



TEEN ASTRONOMY

Café – To Go!



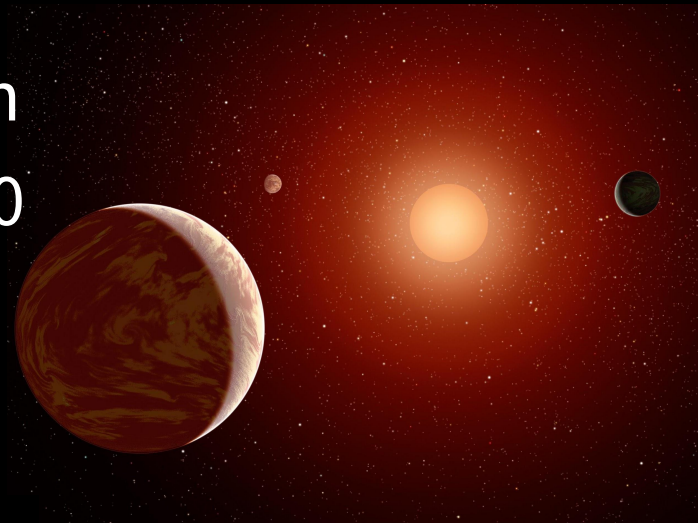


Finding the Ingredients of Other Worlds

How Spectra Tell Us what Extrasolar Planets are Made Of



Everett Schlawin
NOIRLab 10/3/20



With Help from the NIRC2 team: (PI) Marcia Rieke et al.,
Some slides borrowed from John Mather, Christina Williams, George Rieke, Kevin Hainline

Image Credits: <https://www.nasa.gov/>

About Me: Everett Schlawin

Oberlin, OH



Princeton Jct, NJ



Cornell, NY



University of Arizona



How I got interested in Astronomy

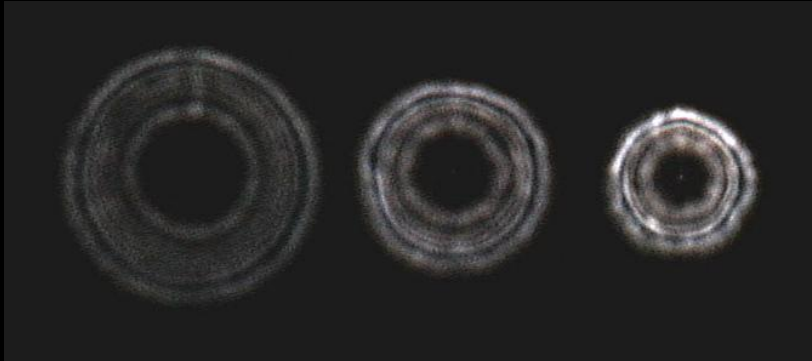


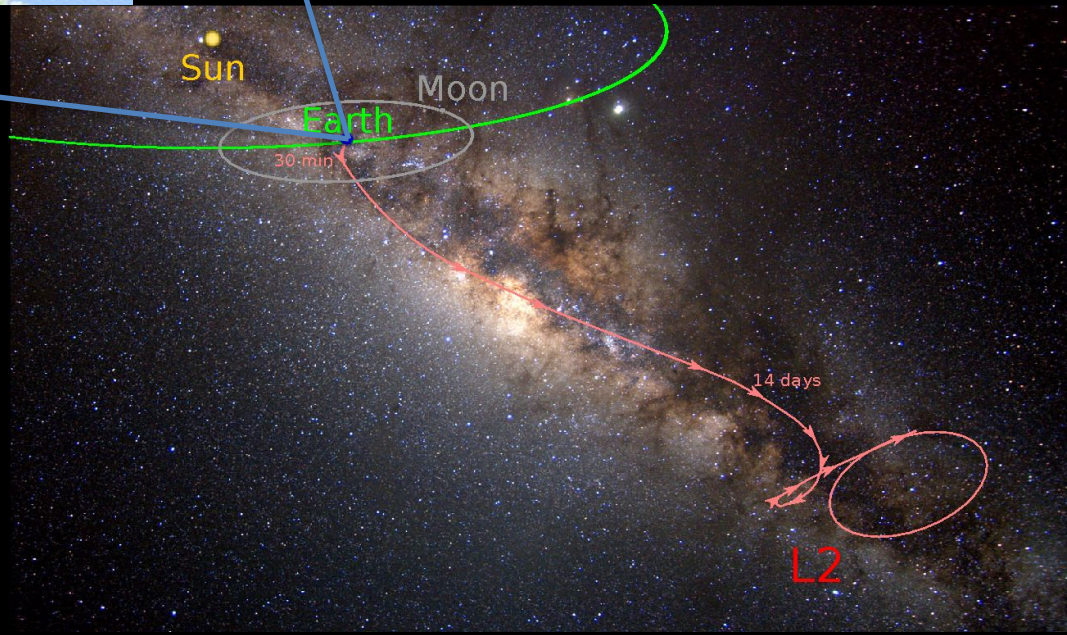
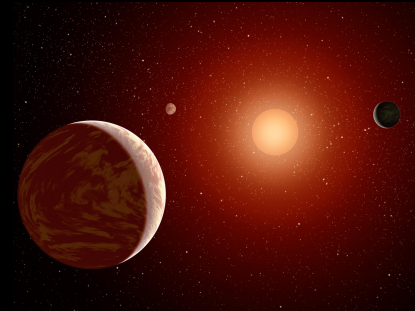
Image credit: arnholm.org



