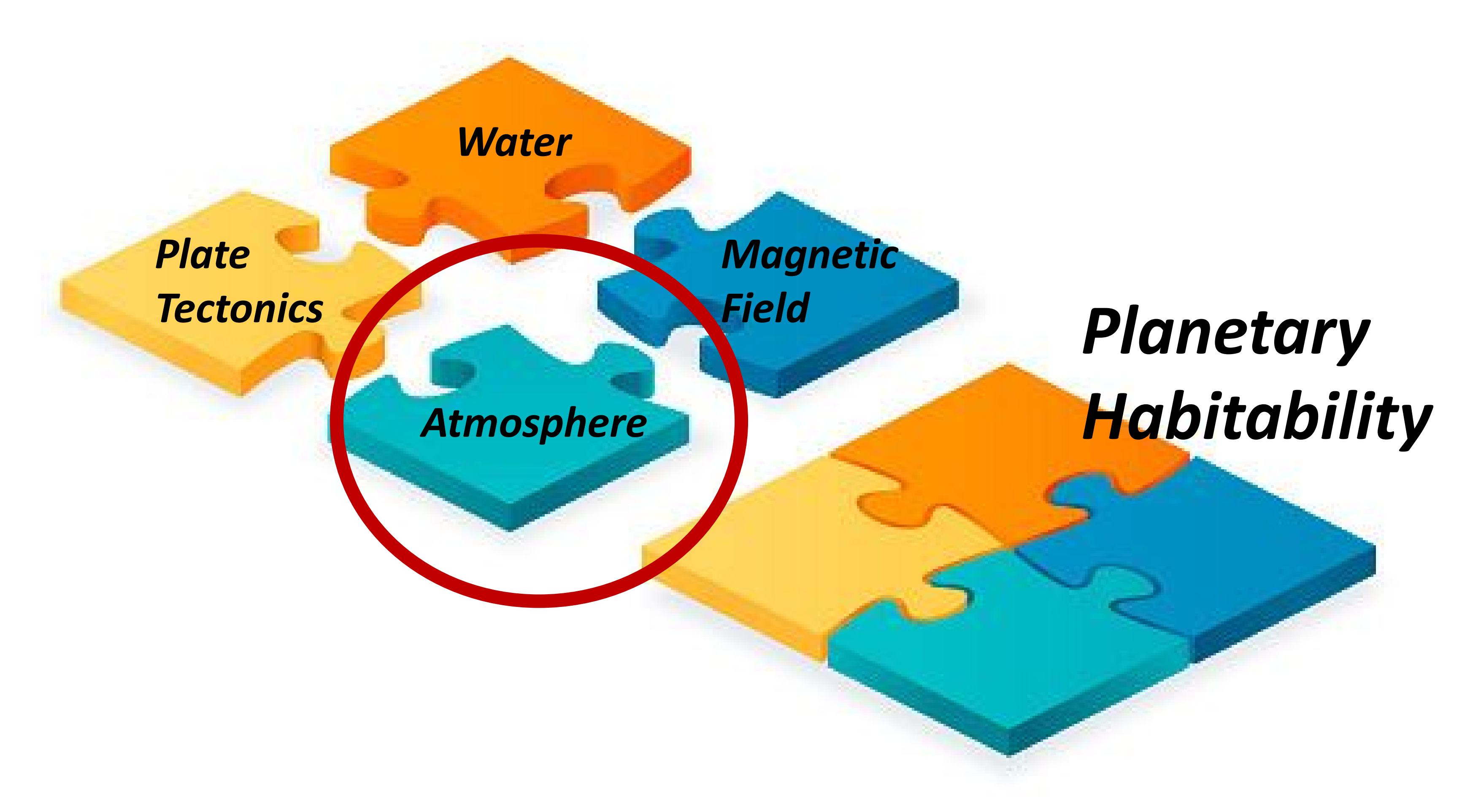


WAMU

Many different components that make up planetary habitability

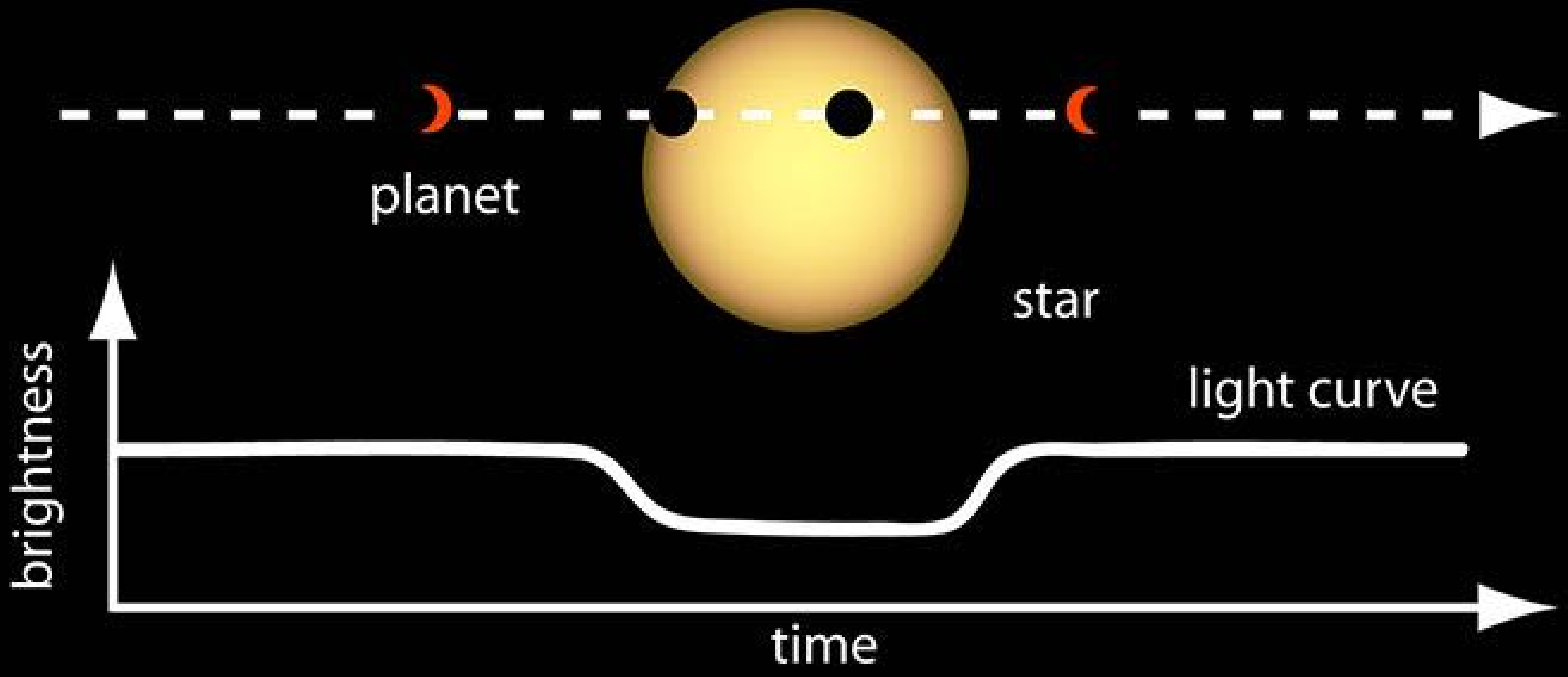


Many different components that make up planetary habitability

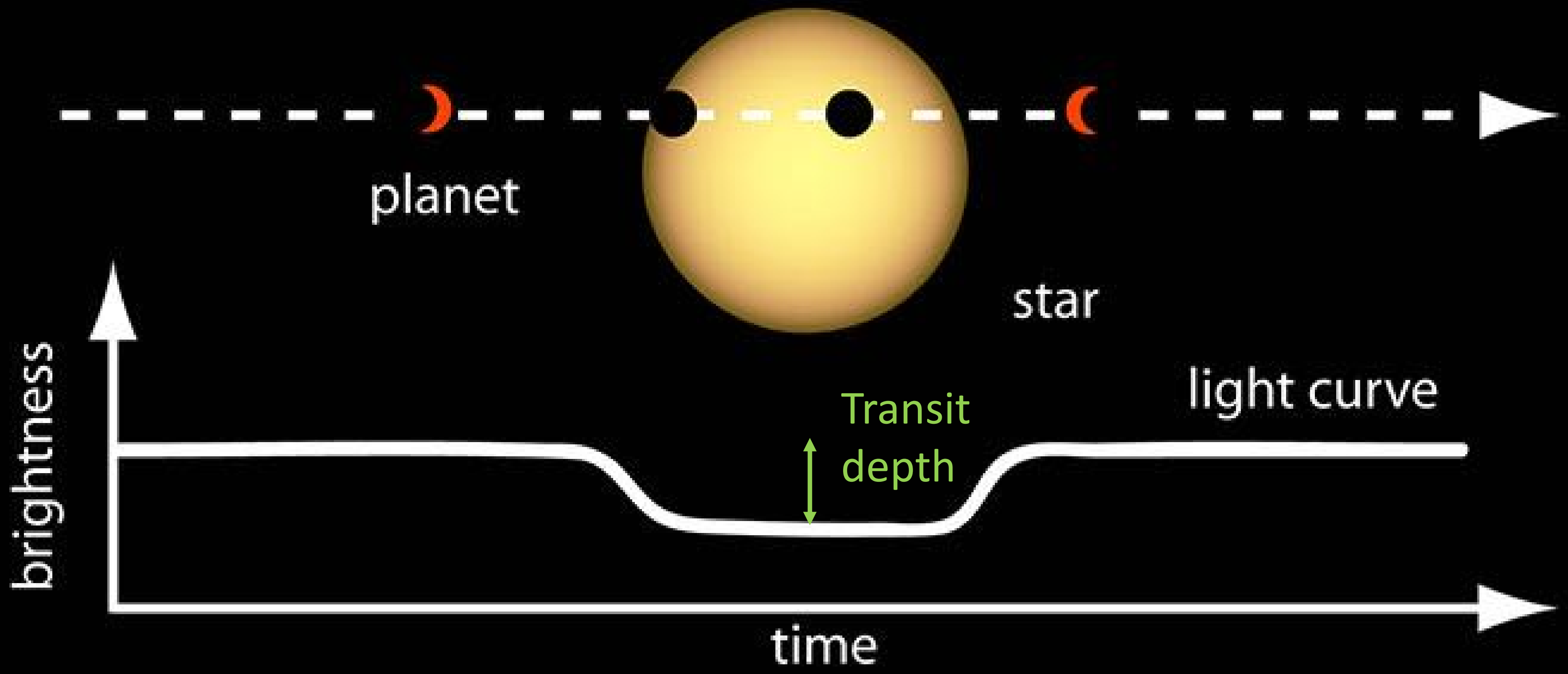



HOW DO
YOU DO
THIS?
Credit: Locale.a

Credit: Unsplash/ Jongsun Lee

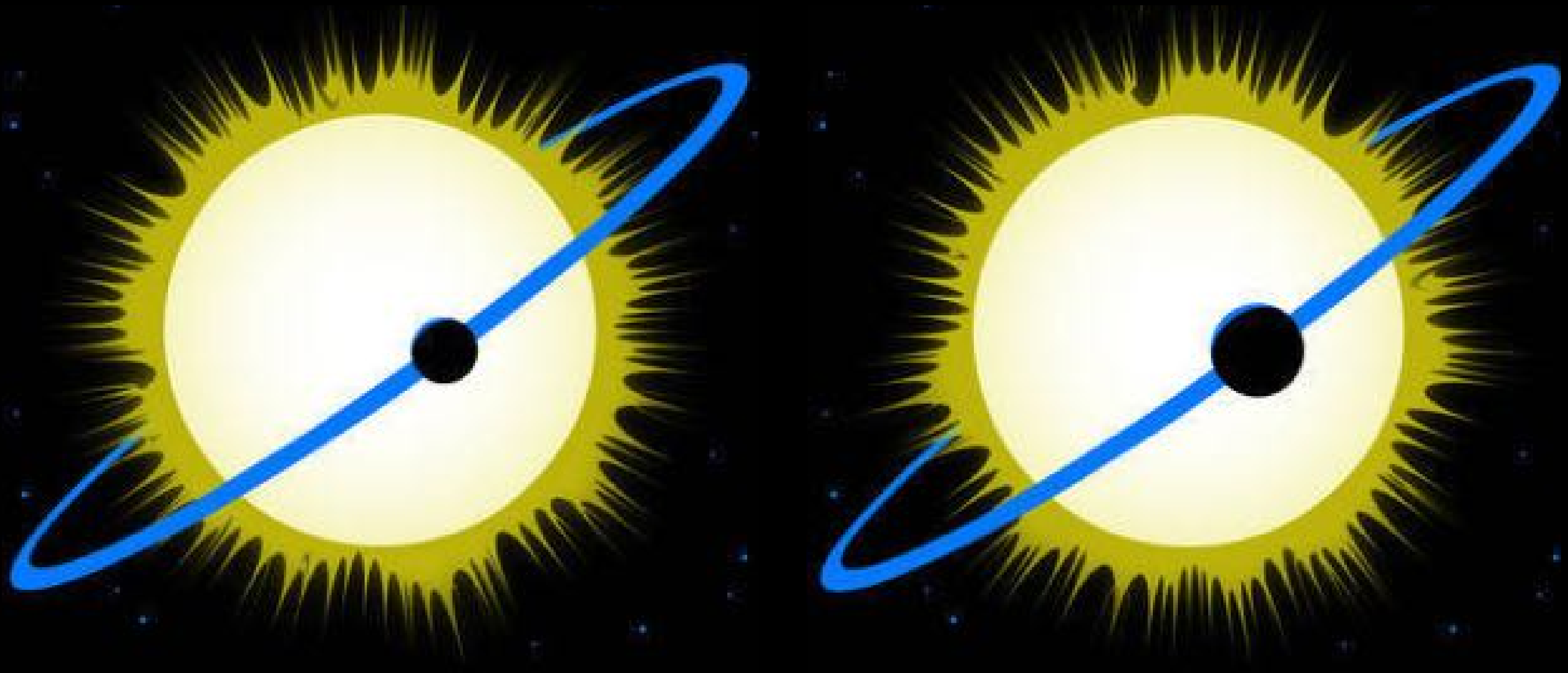


NASA Ames



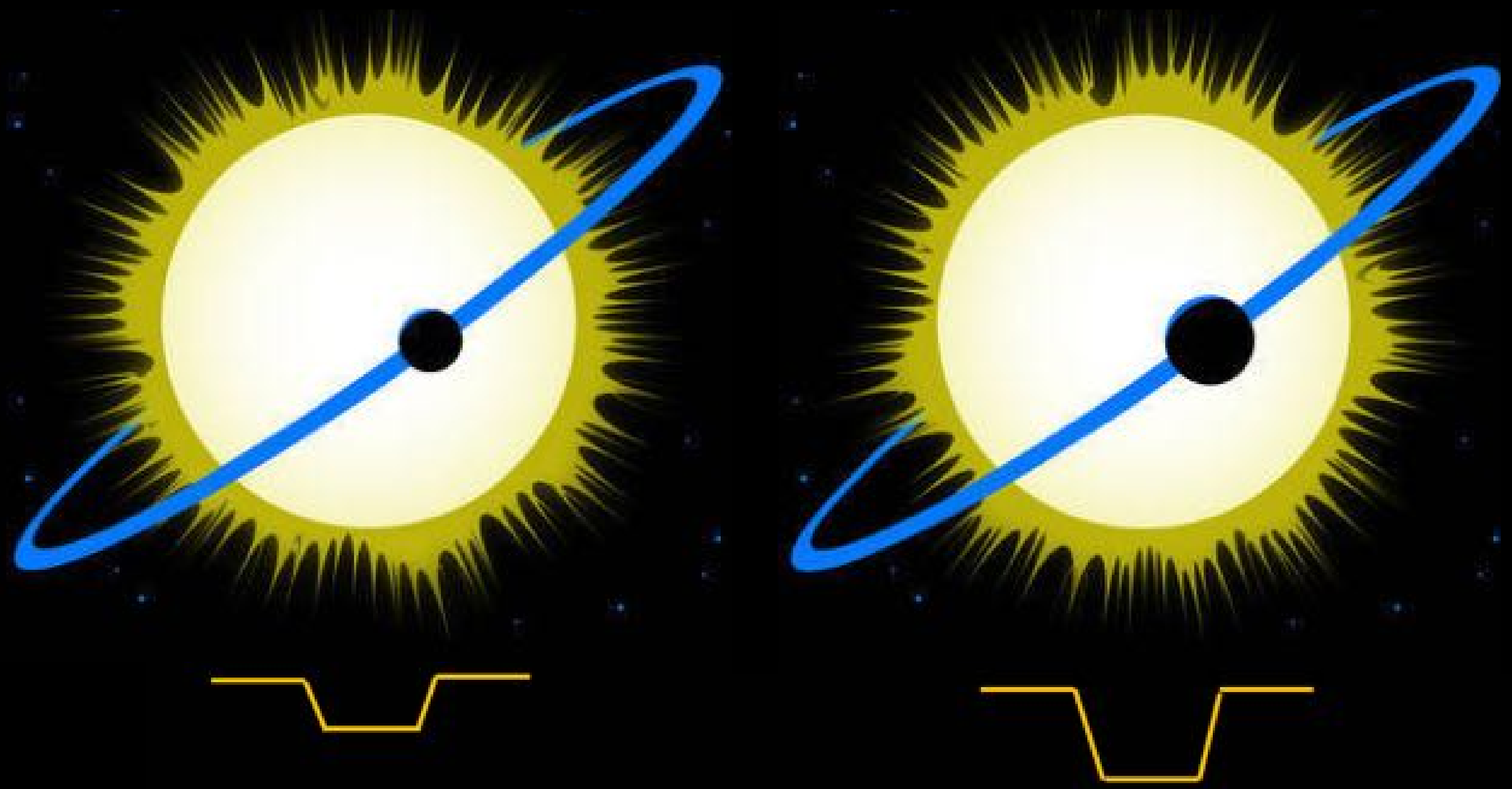
NASA Ames

The size of the planet AND star matter!



Credit: NASA/JPL-Caltech

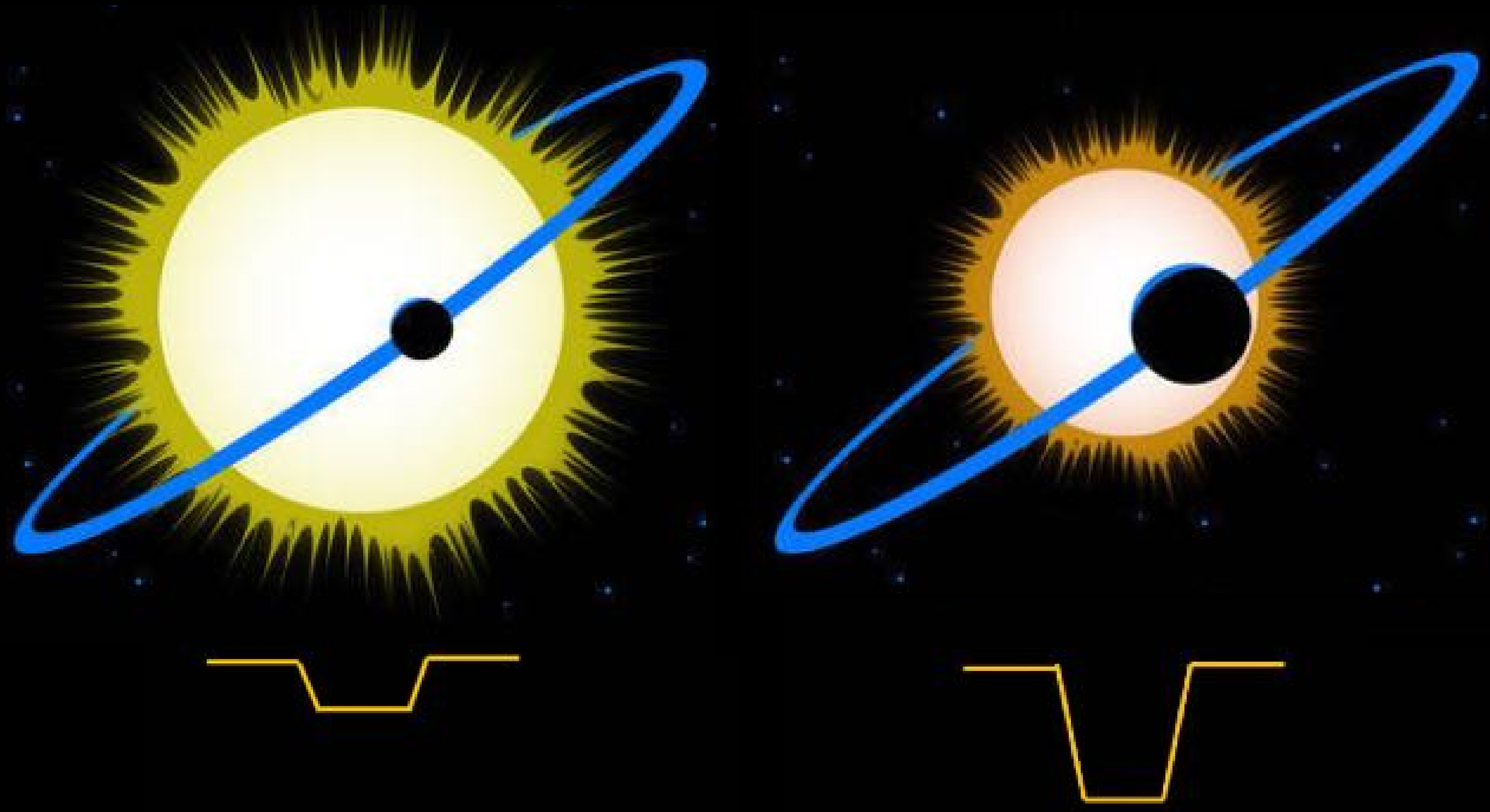
The size of the planet AND star matter!