Image from Oberlin College Observatory

Journey of the James Webb Space Telescope

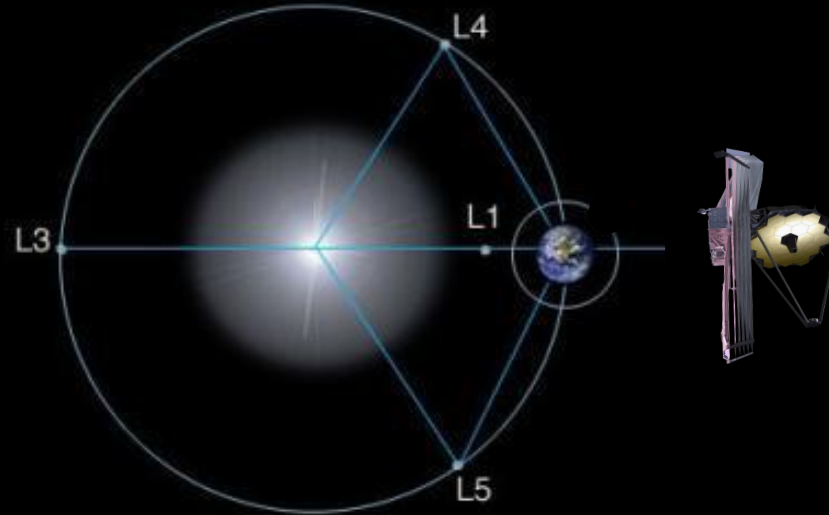




The James Webb Space Telescope Deployment



L2 Orbit – Stable and Uninterrupted

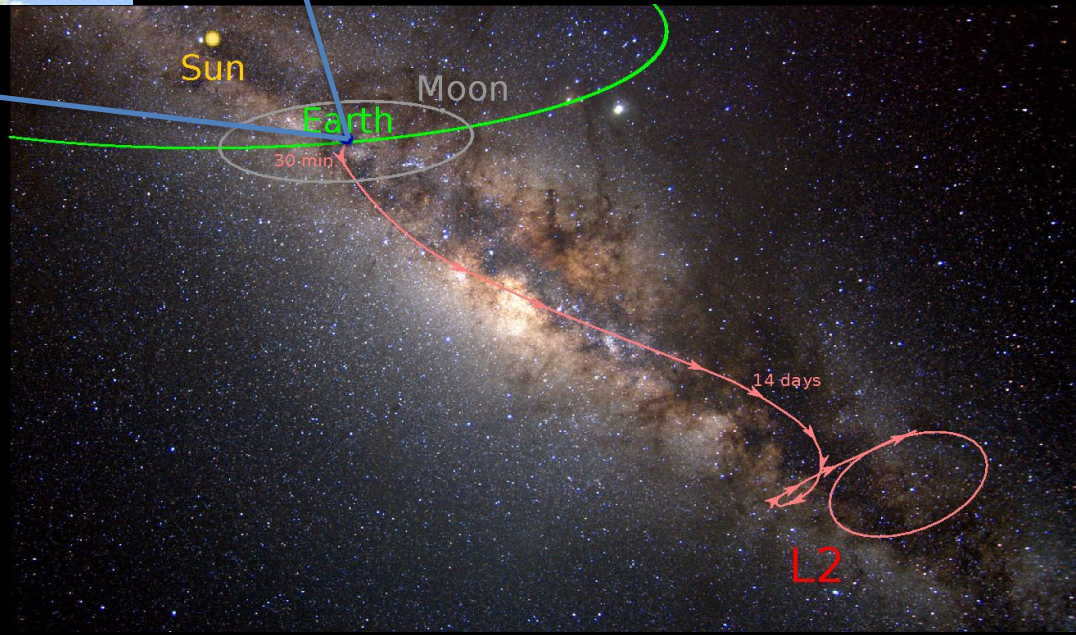
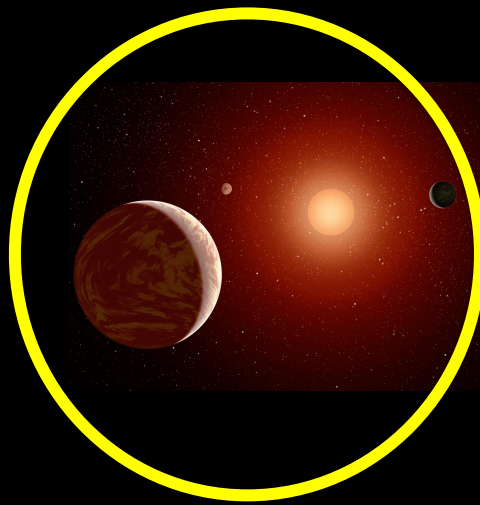


(Image not to scale)

Infrared Light Senses Heat

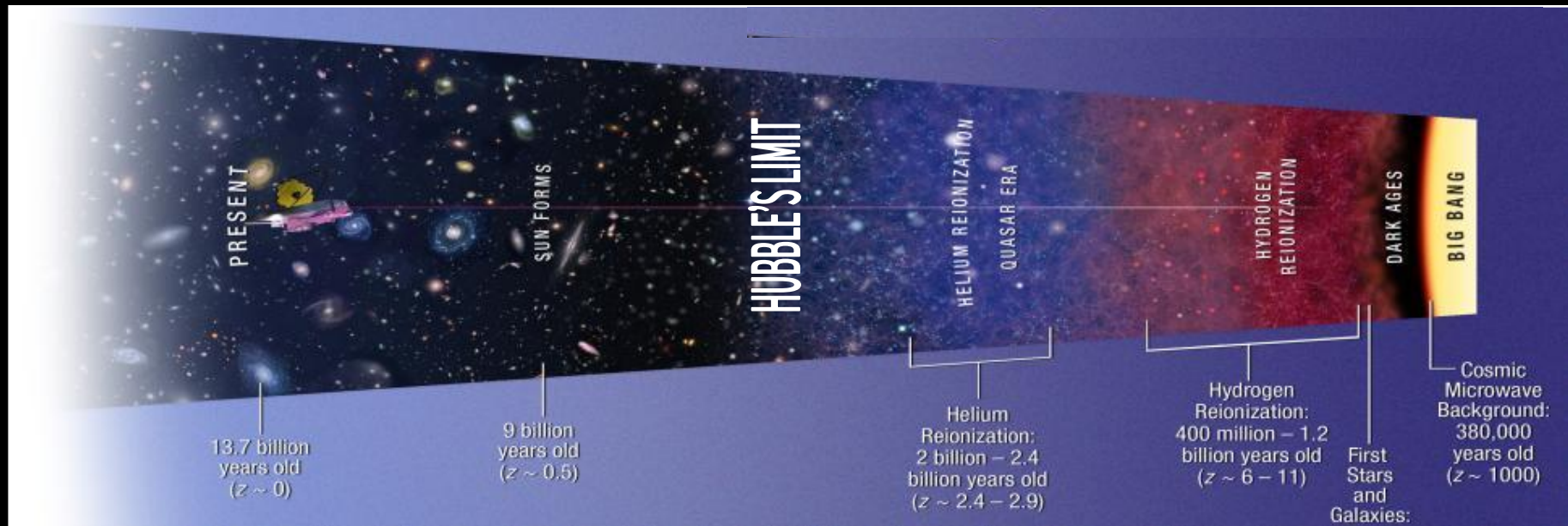


From:
spitzer.caltech.edu



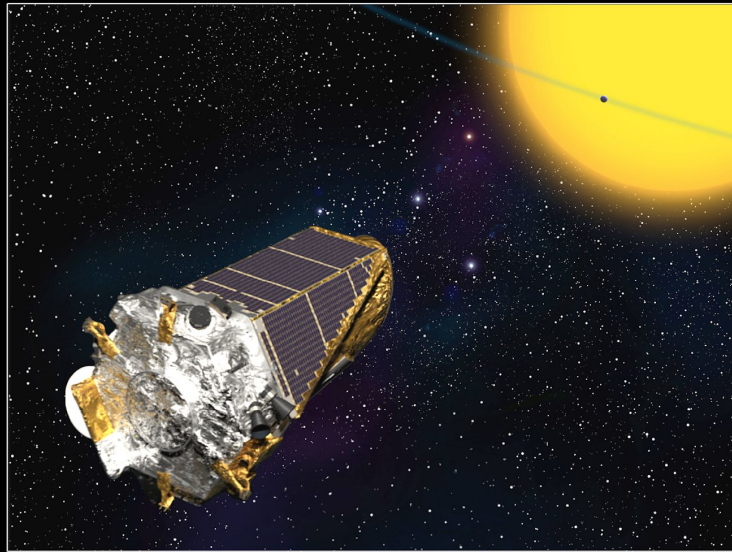
JWST Science Themes

- First Light and the End of the Dark Ages
- Assembly of Galaxies
- Birth of Stars and Protoplanetary Systems
- Planetary Systems and the Origins of Life



NASA's Kepler Mission

- Determine the frequency of Earth-size and larger planets in the habitable zone of sun-like stars
- Determine the size and orbital period distribution of planets



Kepler Orrery IV

30 Nov 2012

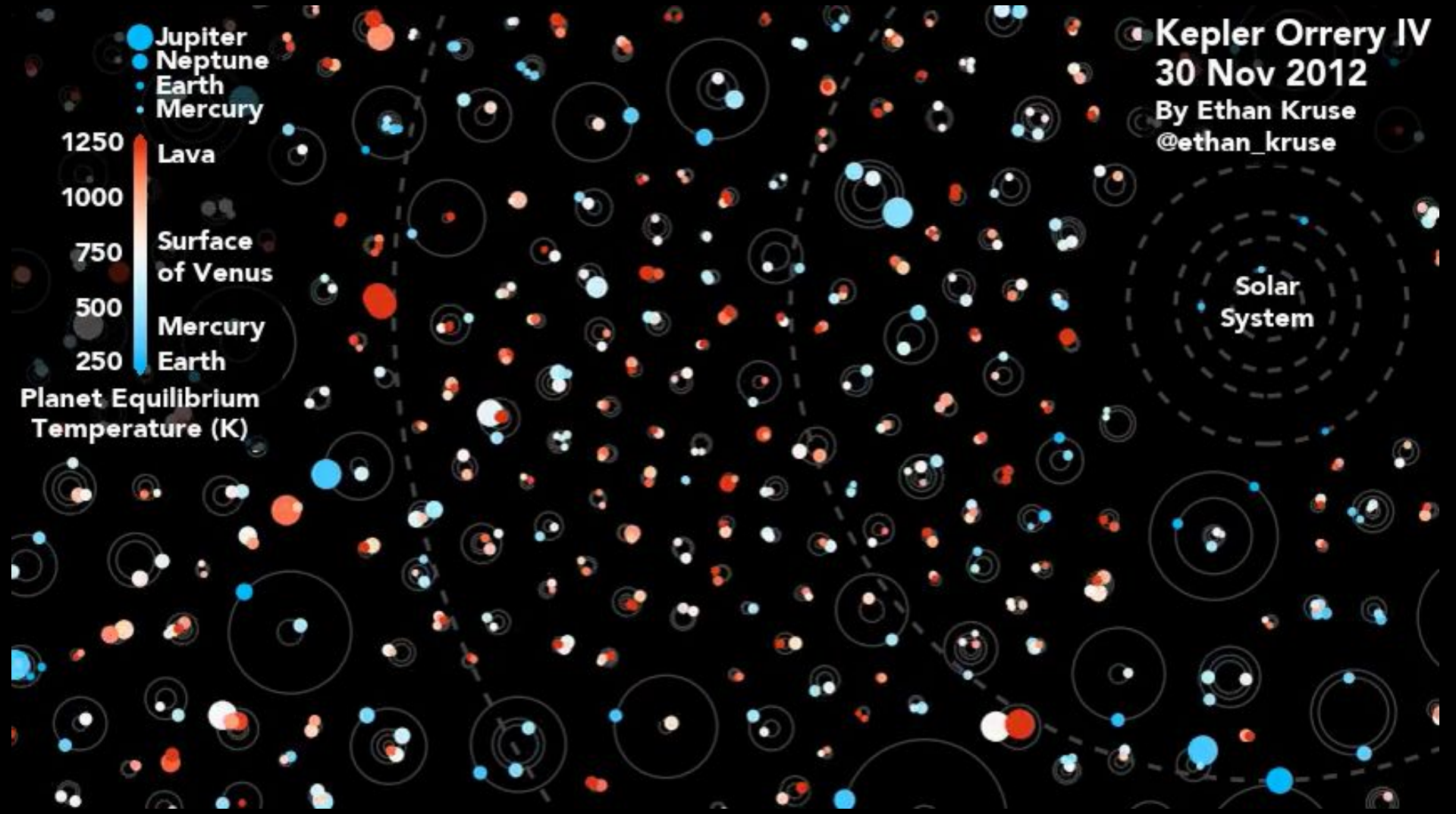
By Ethan Kruse

@ethan_kruse

- Jupiter
- Neptune
- Earth
- Mercury



Planet Equilibrium Temperature (K)



Transiting Planets Reveal Their Atmospheres

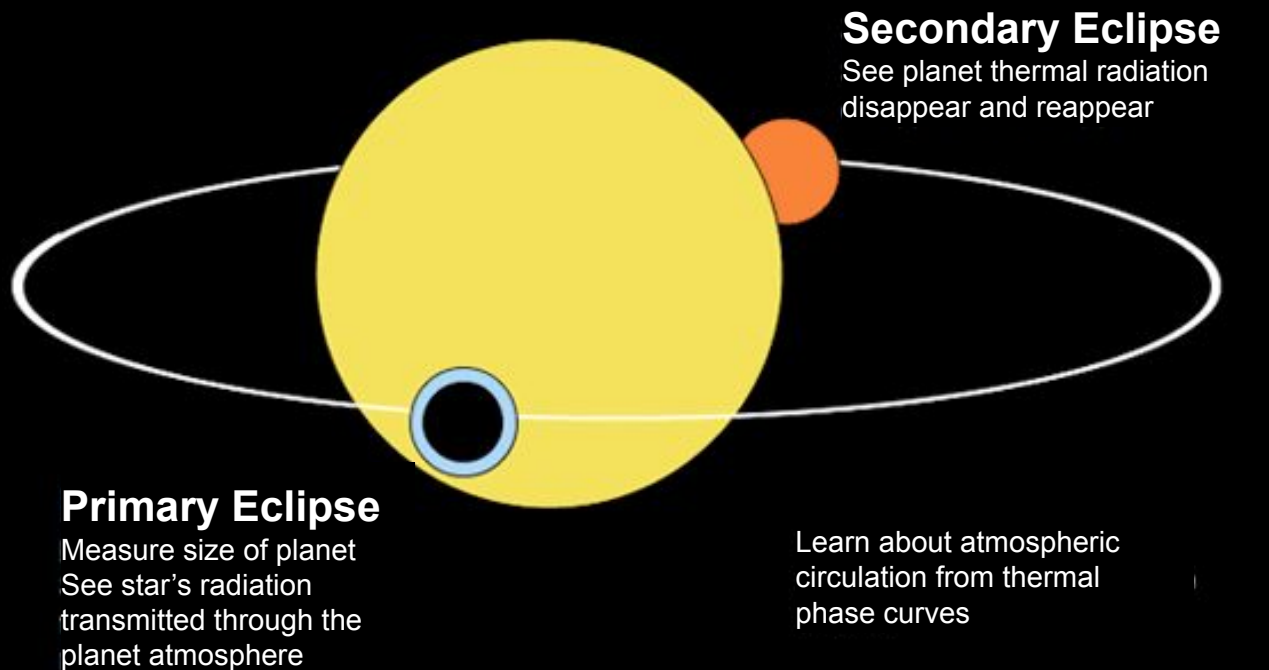
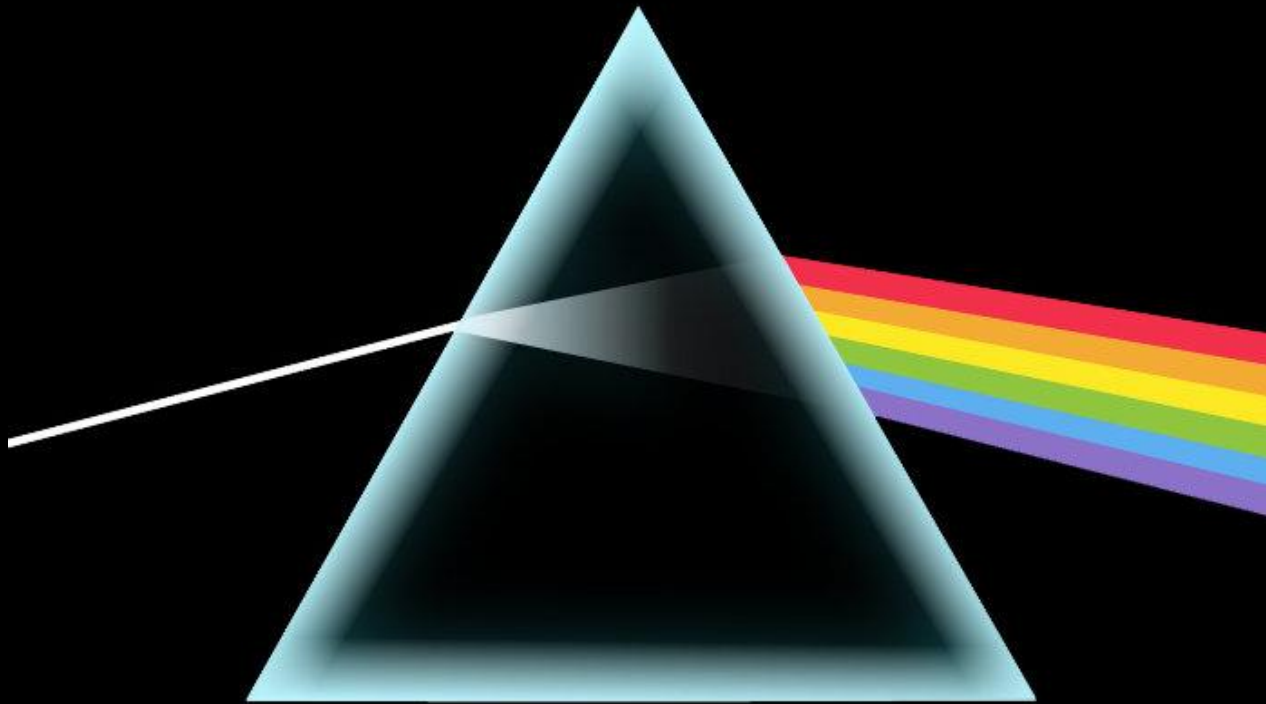