Easier to detect BIGGER planets

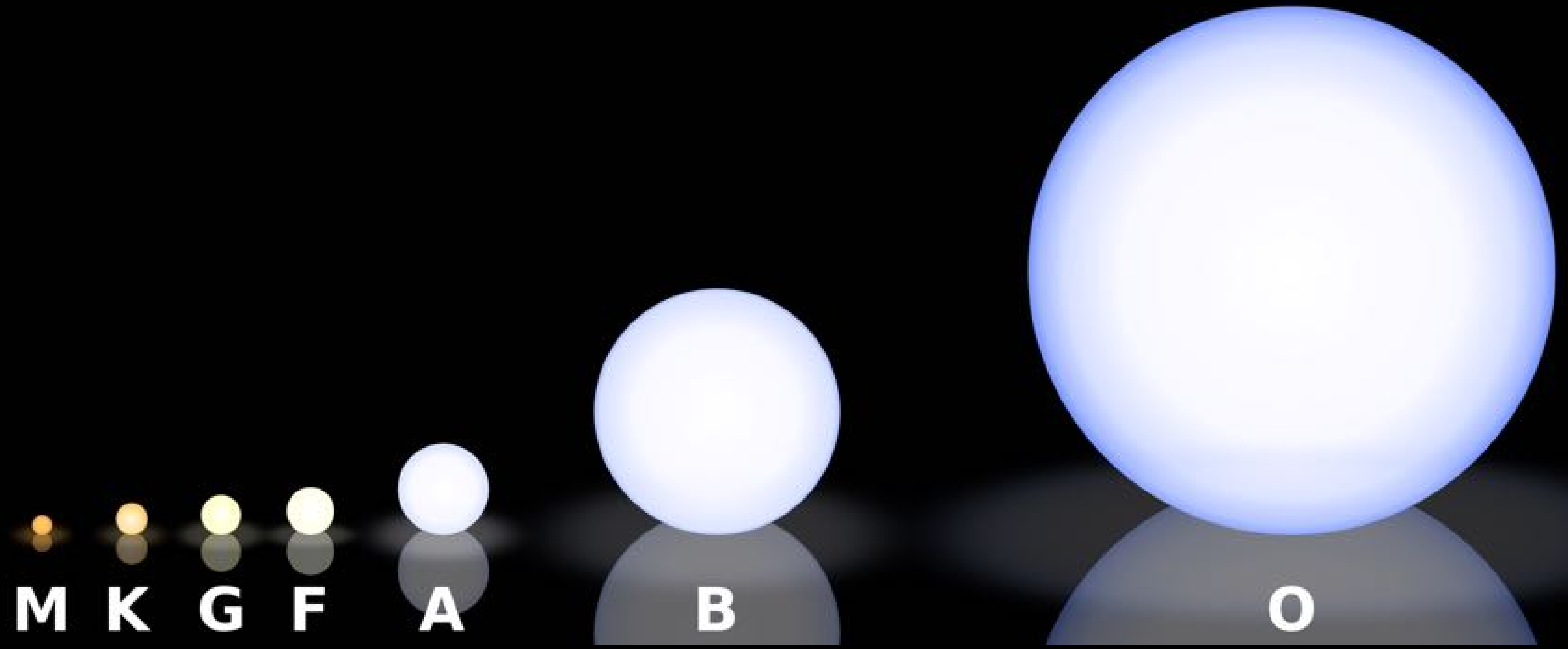
Credit: NASA/JPL-Caltech

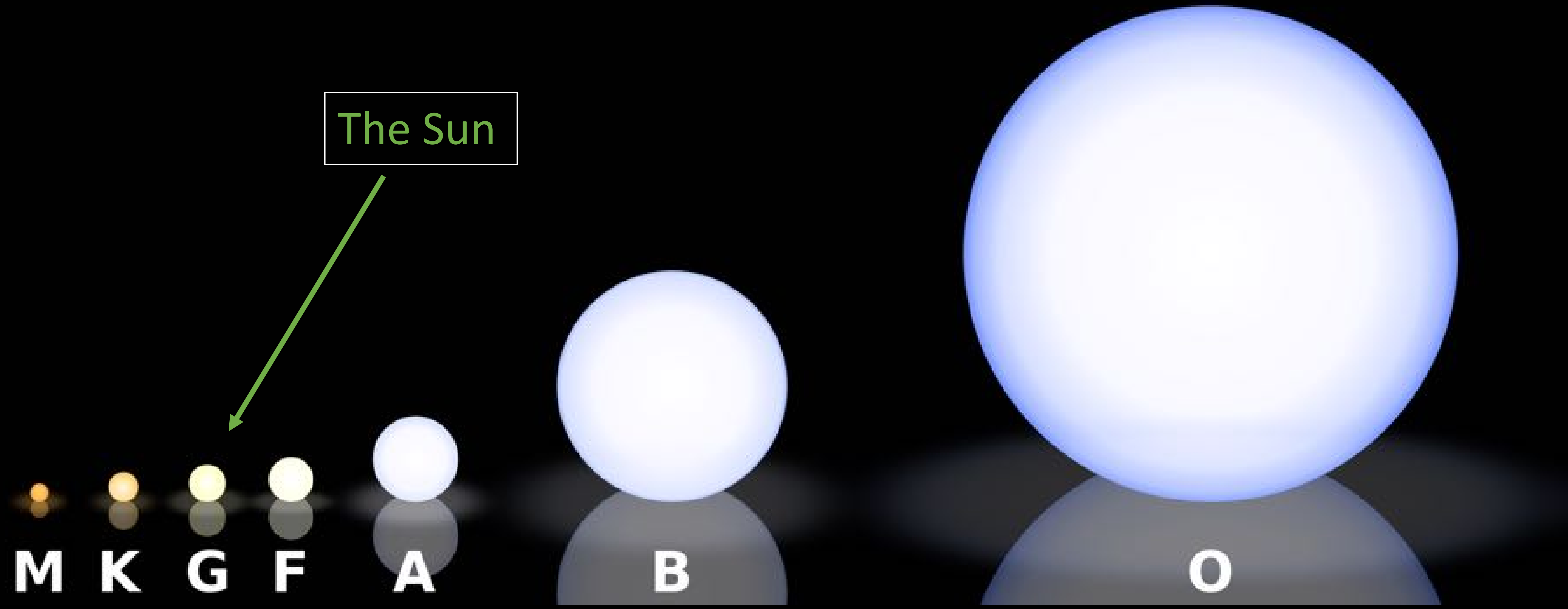
The size of the planet AND star matter!



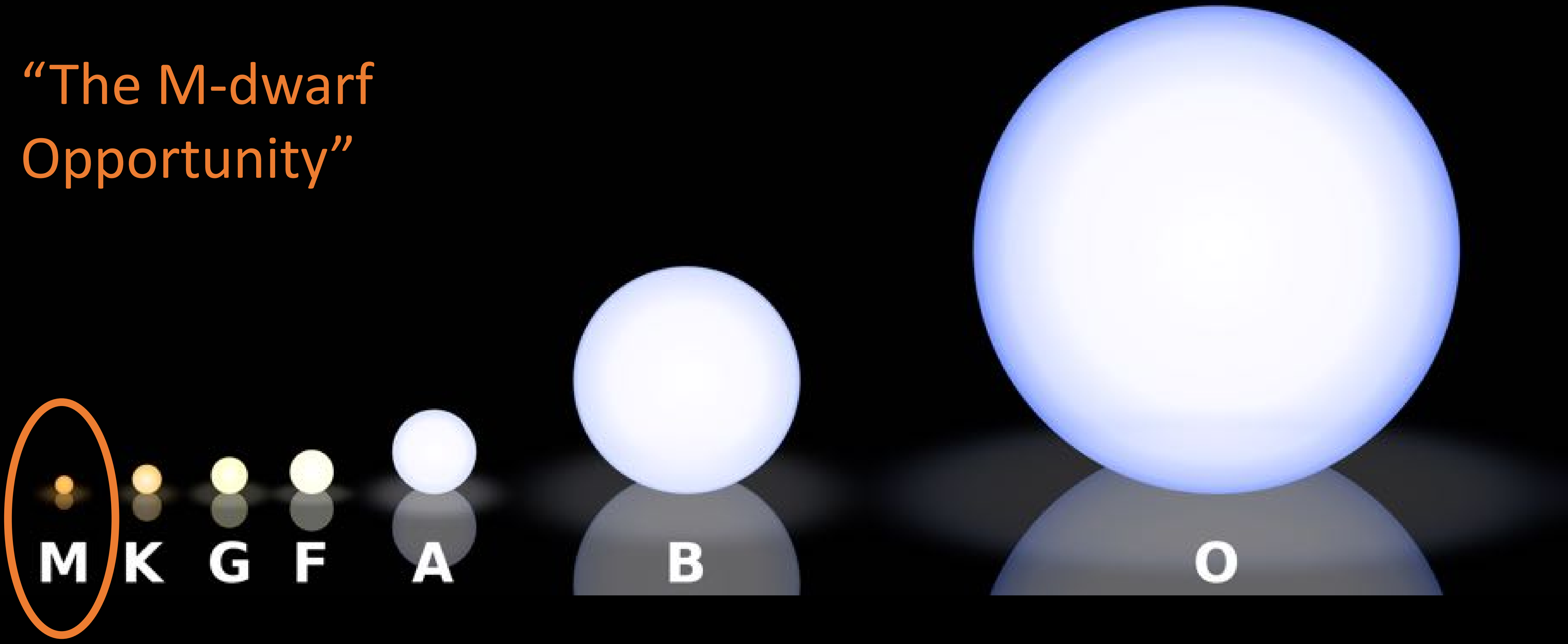
Easier to detect BIGGER planets around SMALLER stars

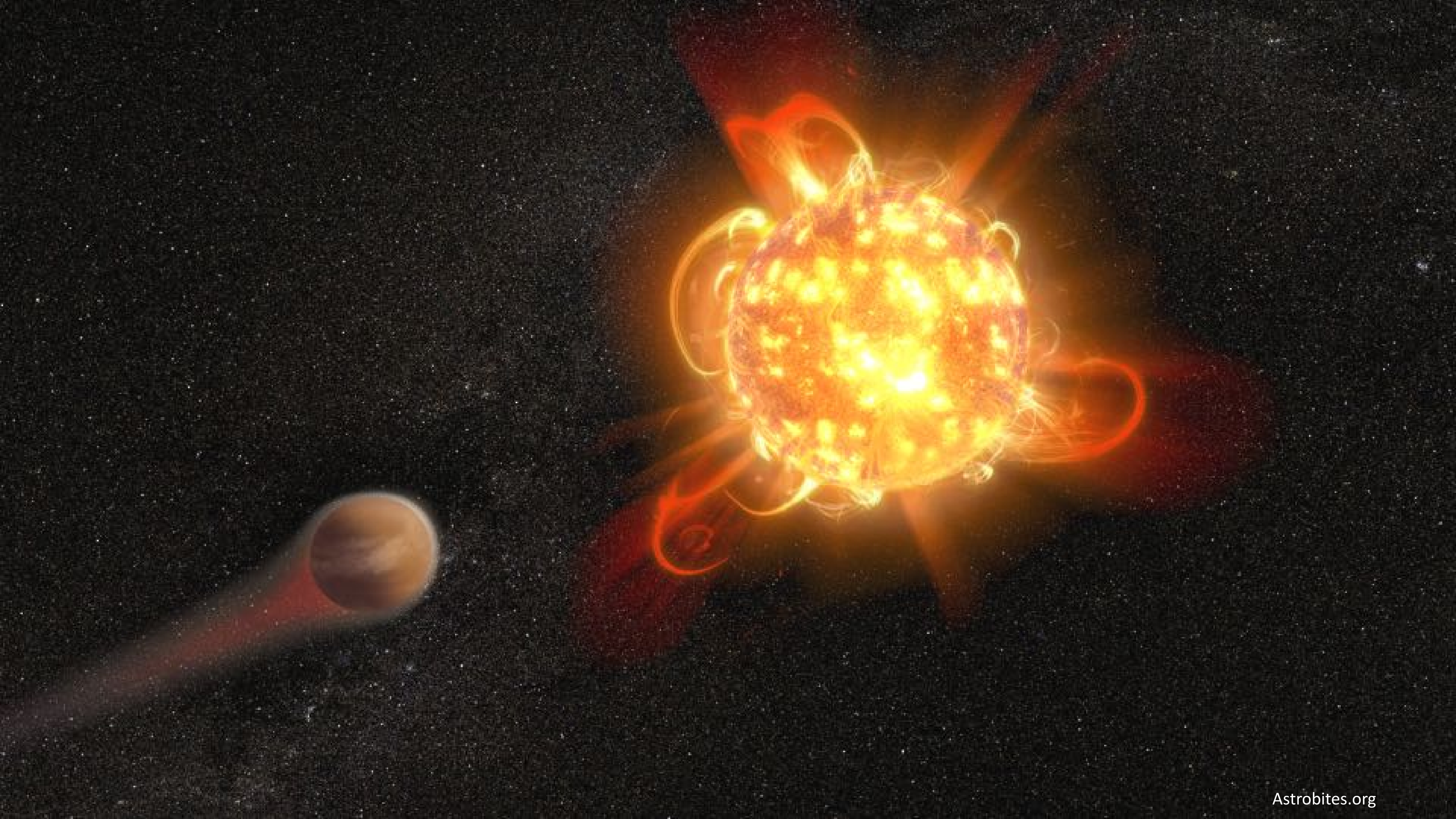
Credit: NASA/JPL-Caltech


M K G F A B O

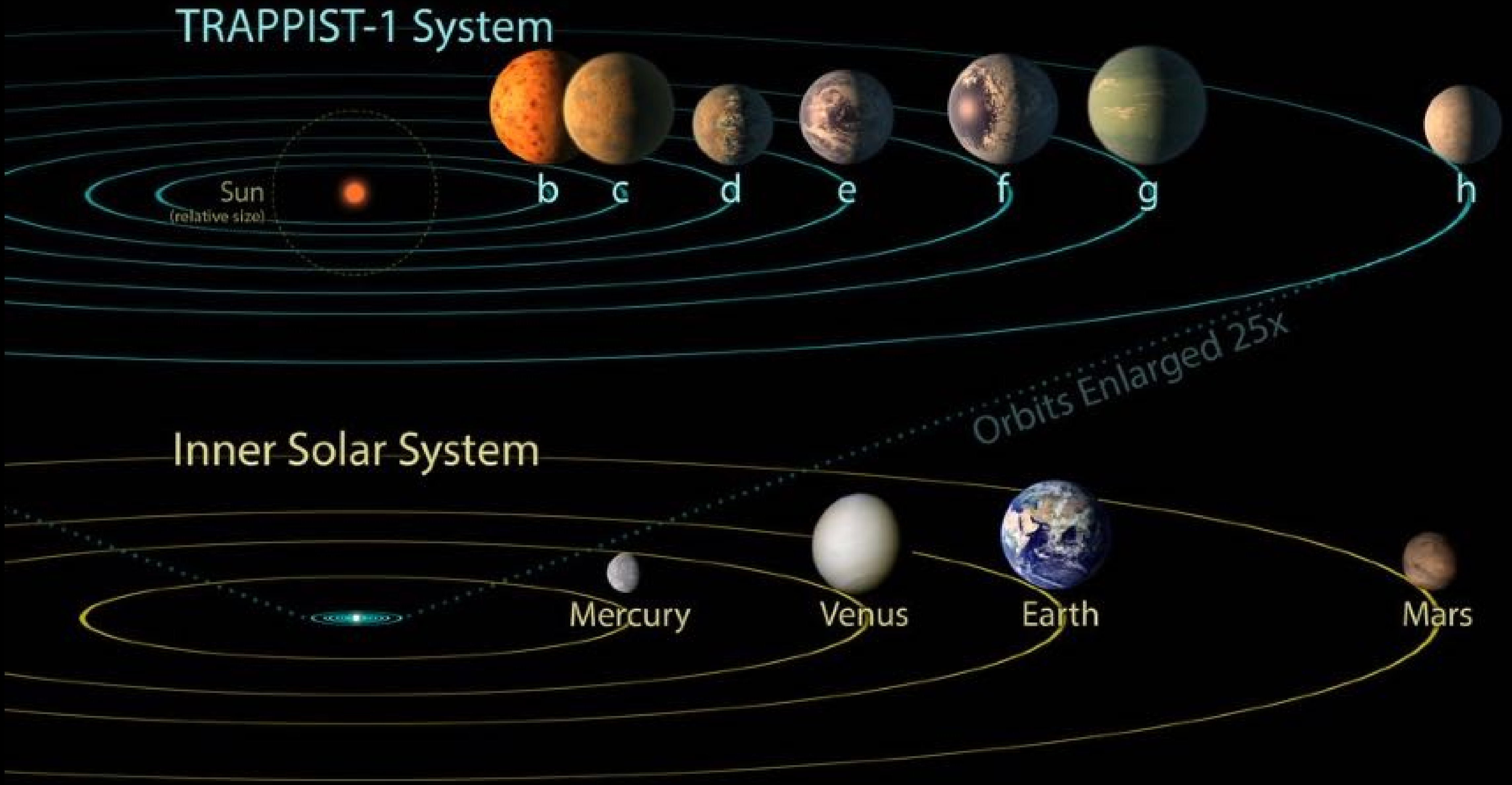

The Sun
M
K
G
F
A
B
O

“The M-dwarf Opportunity”

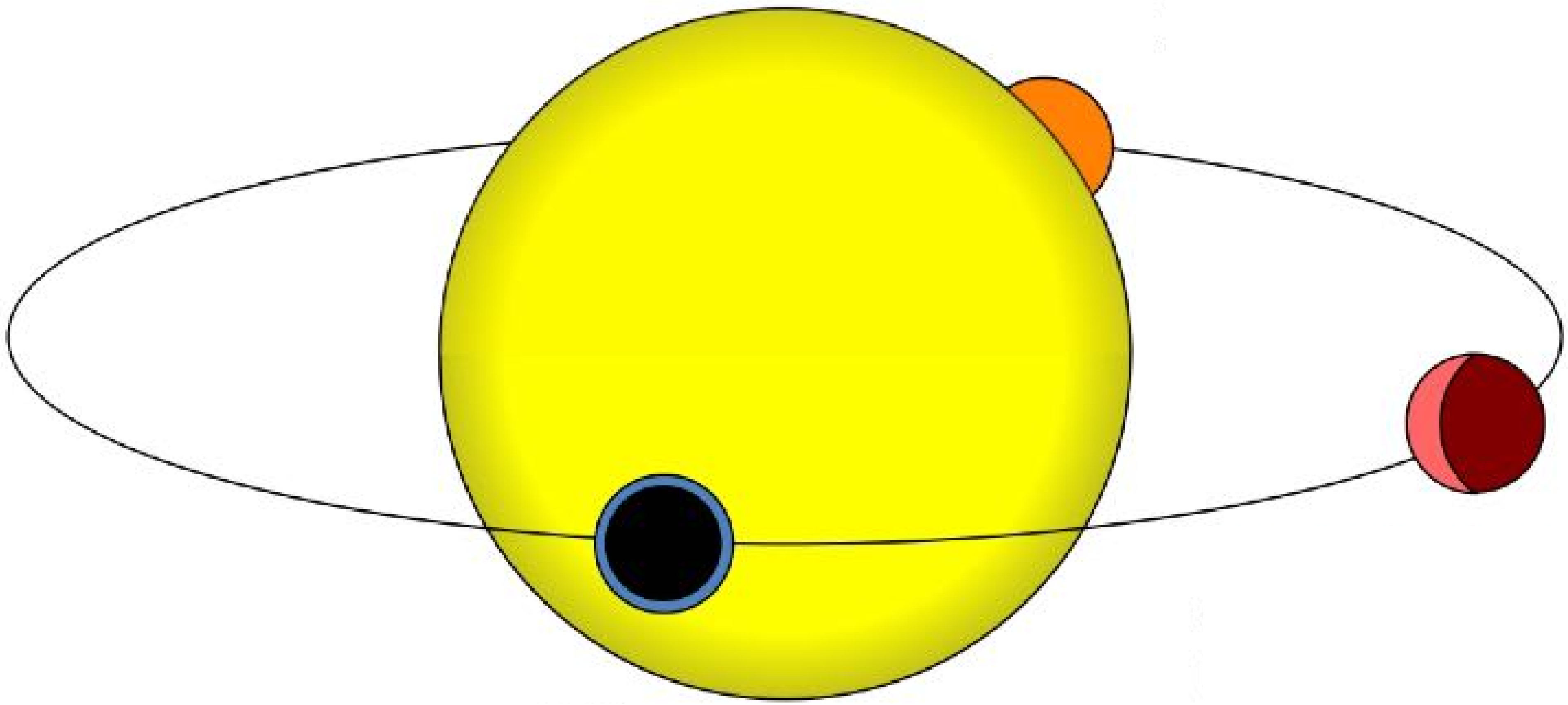




Astrobites.org

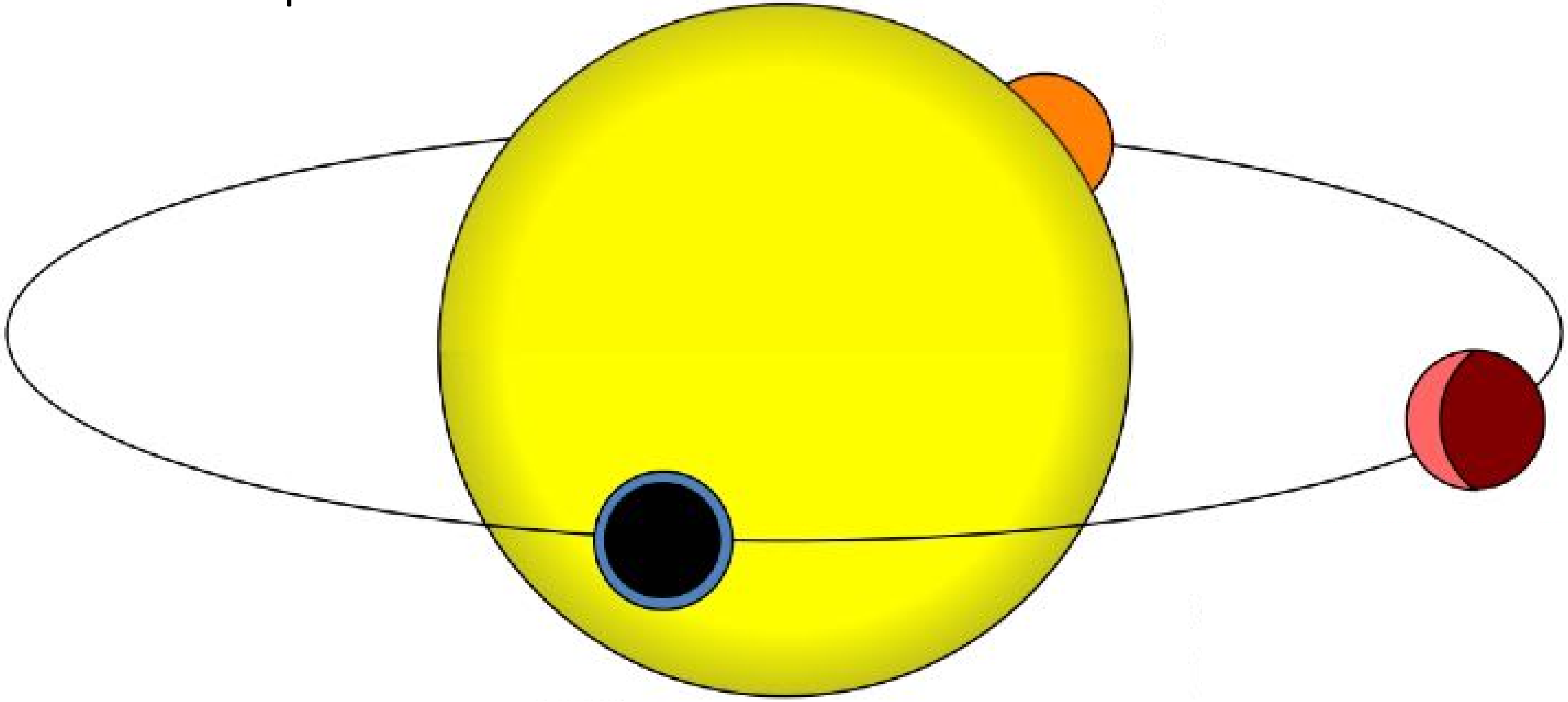


Credit: NASA/JPL-Caltech/R. Hurt, T. Pyle (IPAC)



Credit: S. Seager

Starlight filters through the planet's atmosphere.



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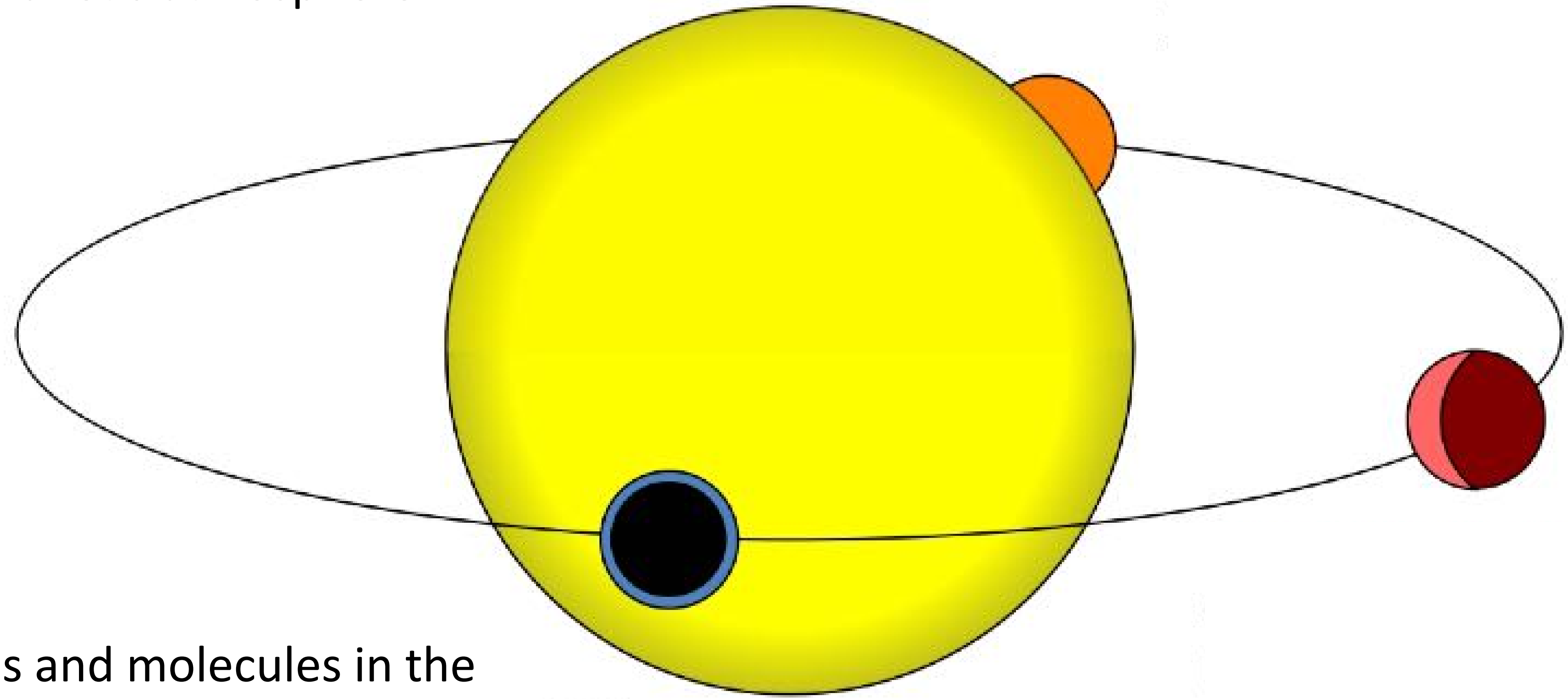
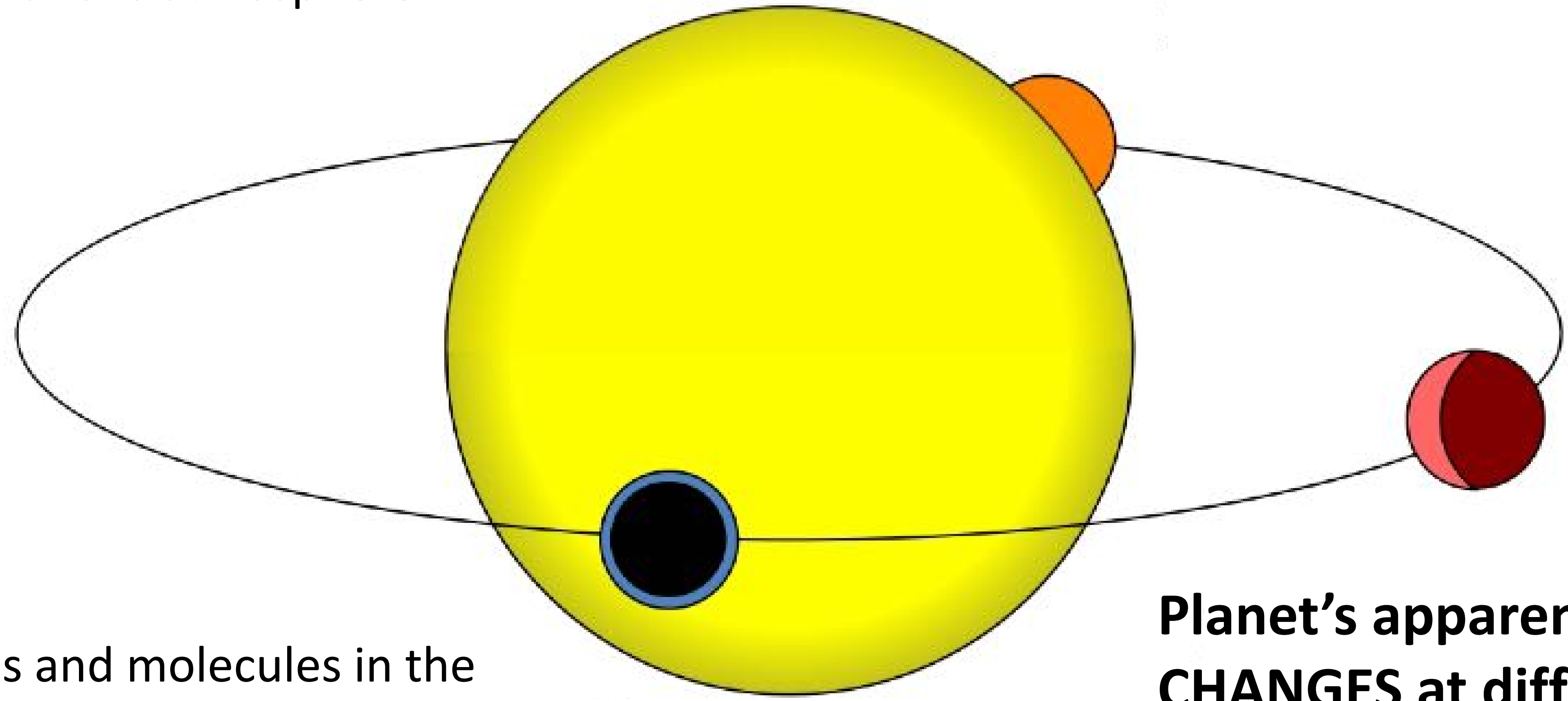
Starlight filters through the planet's atmosphere.



Atoms and molecules in the planet's atmosphere imprint a signature in the light we see.

Credit: S. Seager

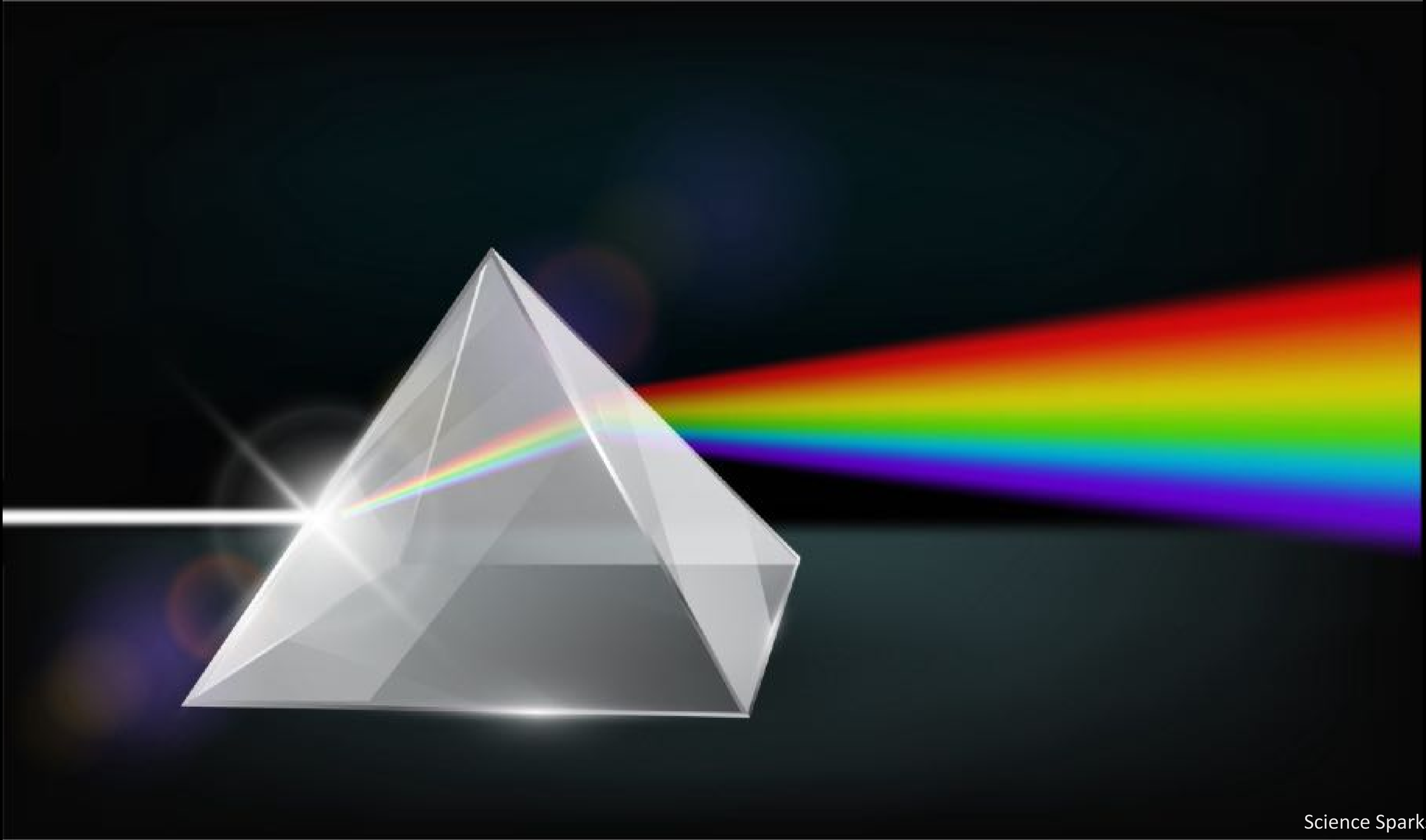
Starlight filters through
the planet’s atmosphere.



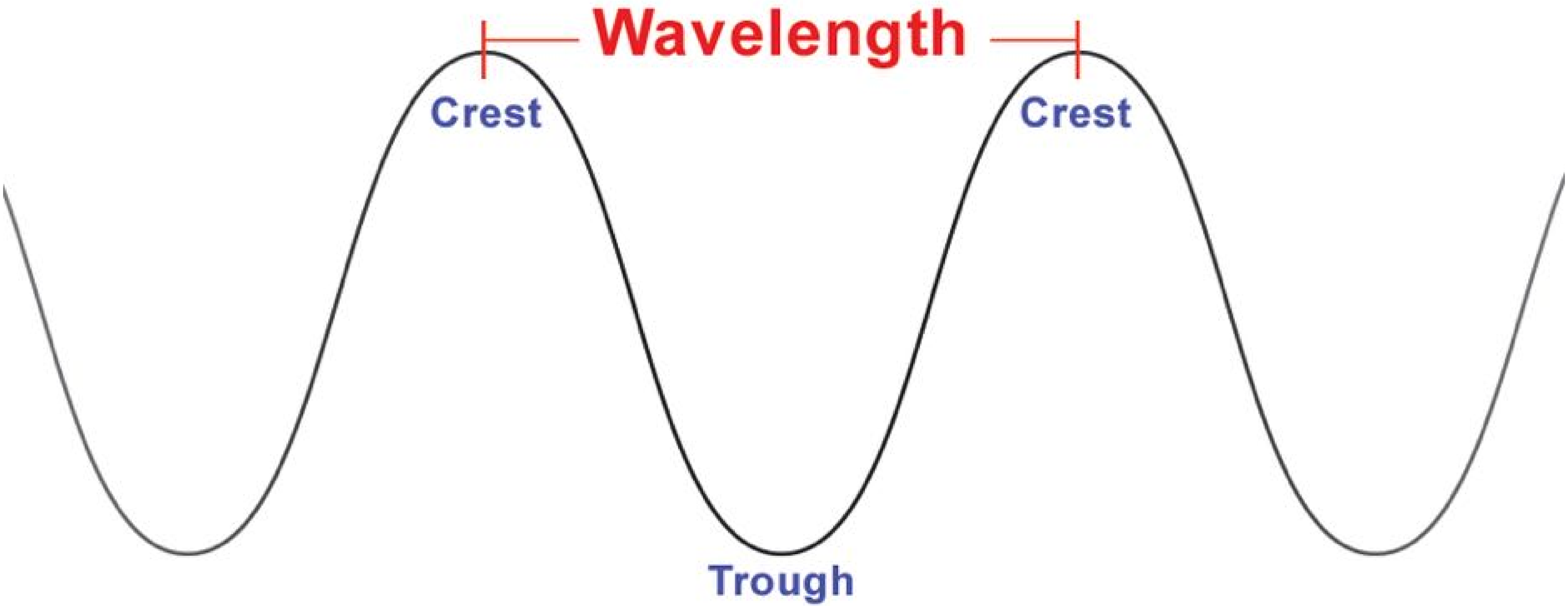
Atoms and molecules in the
planet’s atmosphere imprint a
signature in the light we see.