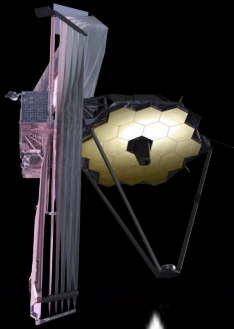
Figure by S. Seager

Spectra Are Made by Splitting Light into its Component Colors



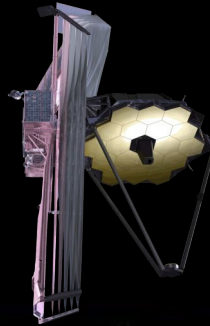
Three types of Spectra

1. Continuum Spectrum



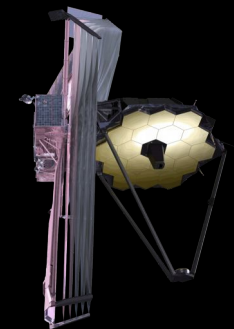
Light source

2. Absorption Spectrum



Light source

3. Emission spectrum



Gas cloud

Gas cloud

Identify This Gas

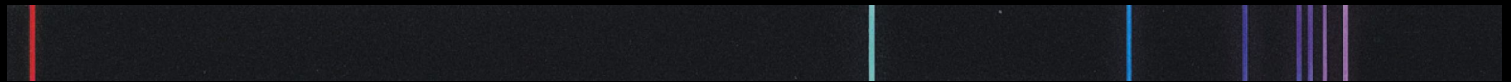
Mystery 1



Spectrum Library



Hydrogen



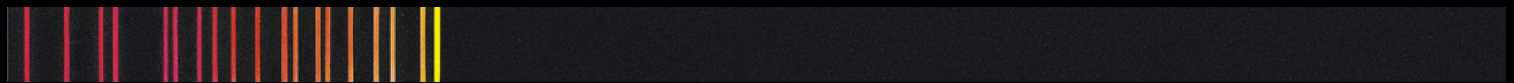
Helium



Mercury



Neon

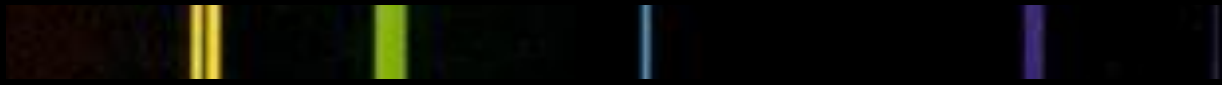


Krypton



Identify This Gas

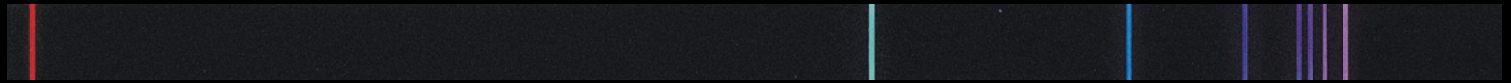
Mystery 2



Spectrum Library



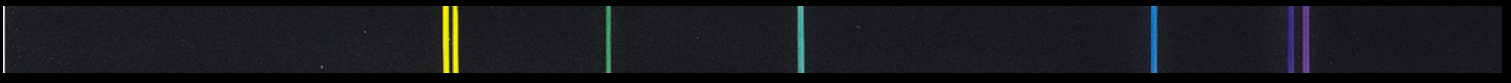
Hydrogen



Helium



Mercury



Neon



Krypton



Identify This Gas

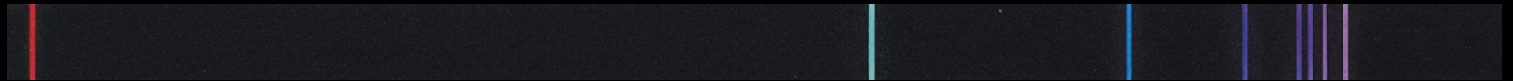
Mystery 3



Spectrum Library



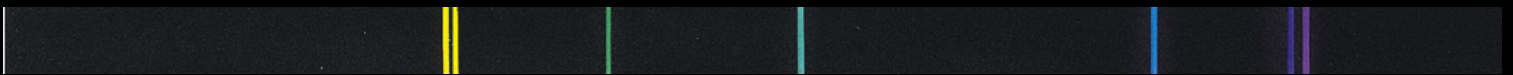
Hydrogen



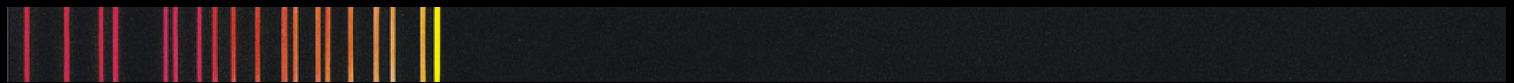
Helium



Mercury



Neon



Krypton



Identify This Gas

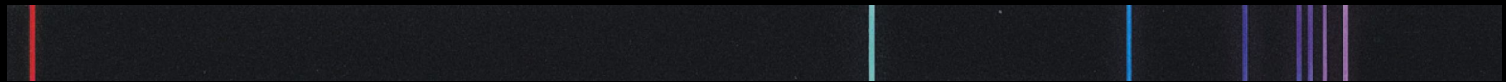
Mystery 5



Spectrum Library



Hydrogen



Helium



Mercury



Neon



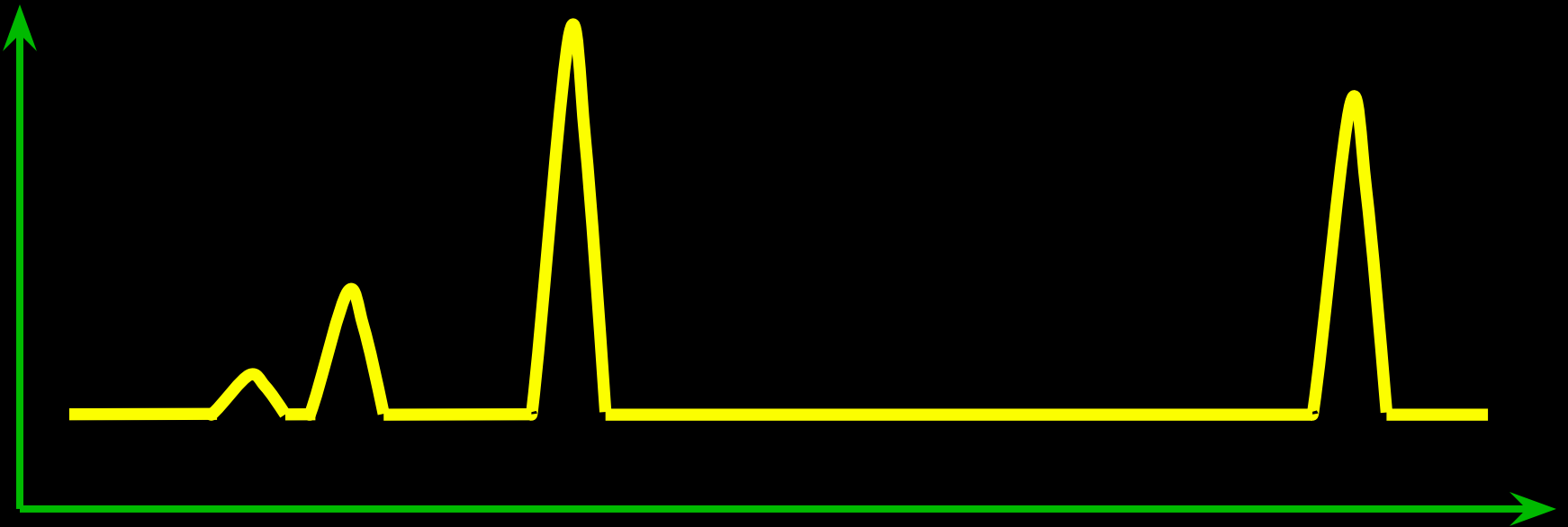
Krypton