Planet’s apparent radius CHANGES at different wavelengths

Credit: S. Seager

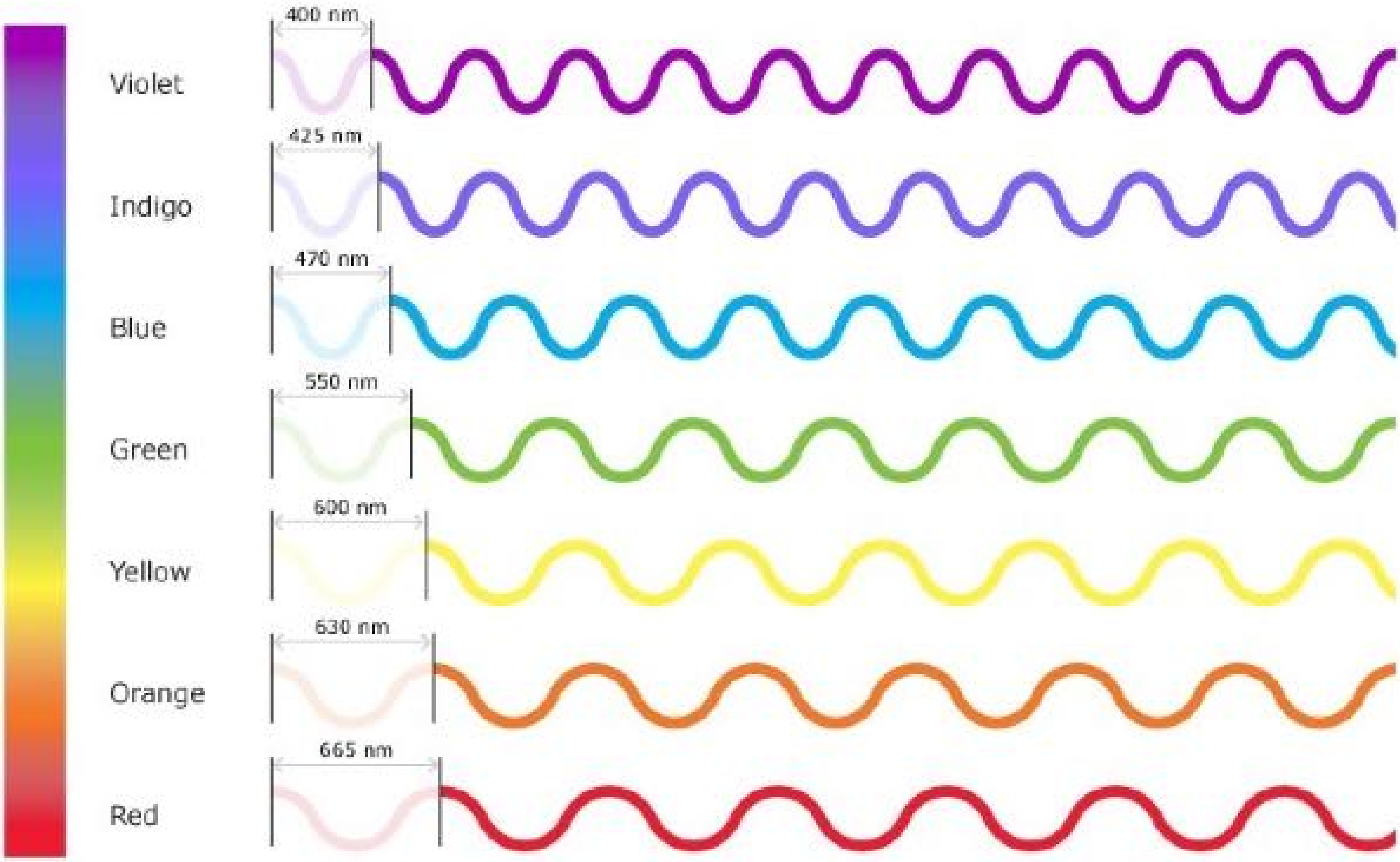


Science Sparks

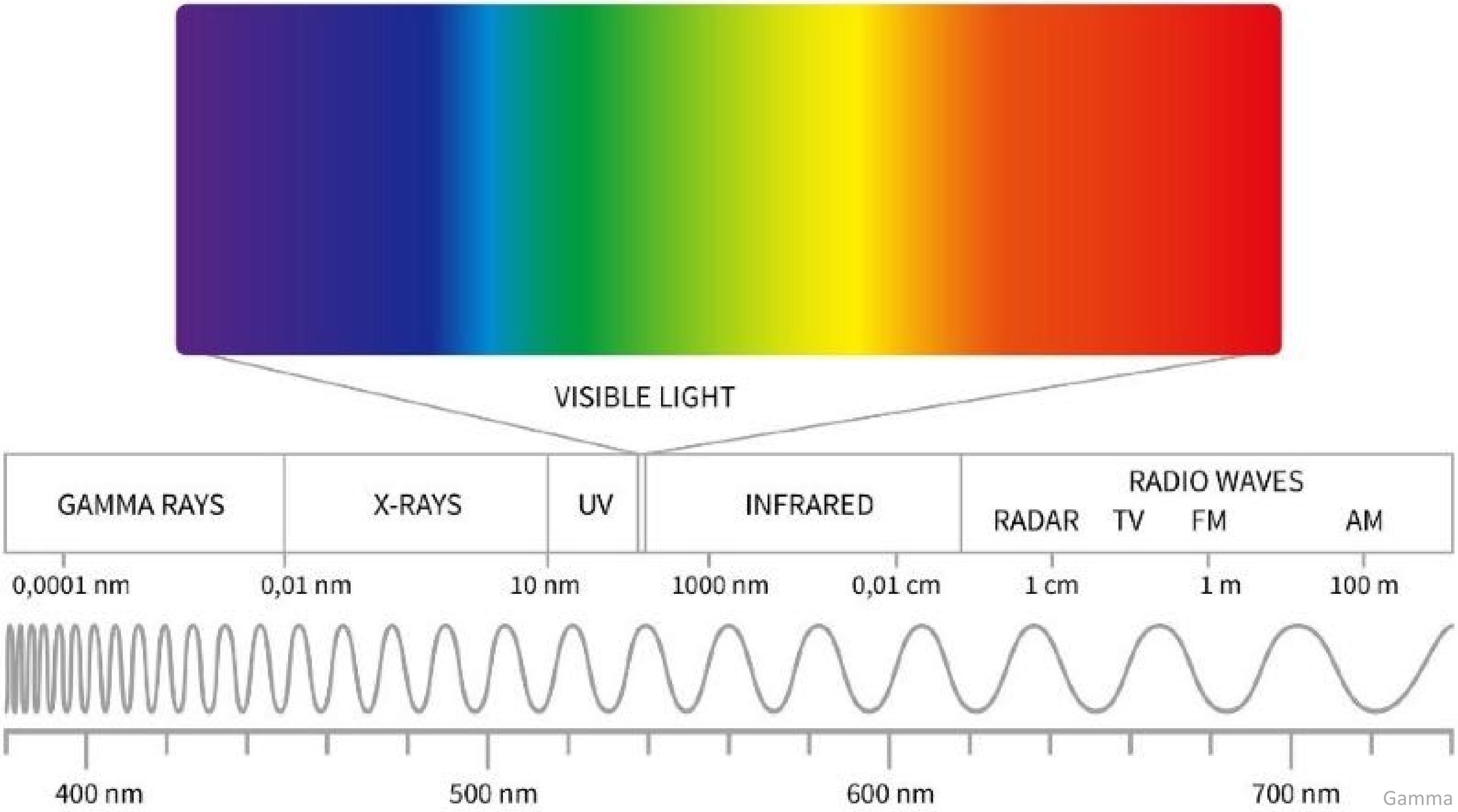


NASA

Light is a wave, with different colors representing different wavelengths

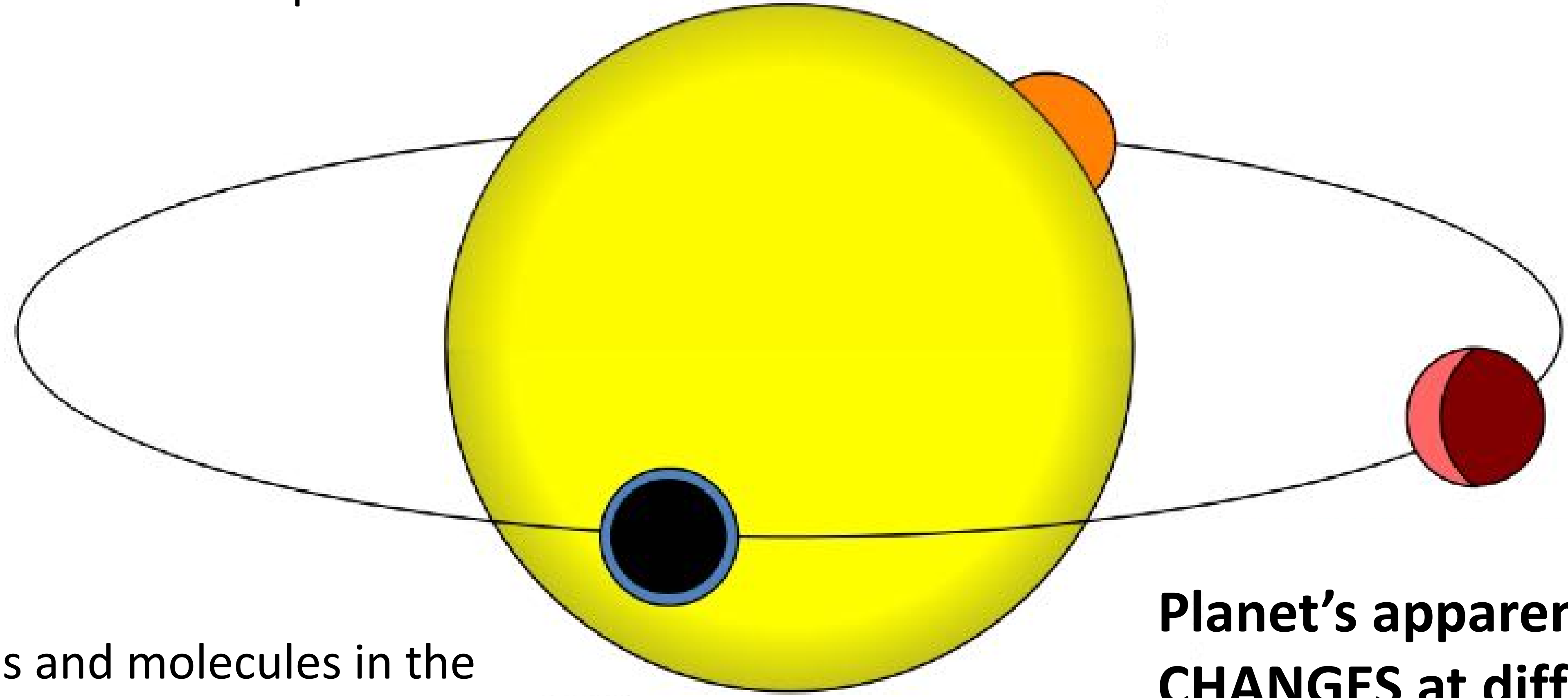


This applies across the entire **electromagnetic spectrum**



Gamma Scientific

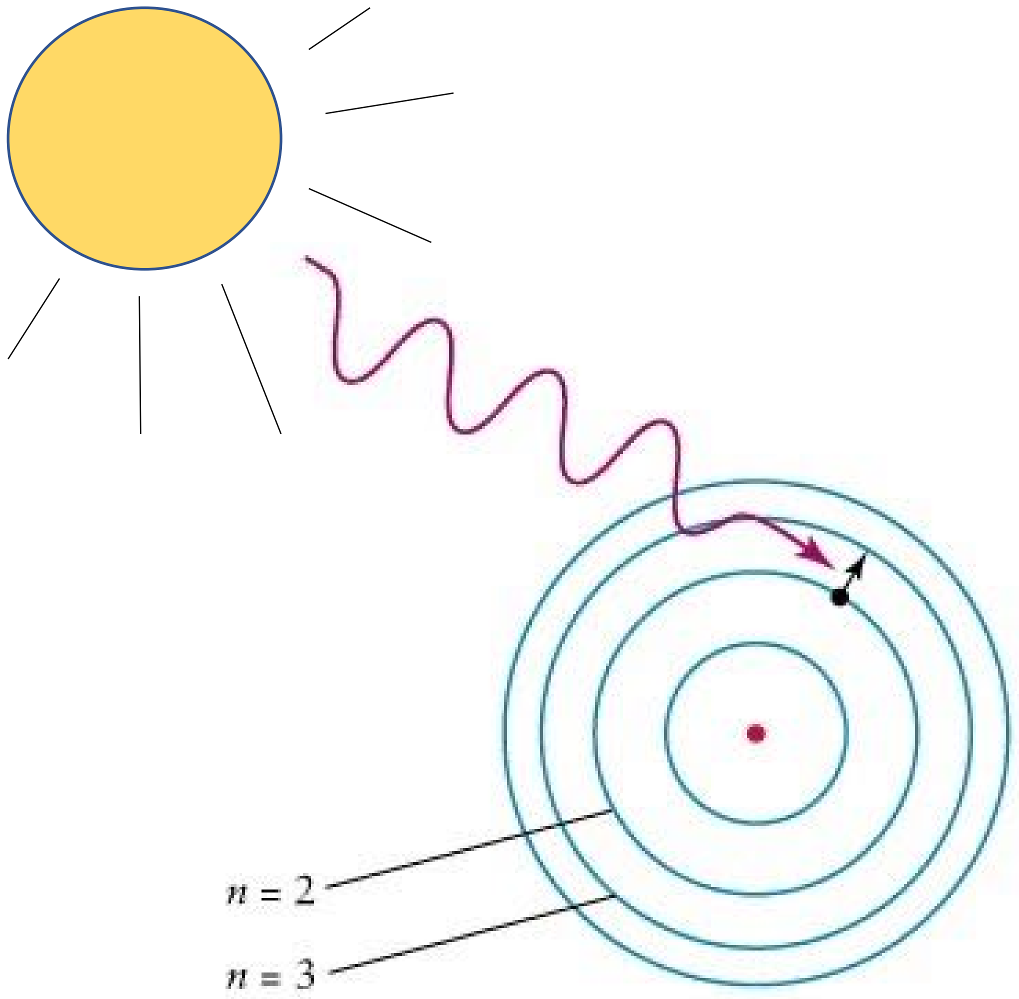
Starlight filters through
the planet’s atmosphere.



Atoms and molecules in the planet’s atmosphere imprint a signature in the light we see.

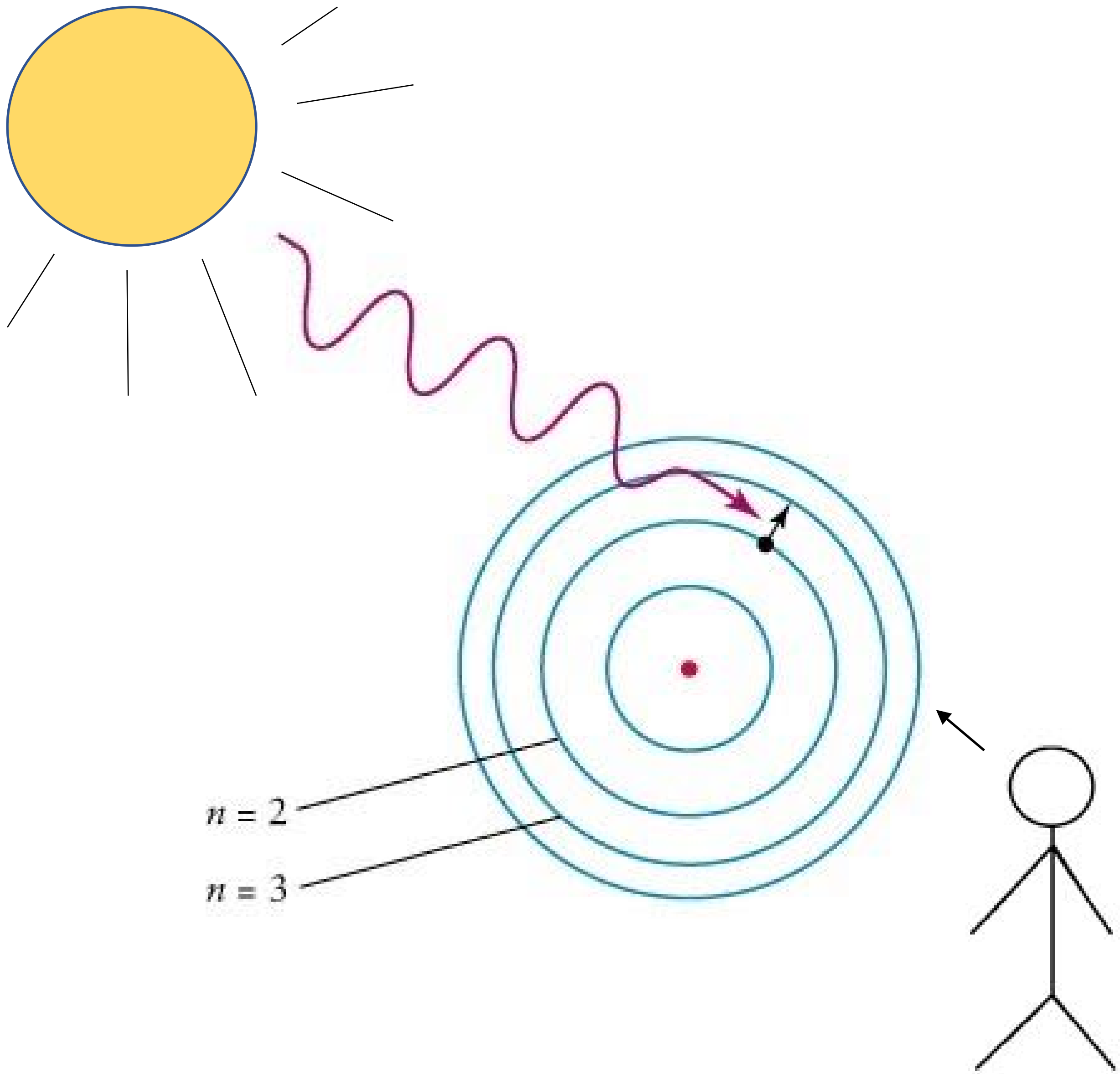
Planet’s apparent radius CHANGES at different wavelengths

Credit: S. Seager



Atoms and molecules absorb light at very specific wavelengths, leaving a "chemical signature"

Credit: Project on the Bohr Model

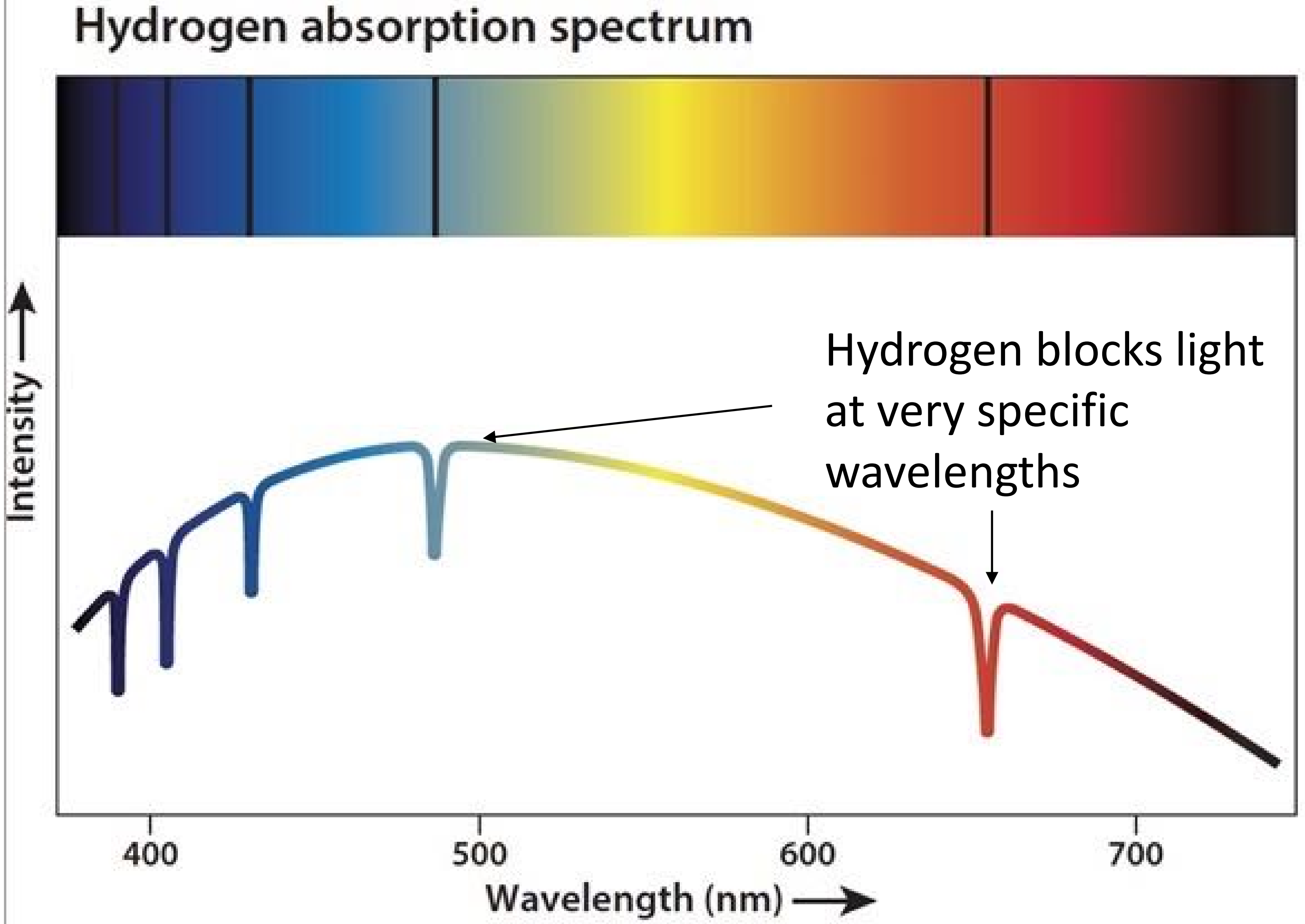


Atoms and molecules absorb light at very specific wavelengths, leaving a "chemical signature"

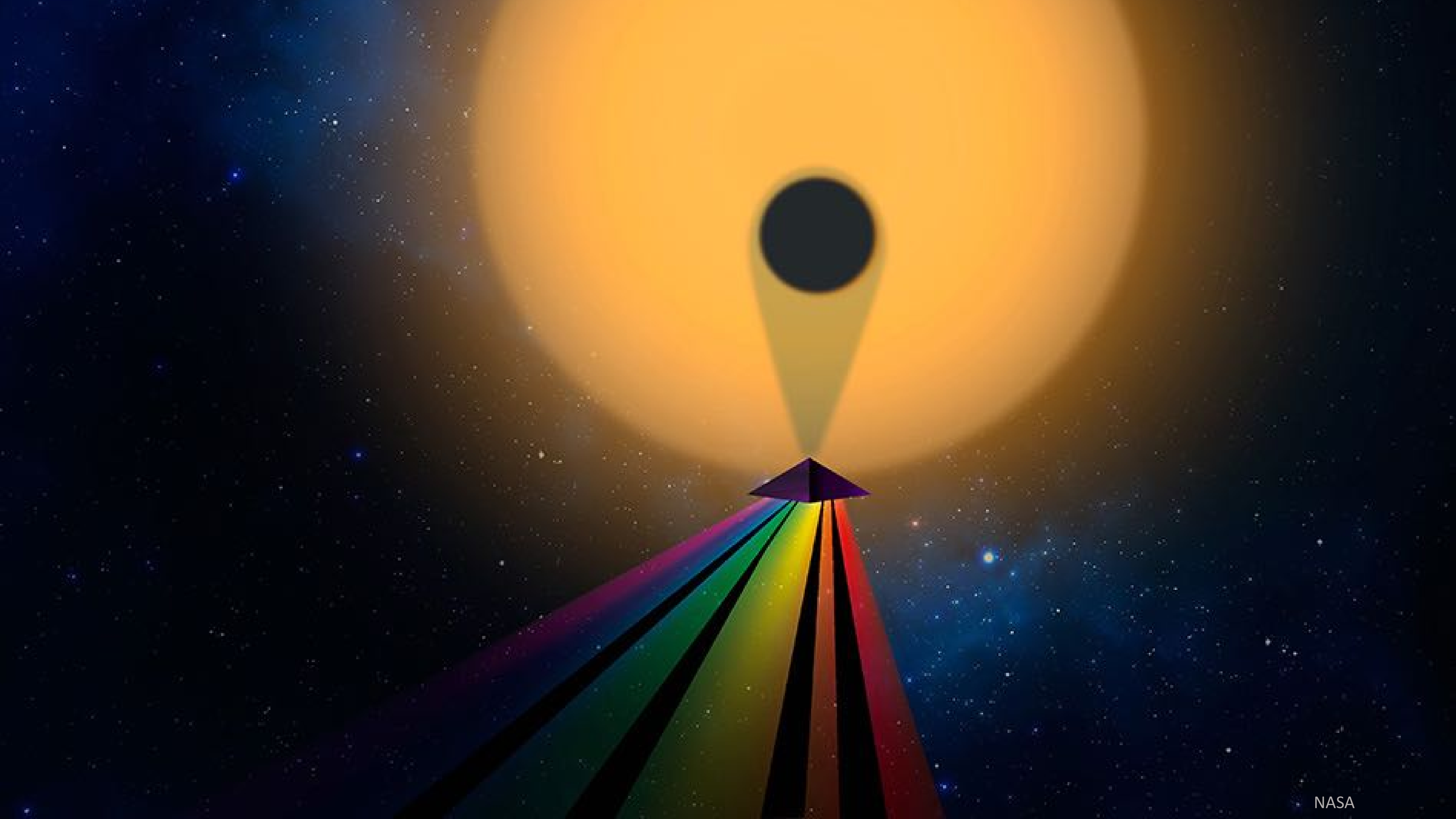
An observer sees light being blocked at very specific wavelengths

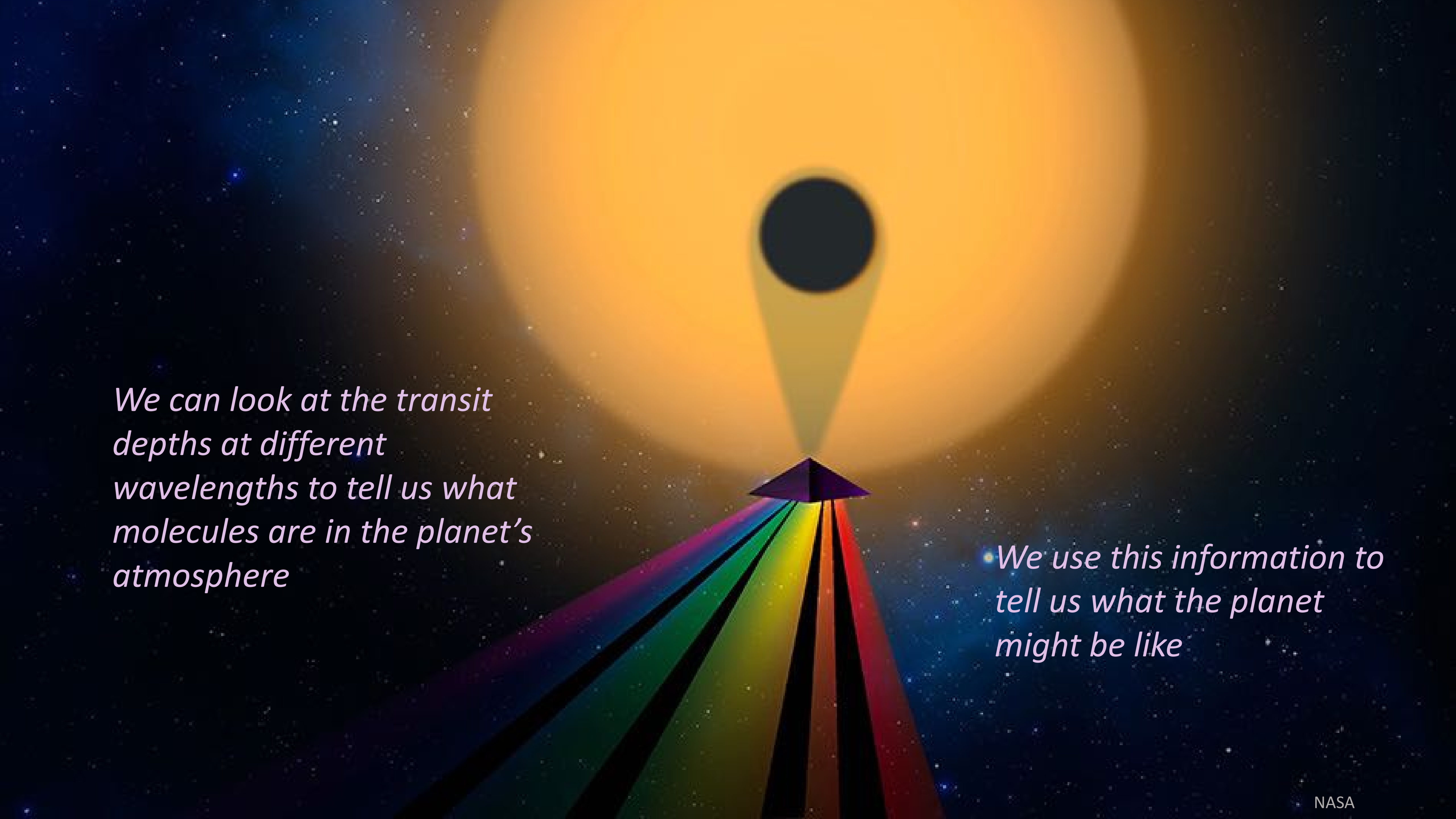
Credit: Project on the Bohr Model

Spectrum: the measurement of the amount of light at different wavelengths



Credit: Astronomy: Rick Johnson

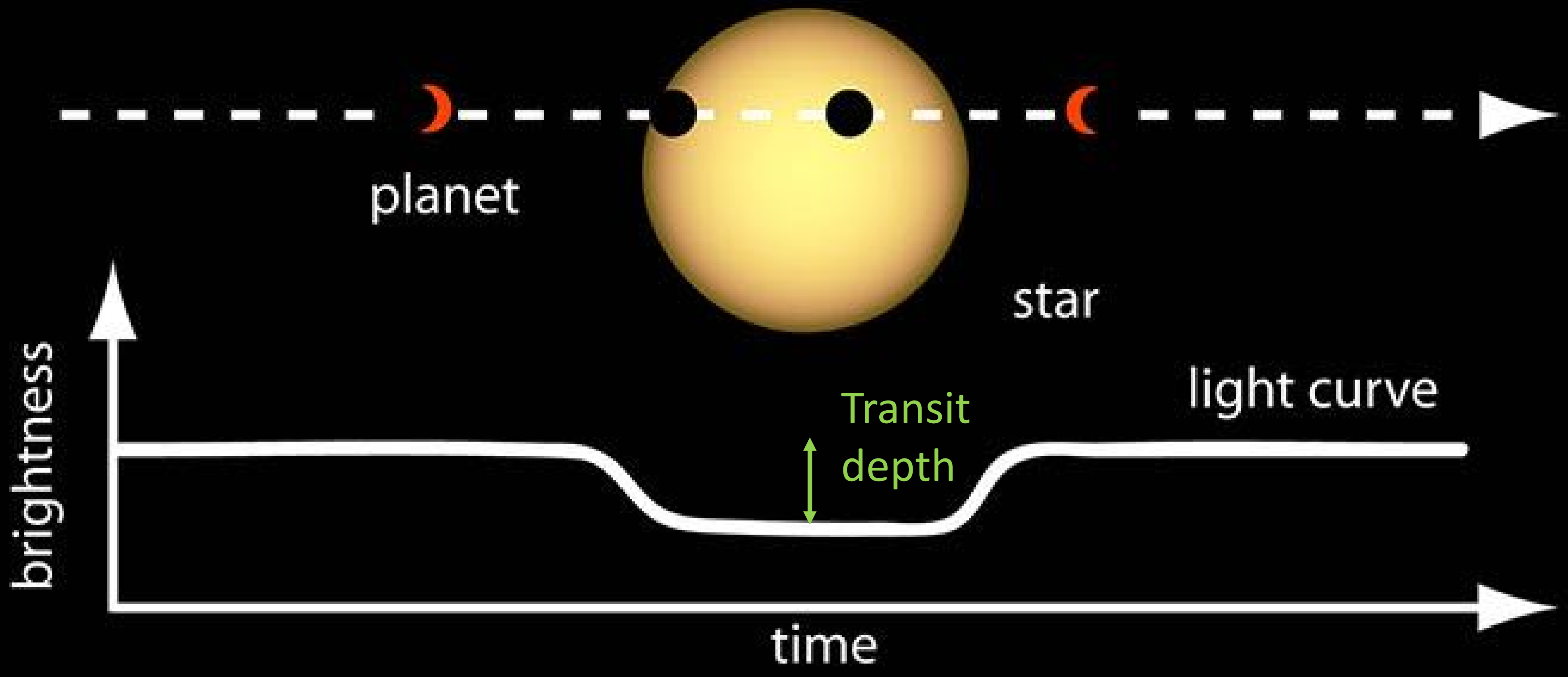

NASA



We can look at the transit depths at different wavelengths to tell us what molecules are in the planet's atmosphere