Spectra Are Usually Represented as a Plot for Analysis



Brightness



Wavelength



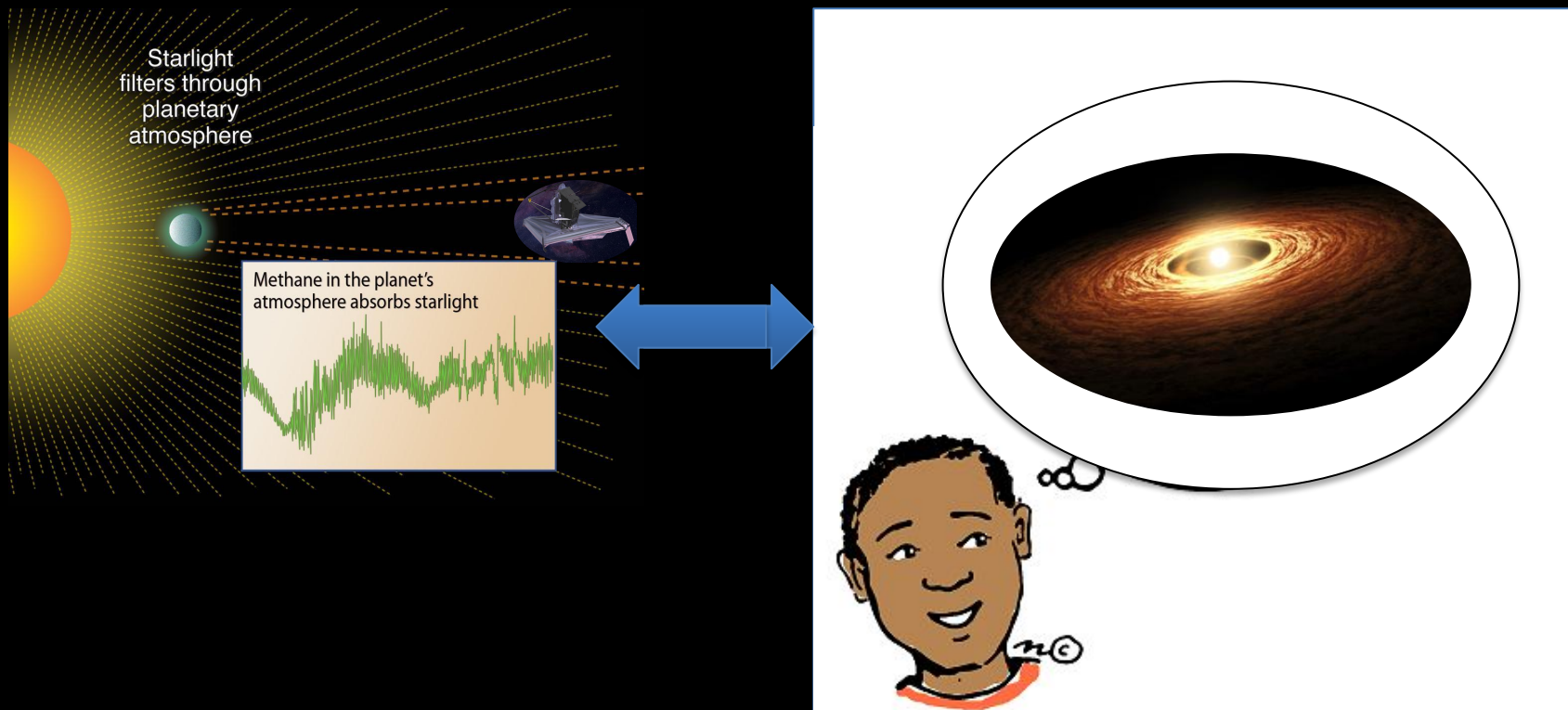
Starlight
filters through
planetary
atmosphere

The diagram illustrates the process of starlight filtering through a planetary atmosphere. On the left, a large orange sun emits numerous parallel yellow dashed lines representing starlight. These lines travel towards a small blue planet in the center. A dashed orange line represents the planet's atmosphere, which is shown as a thin layer around the planet. The starlight lines are shown passing through this atmospheric layer. To the right of the planet, a satellite is shown in orbit, with a dashed orange line representing its path. The satellite is depicted as a white and grey structure with solar panels, orbiting the planet. The background is black, and the overall scene is set against a dark space background.

Methane in the planet's
atmosphere absorbs starlight



We can learn about how planets form by studying their spectra



Planet Spectra Can Tell Us How/Where They Form



Transiting Planets Reveal Their Atmospheres

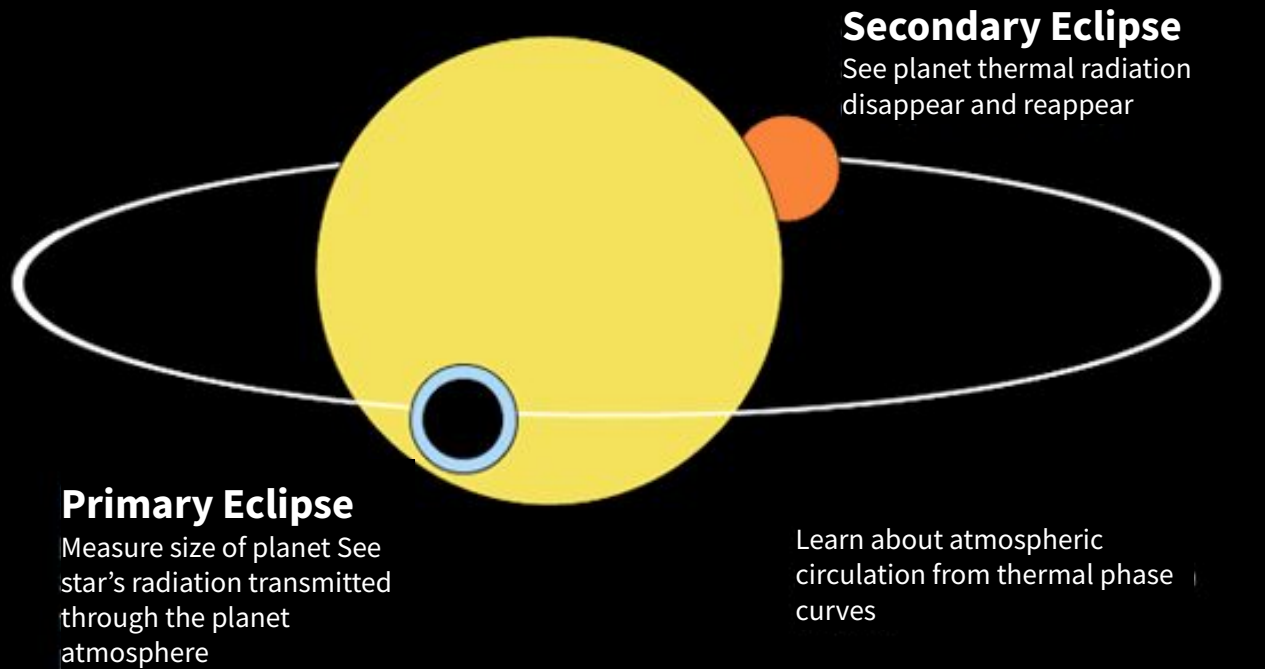
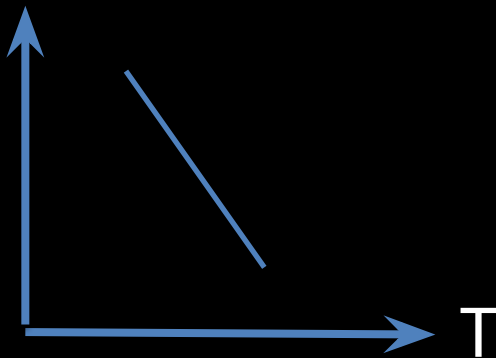


Figure by S. Seager

Secondary eclipses tell you about temperature

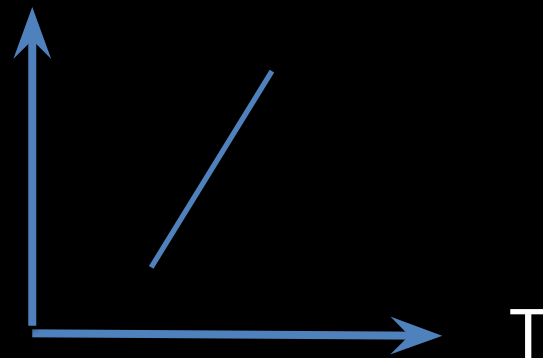
T decreases with height

Height



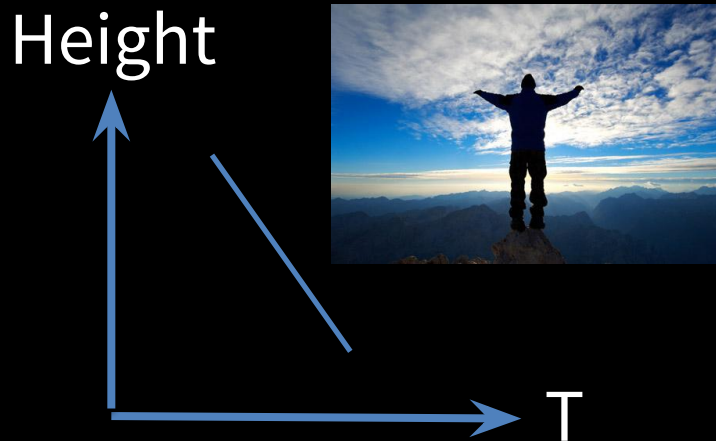
Temperature Inversion

Height

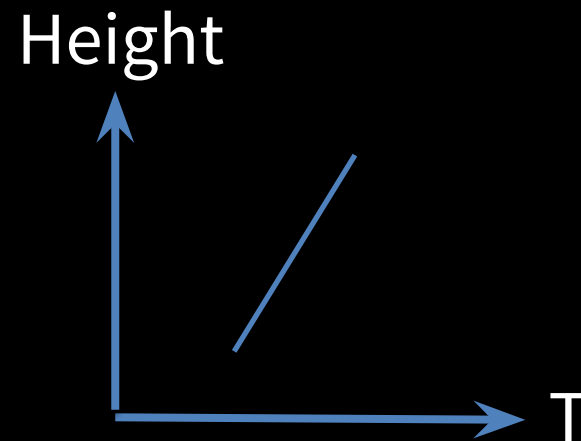


Where would aliens spend the summers?

- T decreases with height
- Temperature Inversion

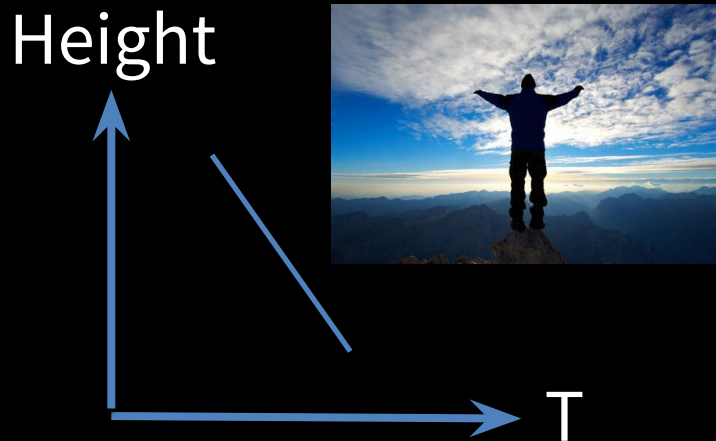


Energy input on bottom
Less stable

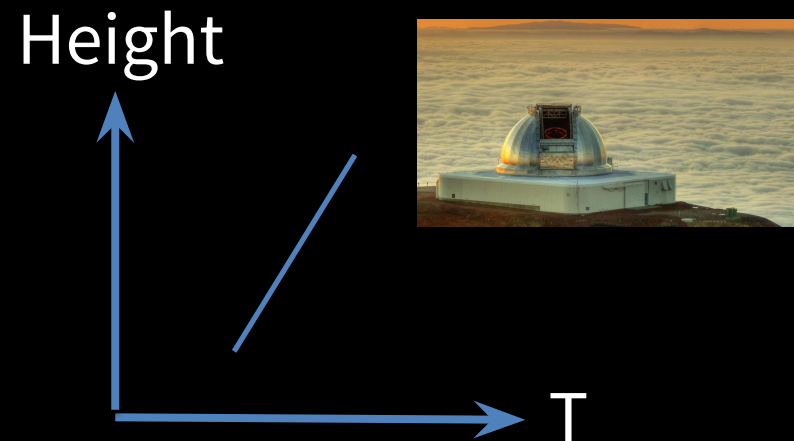


Where would aliens spend the summers?