We use this information to tell us what the planet might be like

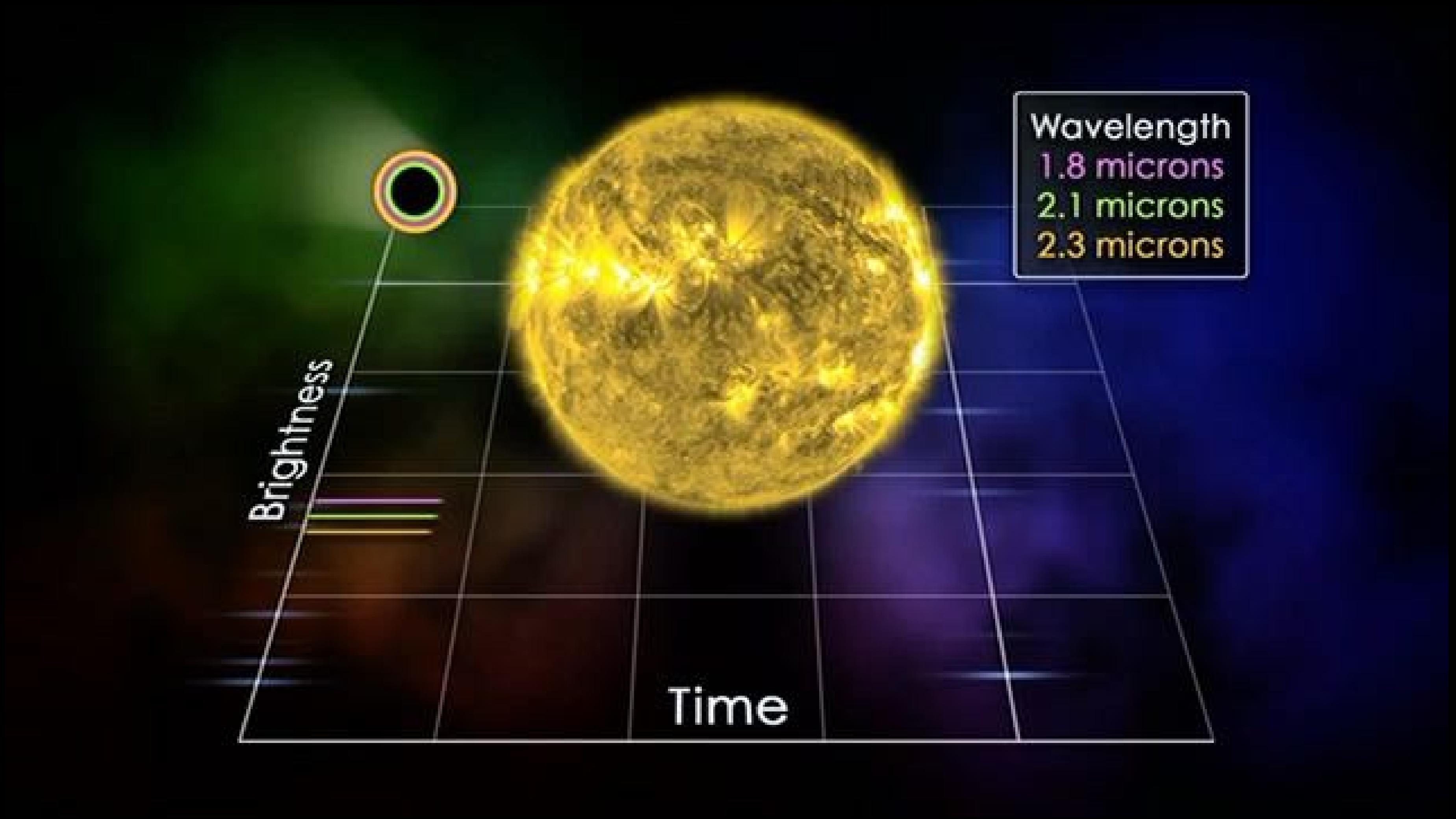
NASA

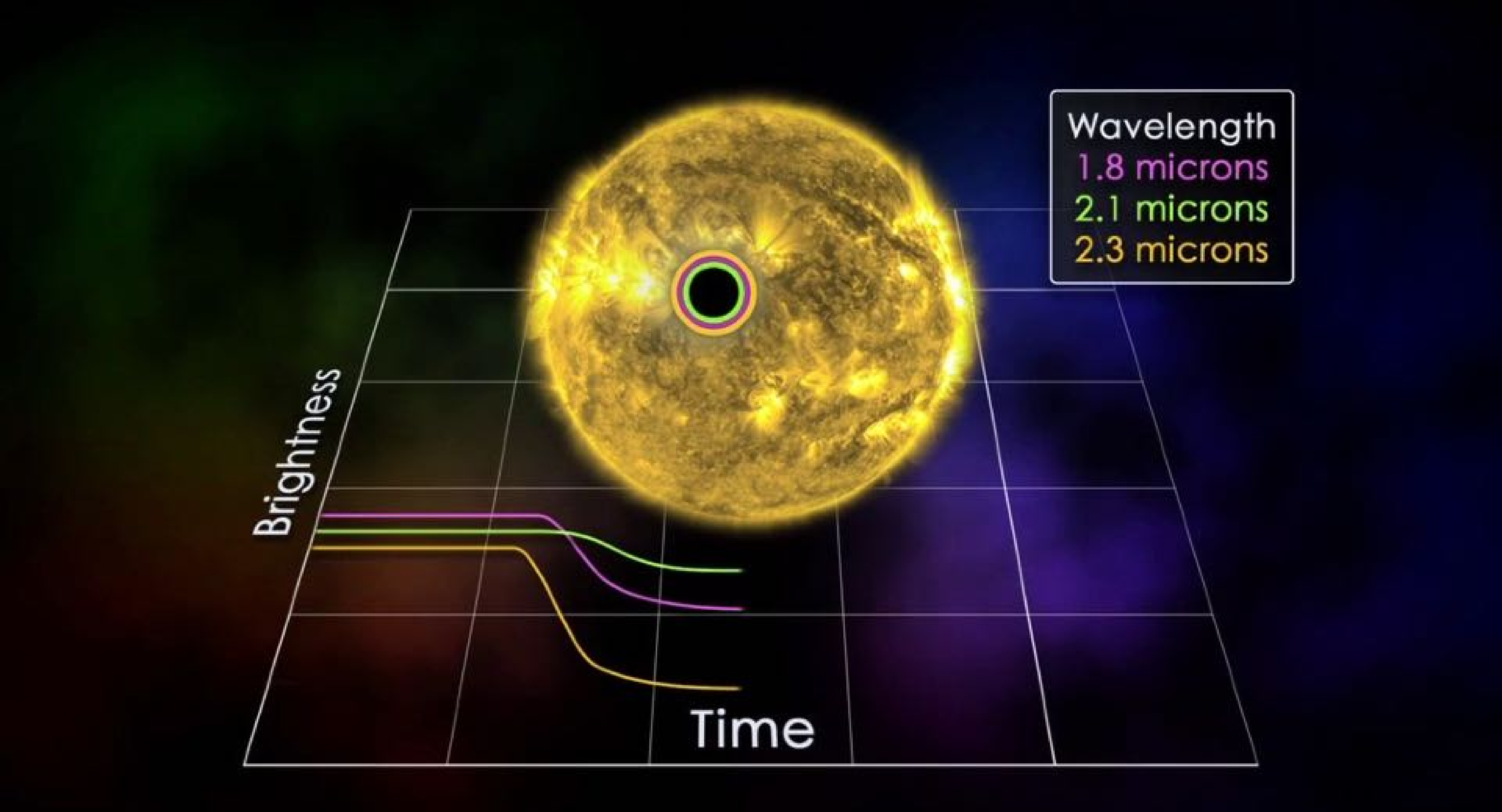


NASA Ames

Transmission Spectroscopy

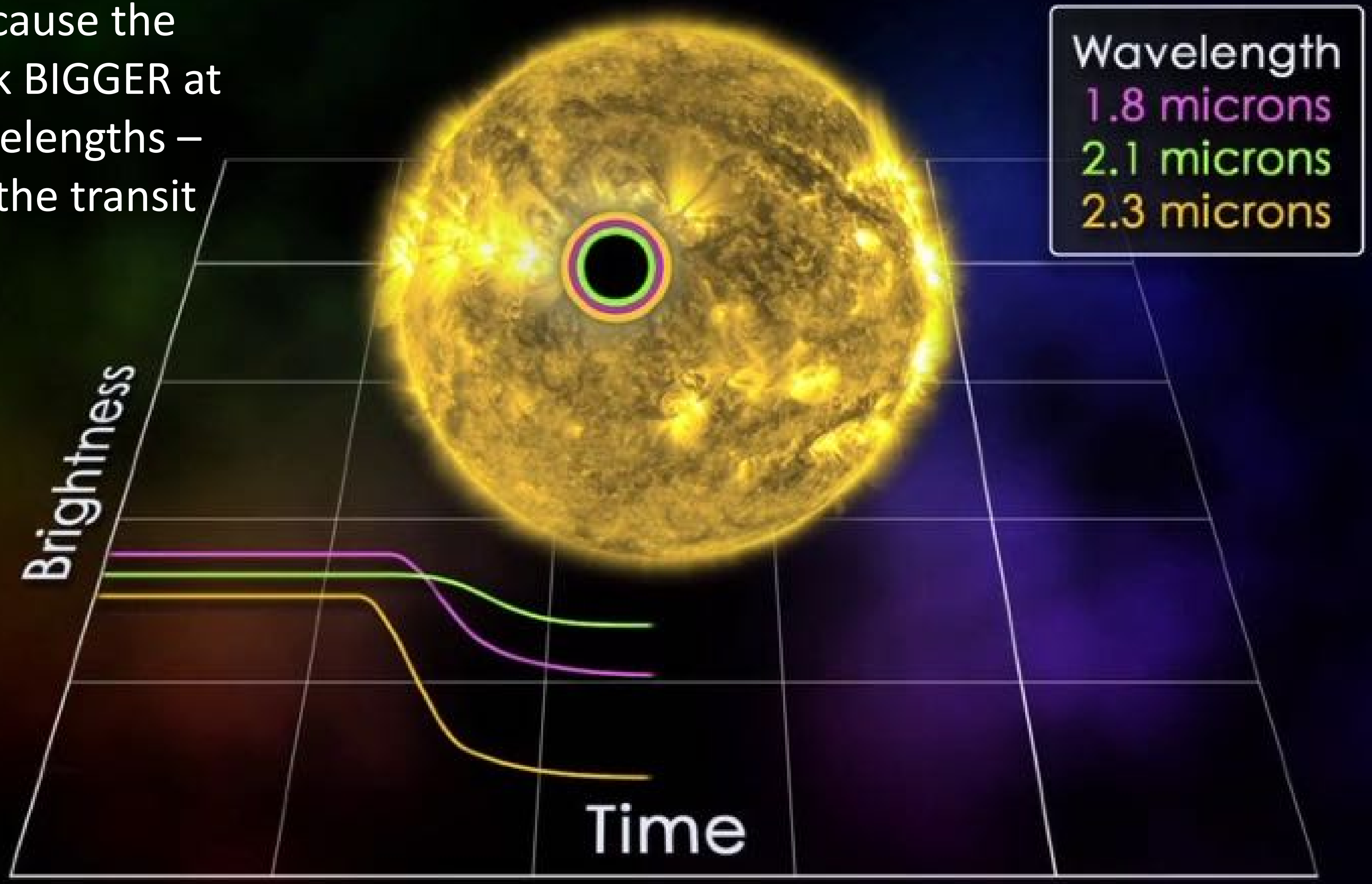
Transit depth is actually a function of wavelength





NASA Scientific Visualization Studio

Molecules in a planet's atmosphere cause the planet to look BIGGER at different wavelengths – this changes the transit depth



NASA Scientific Visualization Studio

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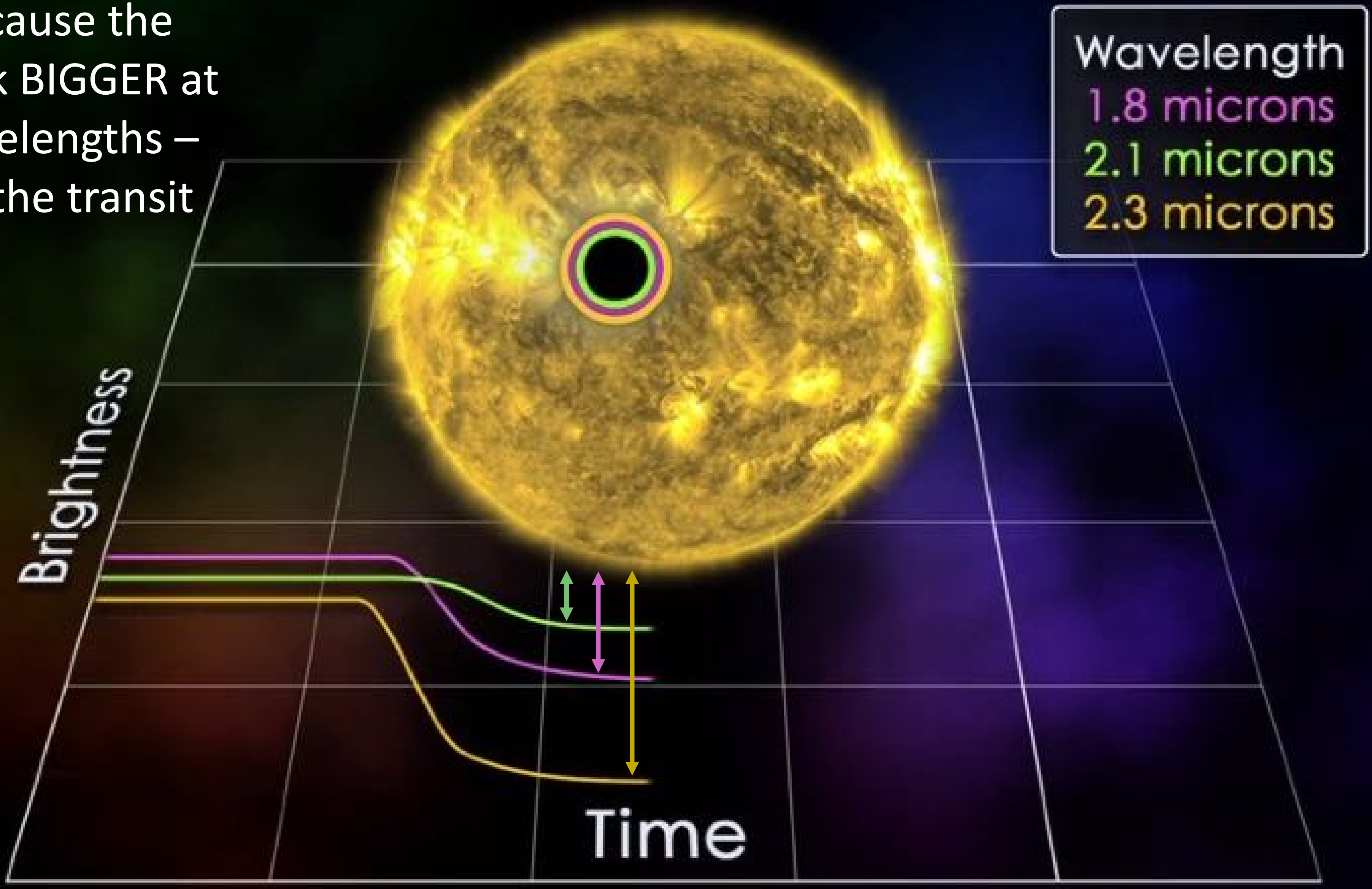
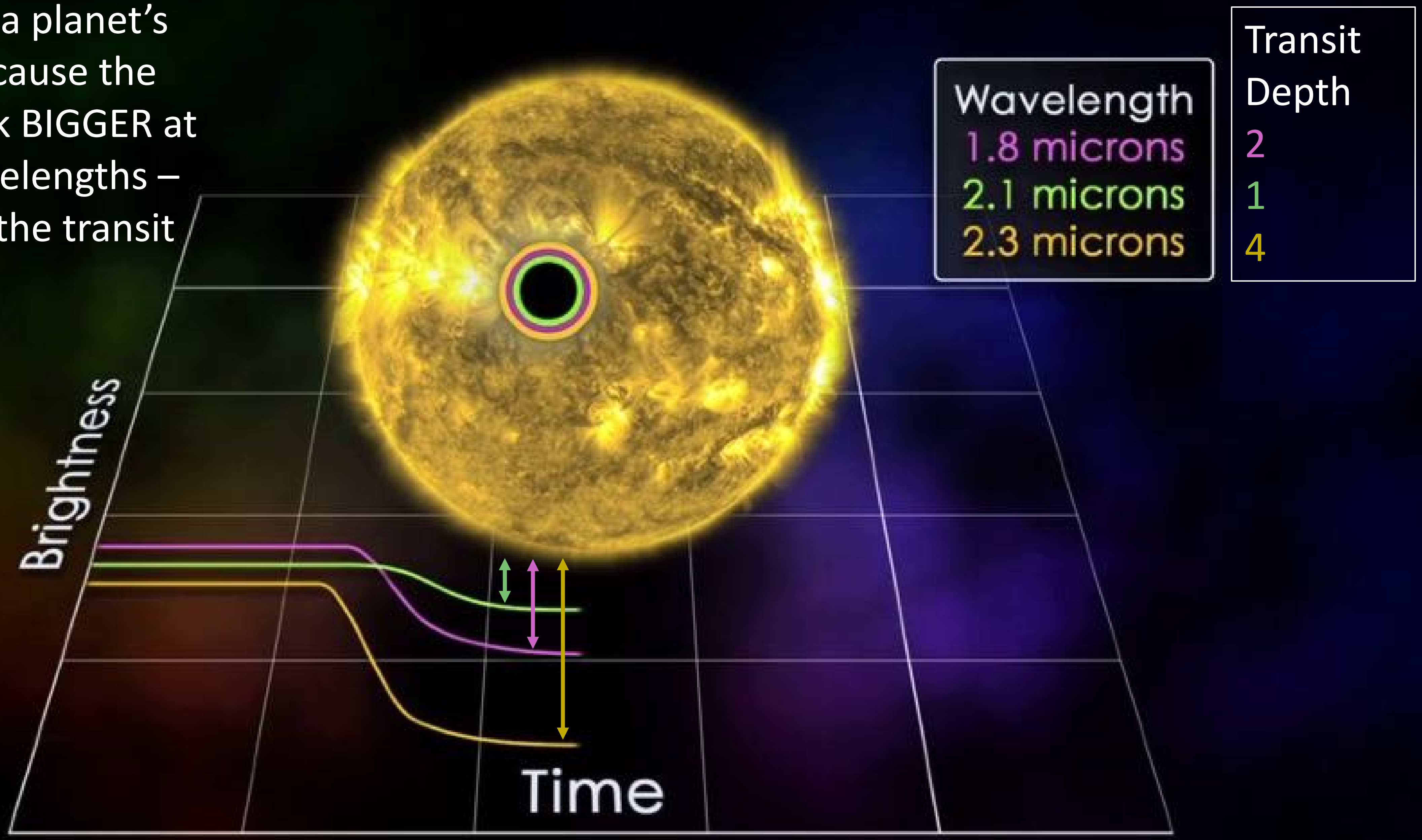


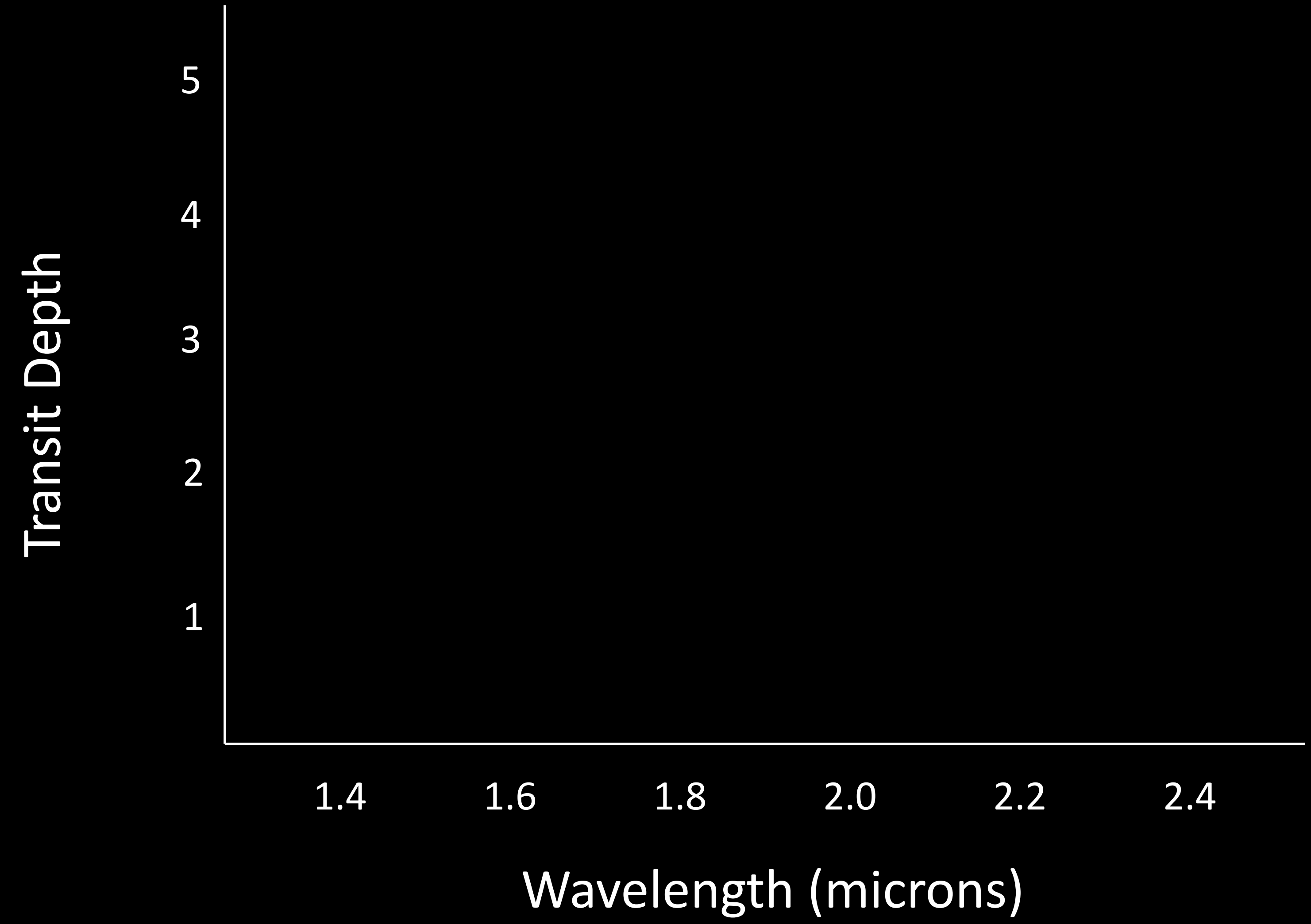
NASA Scientific Visualization Studio

Molecules in a planet's atmosphere cause the planet to look BIGGER at different wavelengths – this changes the transit depth