- T decreases with height
- Temperature Inversion

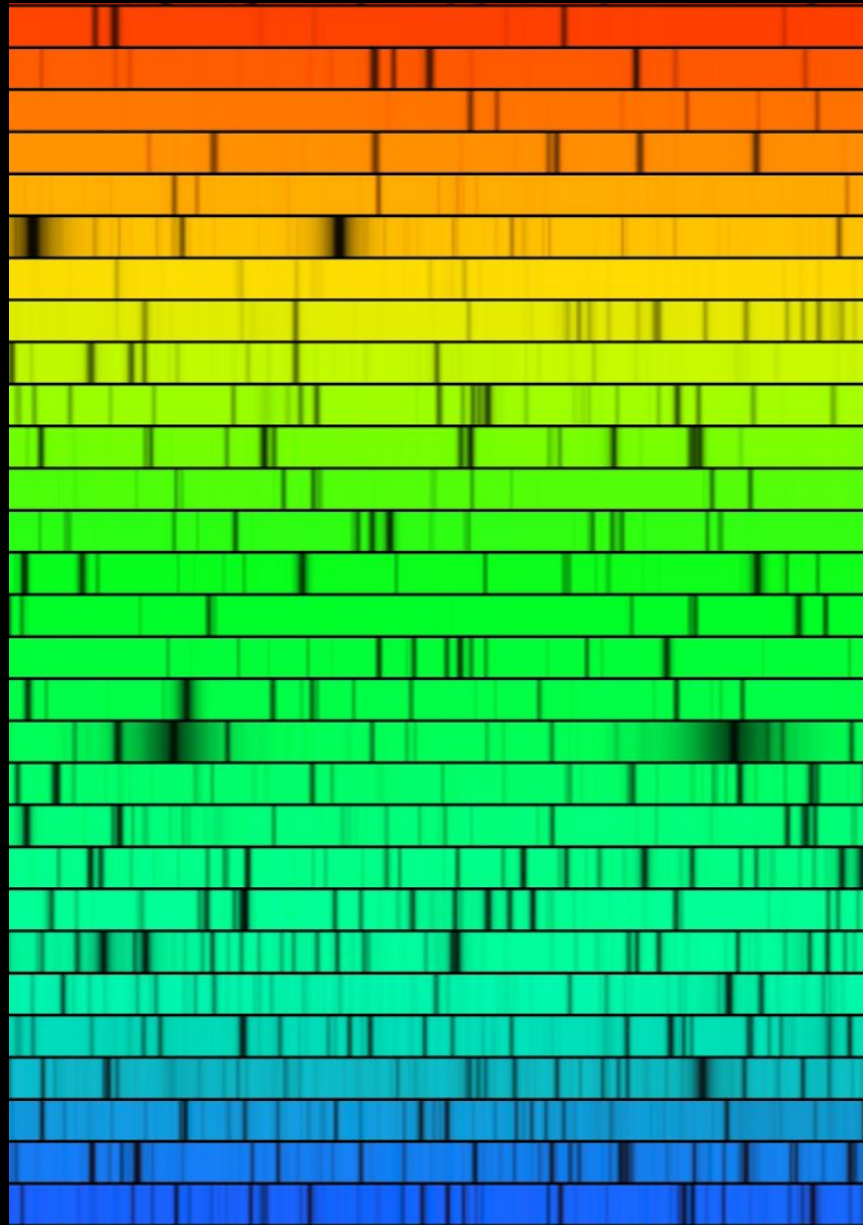


Energy input on bottom
Less stable



Energy input on top
More stable

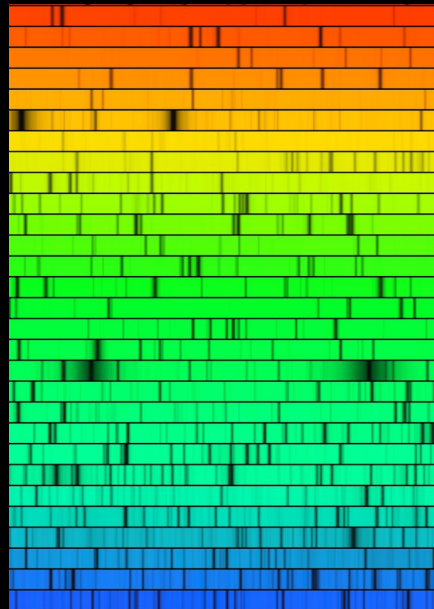
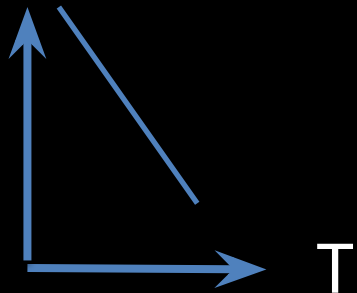
The Solar Spectrum



T Profiles are measured from Emission Spectra

T decreases with z

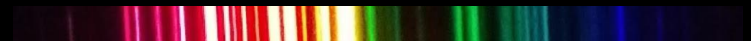
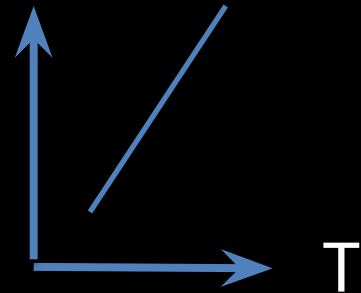
Height



Solar Optical
Spectrum
(Photosphere)

T inversion

Height



Neon Emission Lamp

Transiting Planets Reveal Their Atmospheres

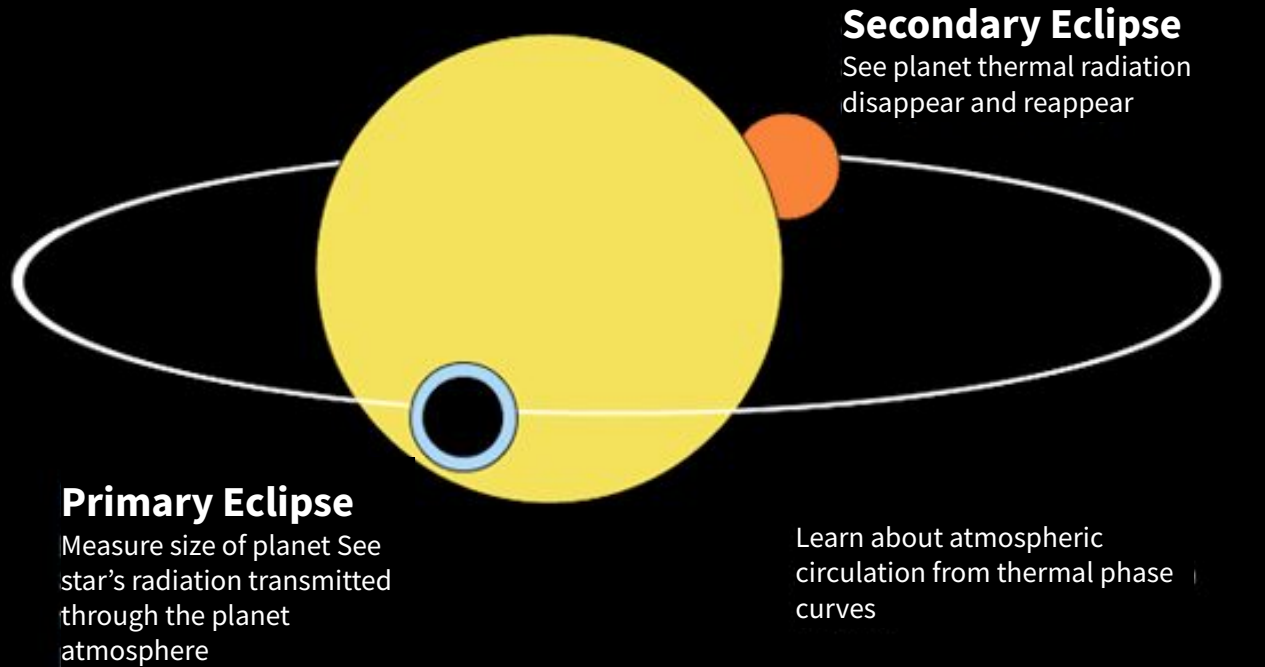
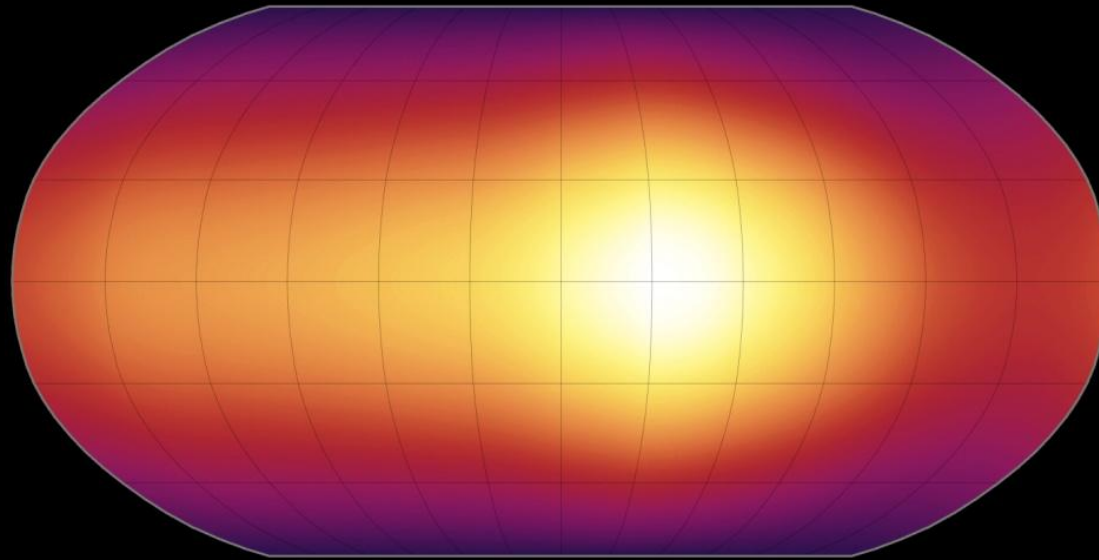
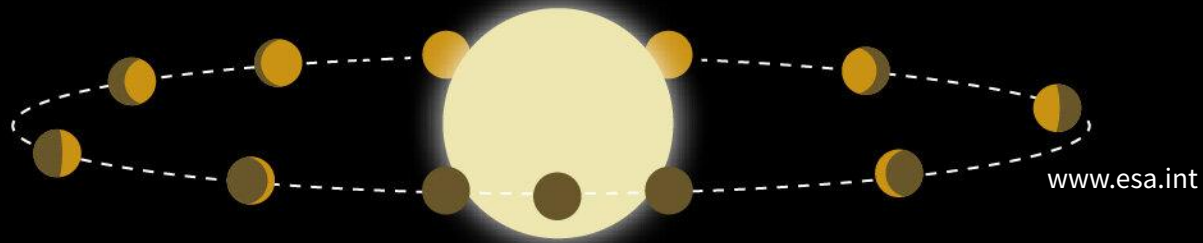