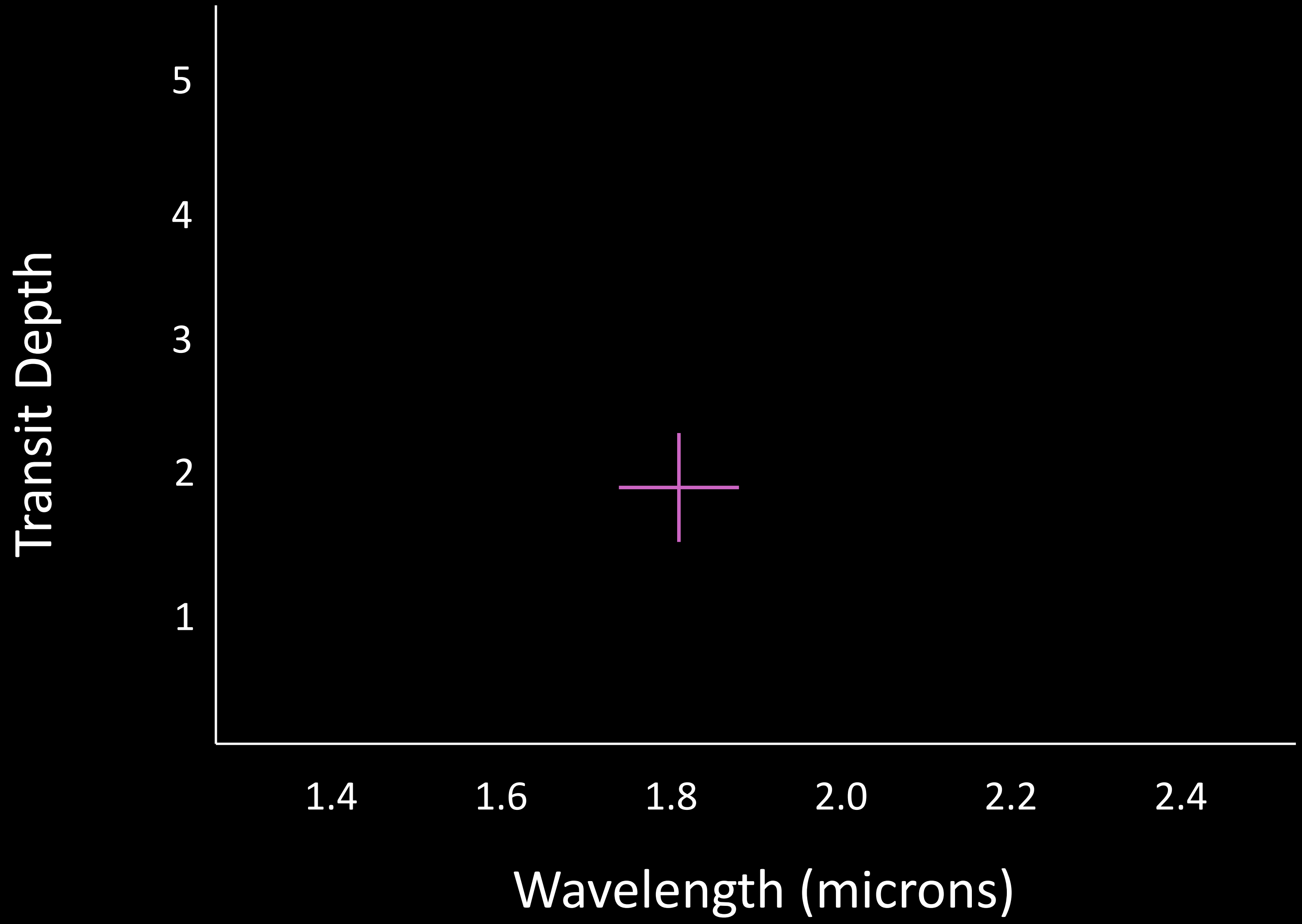


NASA Scientific Visualization Studio

NASA Scientific Visualization Studio

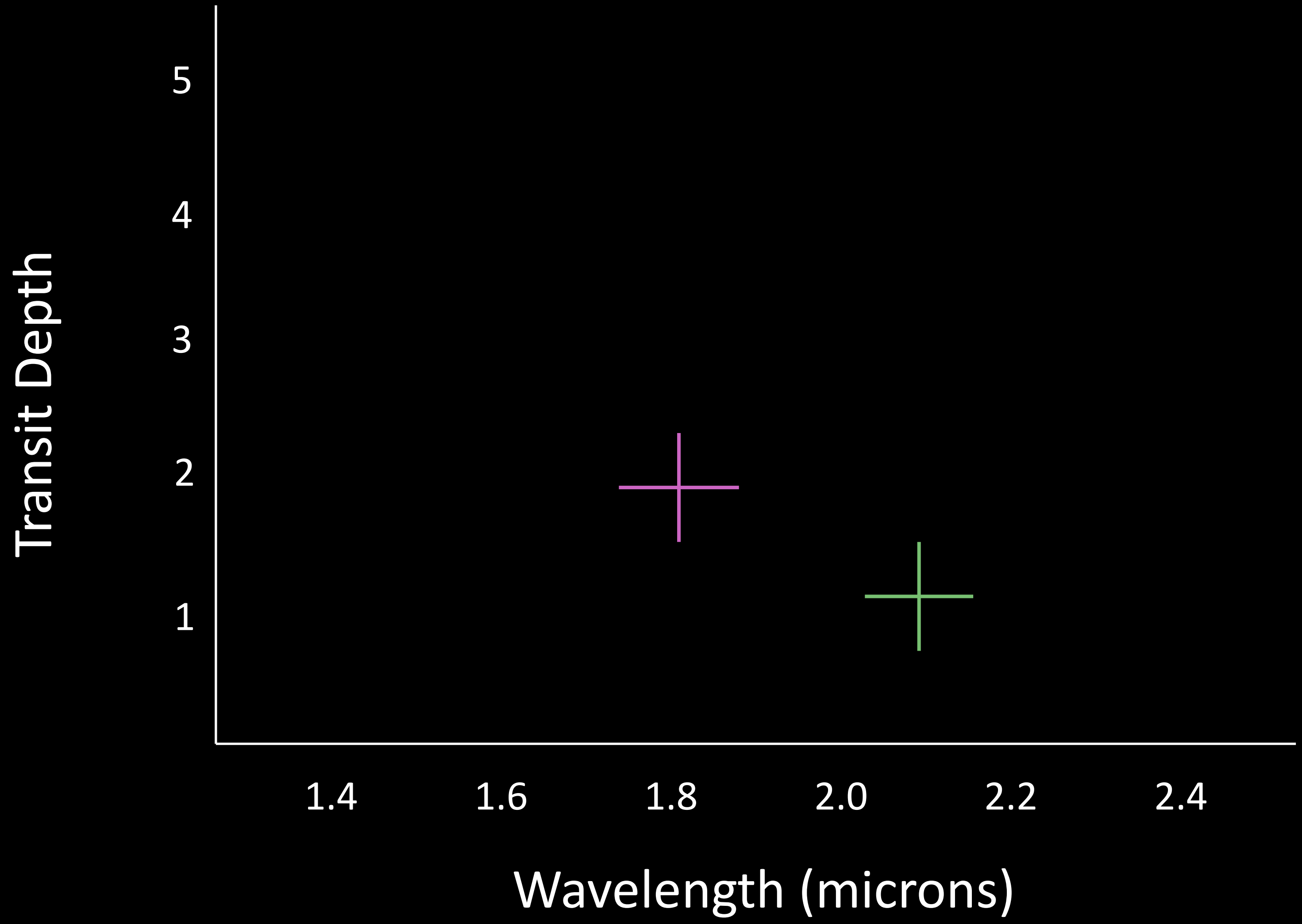


NASA Scientific Visualization Studio

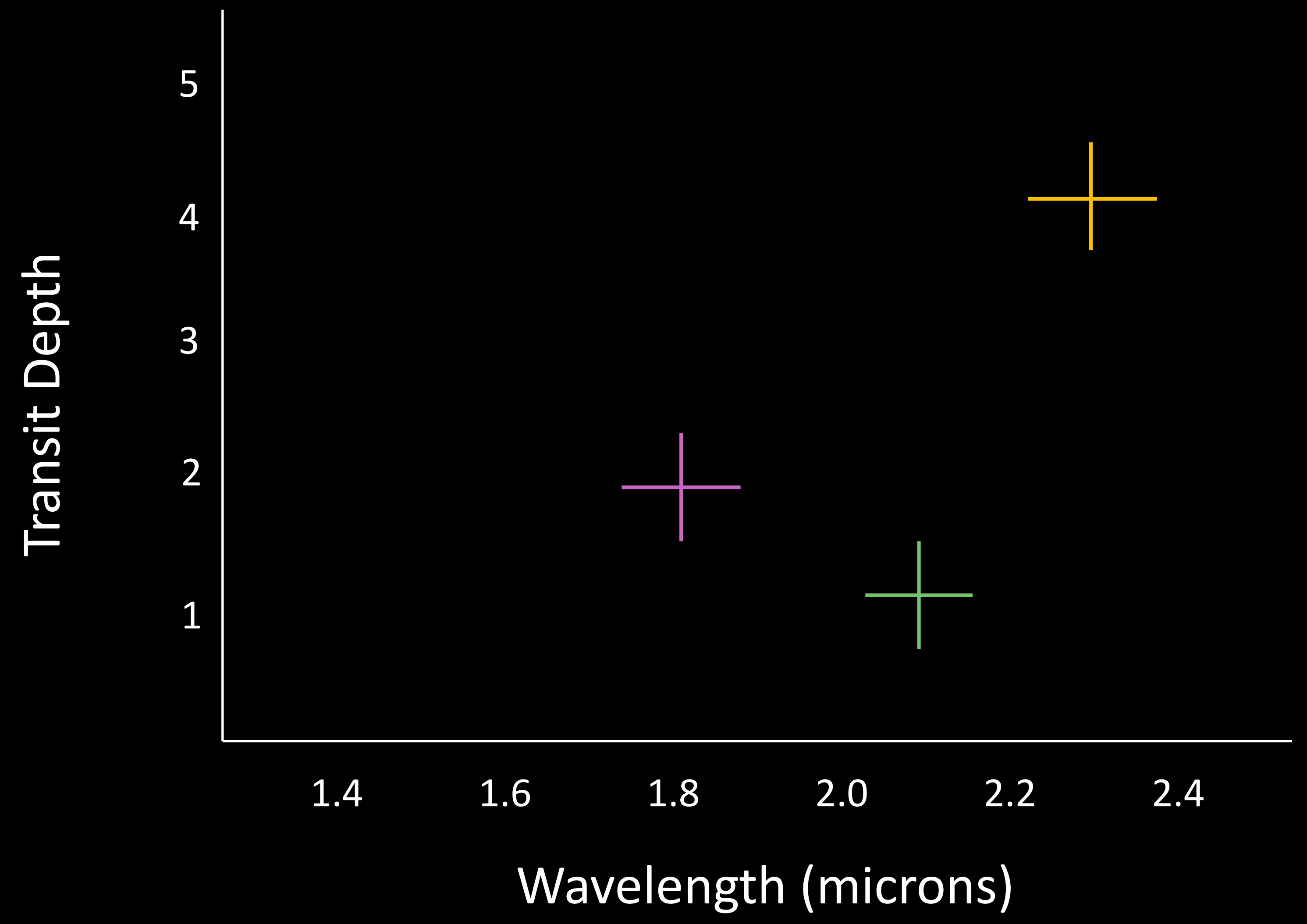


Transit Depth
2
1
4

NASA Scientific Visualization Studio

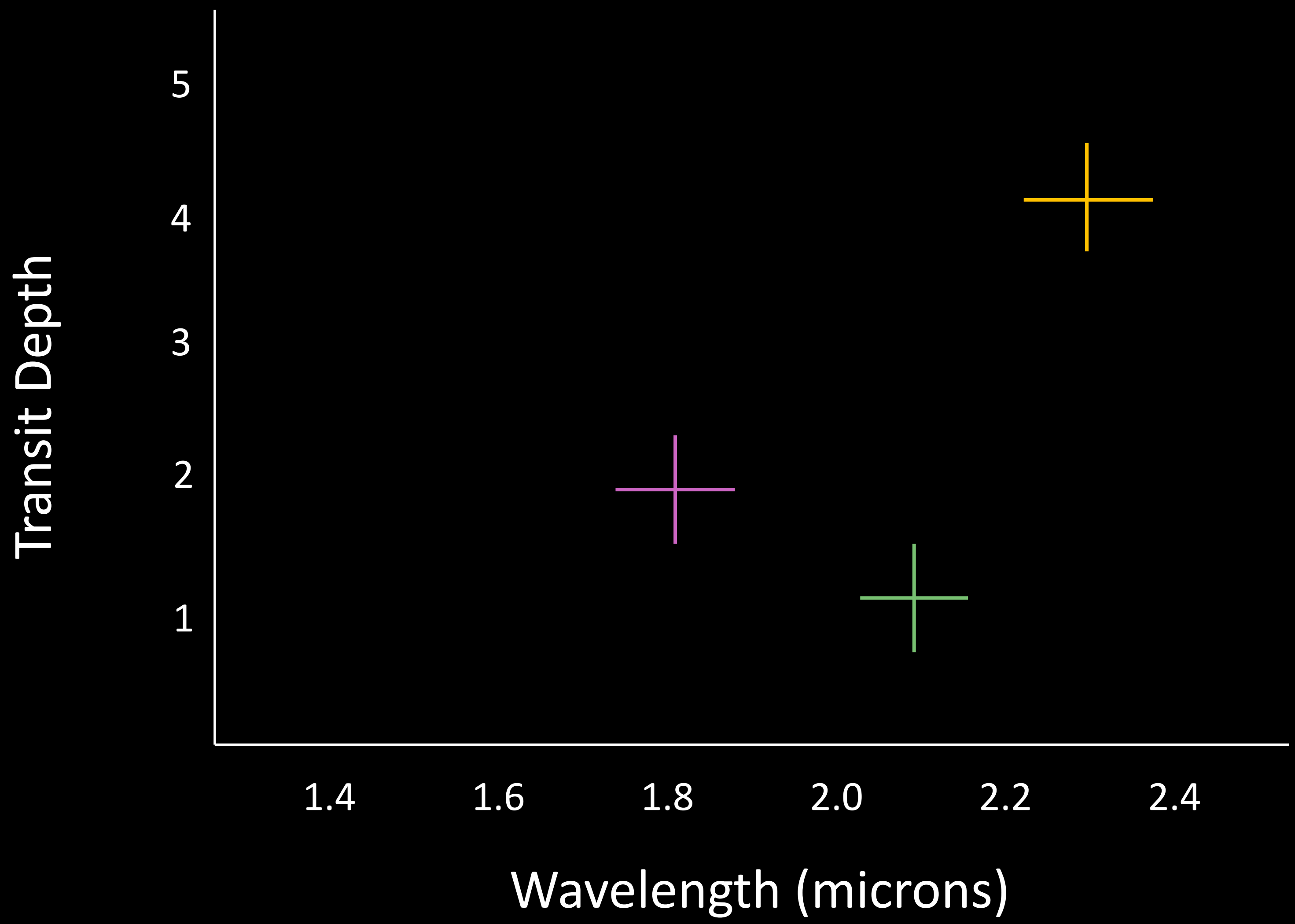


NASA Scientific Visualization Studio

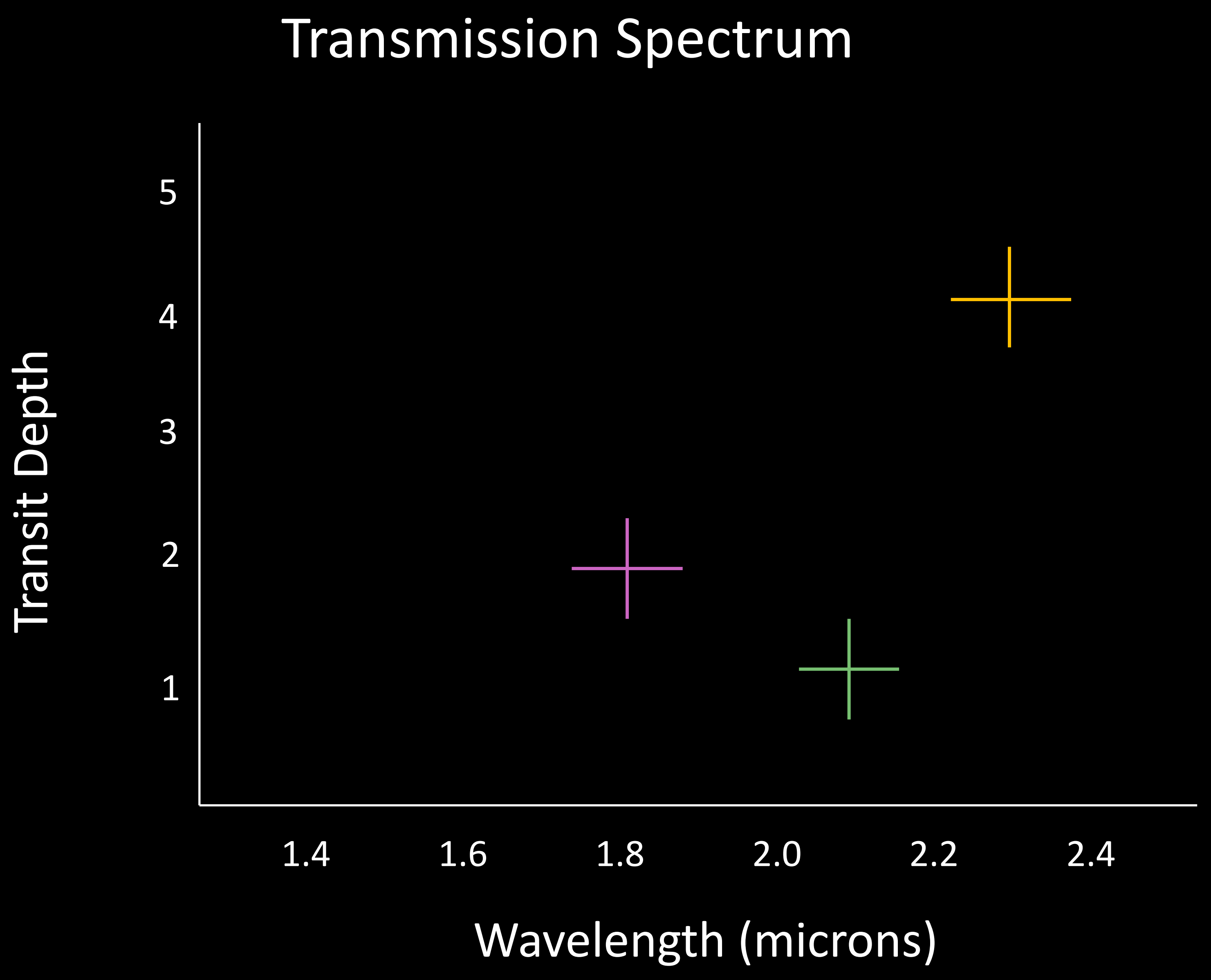


NASA Scientific Visualization Studio

Transmission Spectrum



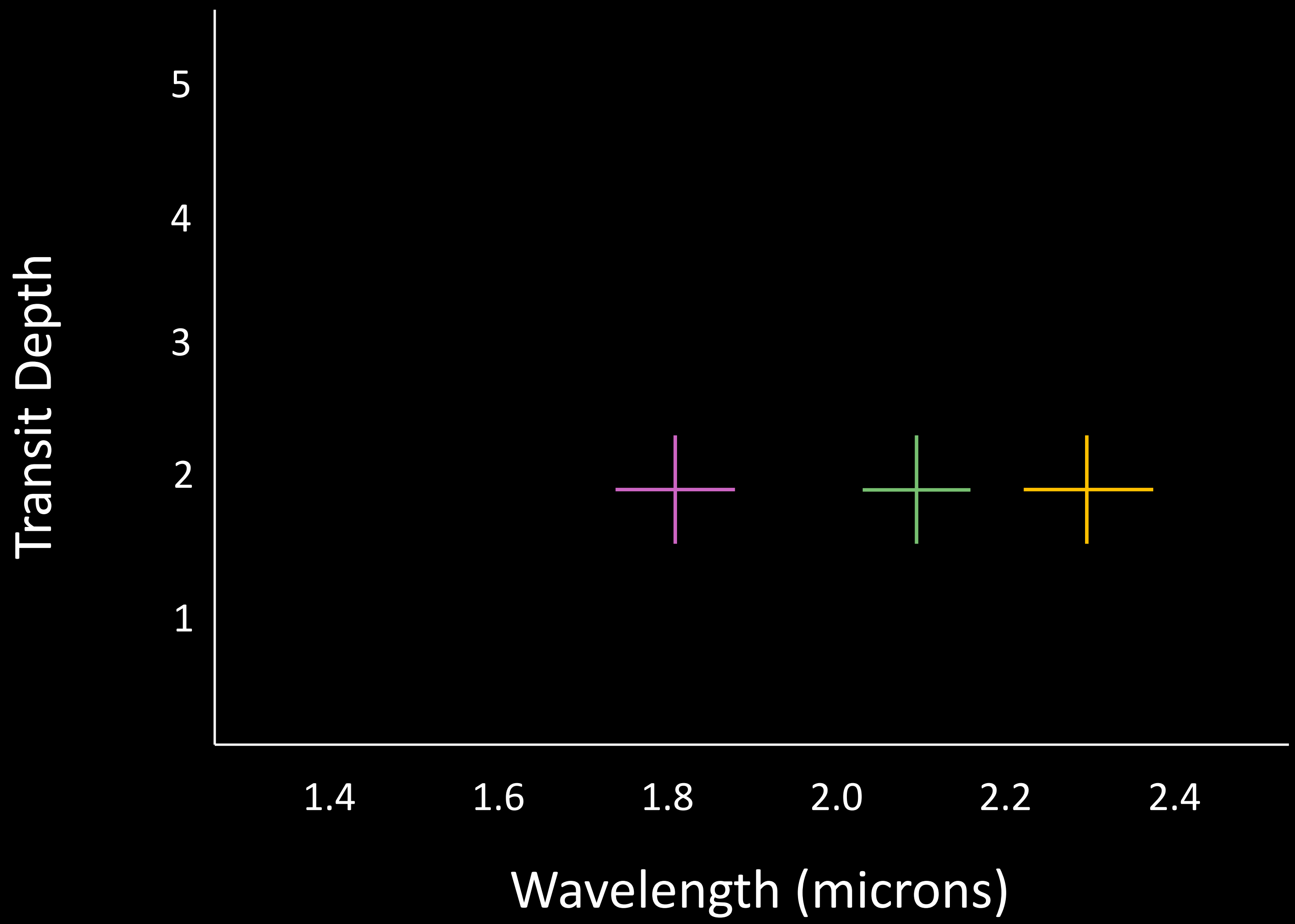
NASA Scientific Visualization Studio



The fact that these points are NOT at the same transit depth means this planet HAS an atmosphere

NASA Scientific Visualization Studio

Transmission Spectrum



If the spectrum is “flat”, this suggests the planet has NO atmosphere

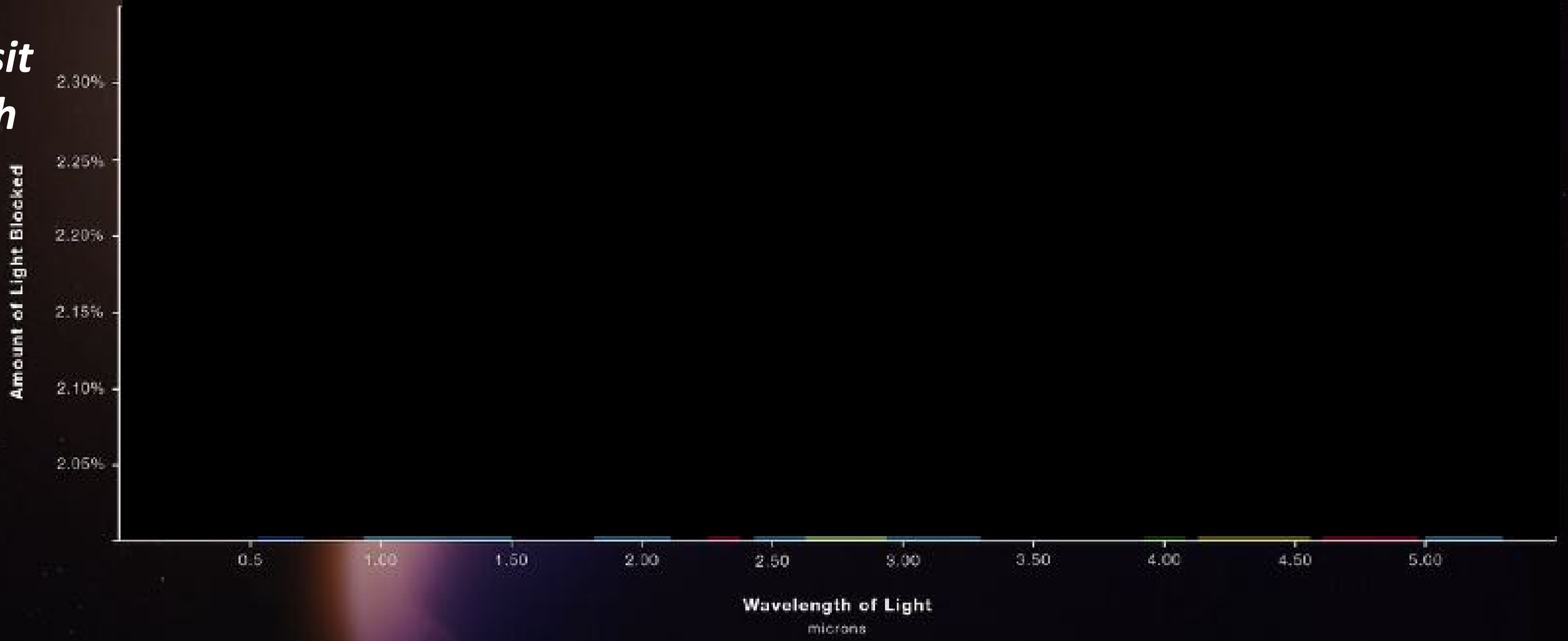
NASA Scientific Visualization Studio

HOT GAS GIANT EXOPLANET WASP-39 b

ATMOSPHERE COMPOSITION

NIRSpec PRISM

Transit Depth



WEBB SPACE TELESCOPE

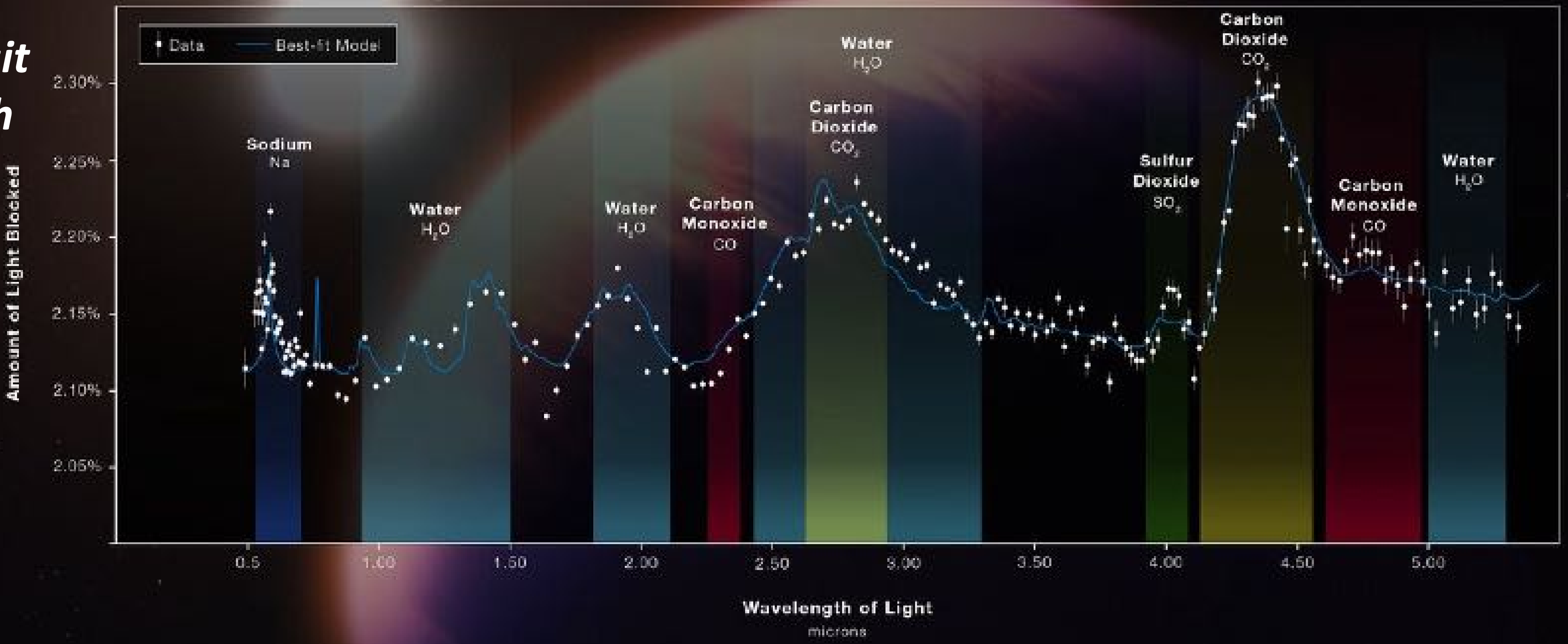
Credit: NASA, ESA, CSA, Joseph Olmsted (STScI)

HOT GAS GIANT EXOPLANET WASP-39 b

ATMOSPHERE COMPOSITION

NIRSpec PRISM

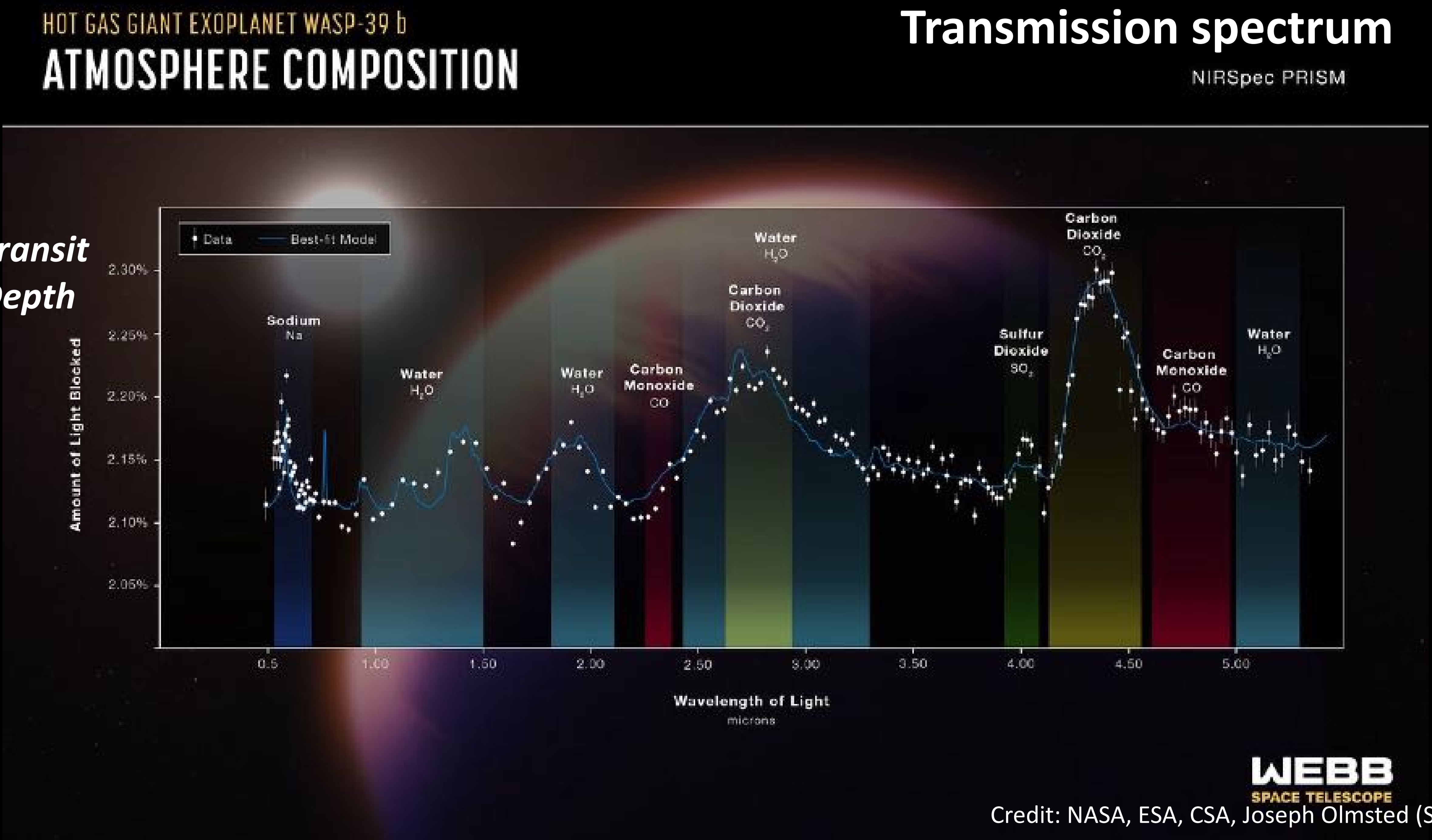
Transit Depth



WEBB SPACE TELESCOPE

Credit: NASA, ESA, CSA, Joseph Olmsted (STScI)

Transmission spectrum

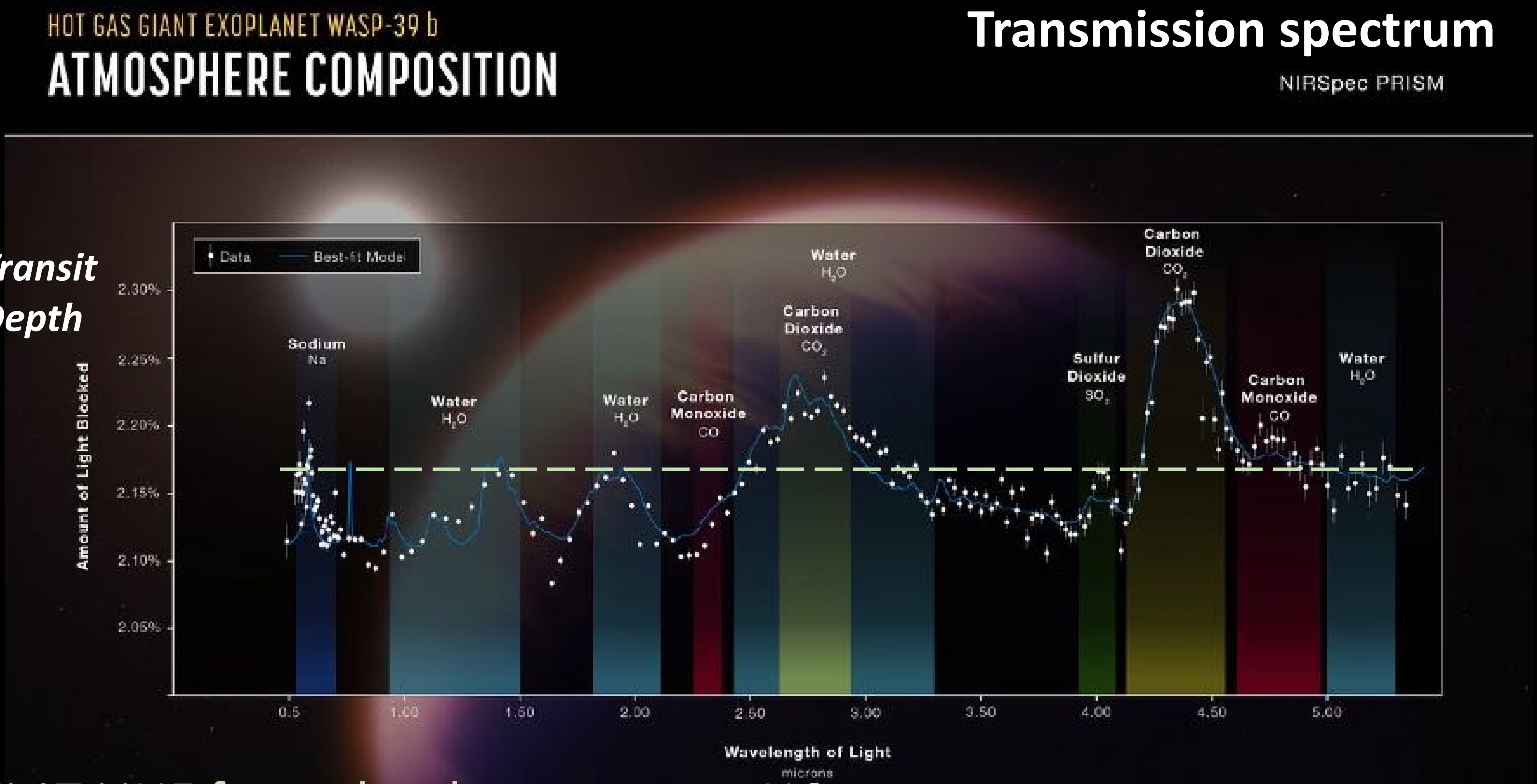


Transit Depth

Credit: NASA, ESA, CSA, Joseph Olmsted (STScI)

Transmission spectrum

Transit Depth



FLAT LINE for rocky planets means NO ATMOSPHERE (most likely)

WEBB SPACE TELESCOPE

Credit: NASA, ESA, CSA, Joseph Olmsted (STScI)

ROCKY EXOPLANET LHS 475 b

TRANSMISSION SPECTRUM

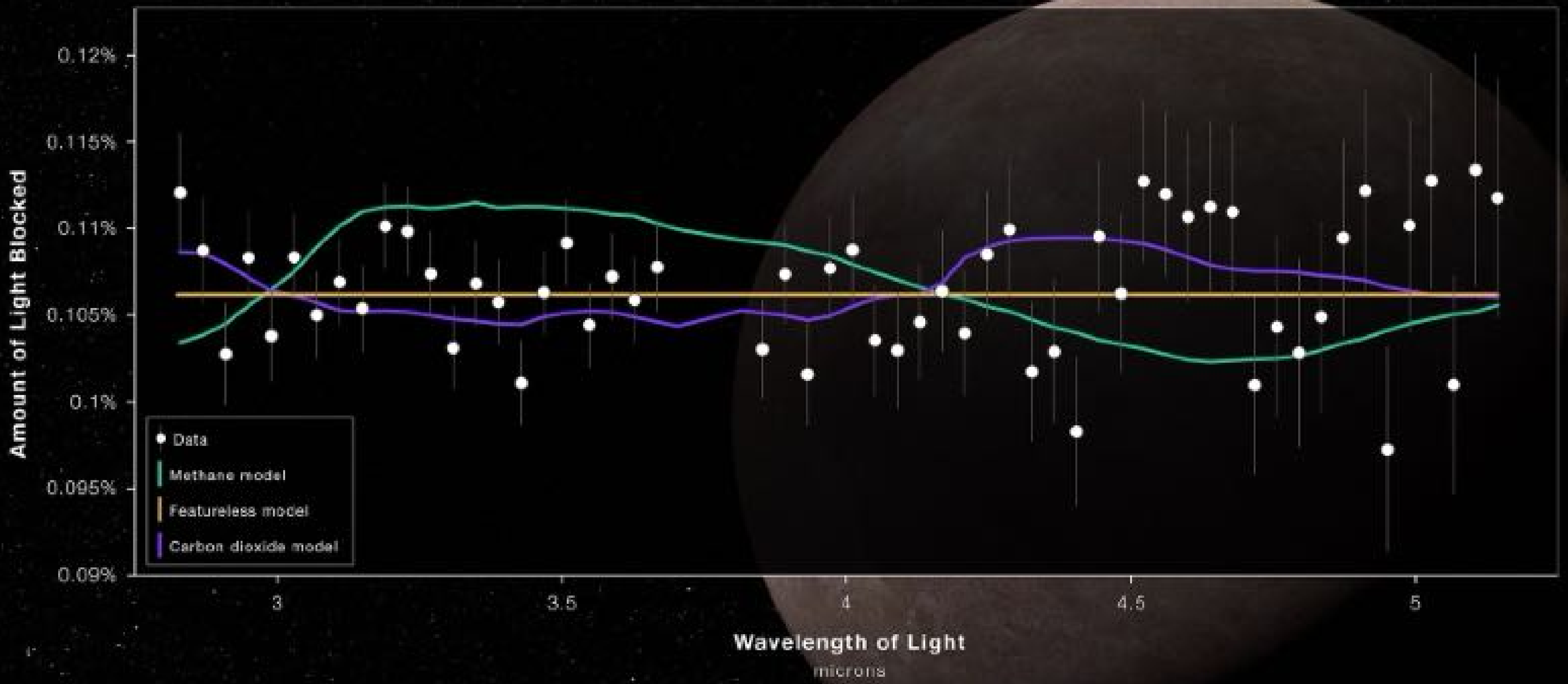
NIRSpec | Bright Object Time-Series Spectroscopy

WEBB
SPACE TELESCOPE

ROCKY EXOPLANET LHS 475 b

TRANSMISSION SPECTRUM

NIRSpec | Bright Object Time-Series Spectroscopy



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K2-18b

K2-18b

An Earth-like planet? Tantalising proof of life on THIS exoplanet has scientists in 'shock'

Cambridge, England • Edited By: Trisha Pathak • Updated: Apr 29, 2024, 03:08 PM IST

Forget Mars, are there aliens on... K2-18b? Discovery of planet twice as big as Earth emitting gas 'only produced by life' sparks huge excitement among astronomers

Planet K2-18b: 5 Facts About "Super Earth" Being Probed For Alien Life

Planet K2-18b: 5 Facts About "Super Earth" Being Probed For Alien Life

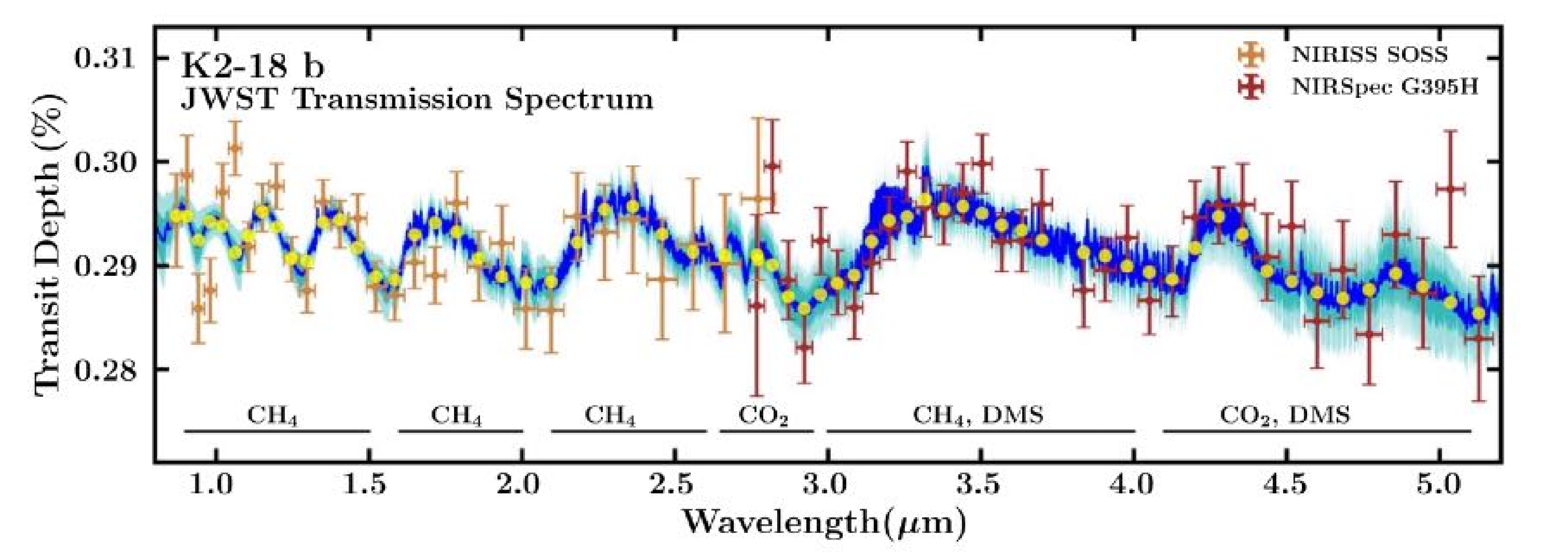
K2-18b orbits a red dwarf star, which is smaller and dimmer than our sun, and it completes one orbit in32.9 days.

Science | Edited by NDTV News Desk | Updated: April 29, 2024 12:21 pm IST

K2-18b

Webb Discovers Methane, Carbon Dioxide in Atmosphere of K2-18 b

K2-18b



Madhusudhan et al. 2023


knowyourmeme.com
Right. Where are we going?

Credit: ESA