Figure by S. Seager

Thermal Phase Curves- Where's the Heat?

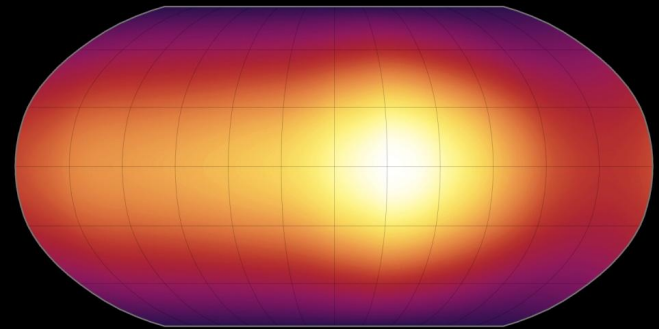
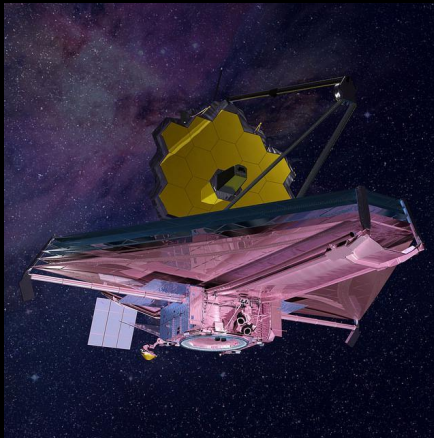
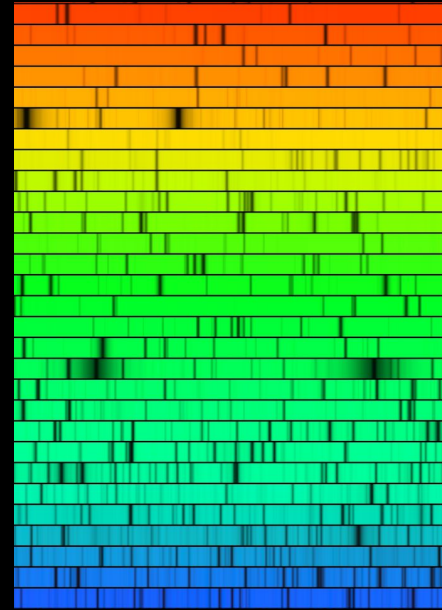


↑
Sun-Facing Longitude

(Grid Spacing: 30°)

Global Temperature Map for Exoplanet HD189733b
NASA / JPL-Caltech / H. Knutson (Harvard-Smithsonian CfA)

Spitzer Space Telescope • IRAC
ssc2007-09a



Are We Alone?





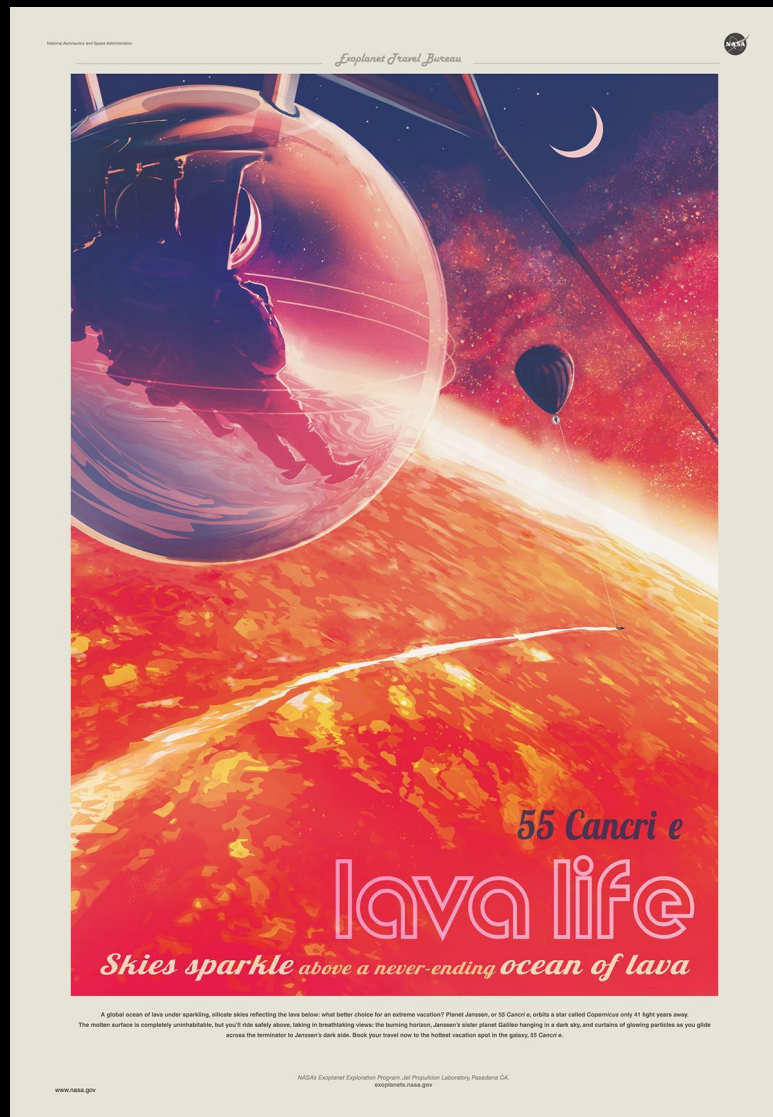
PLANET HOP FROM
TRAPPIST-1e



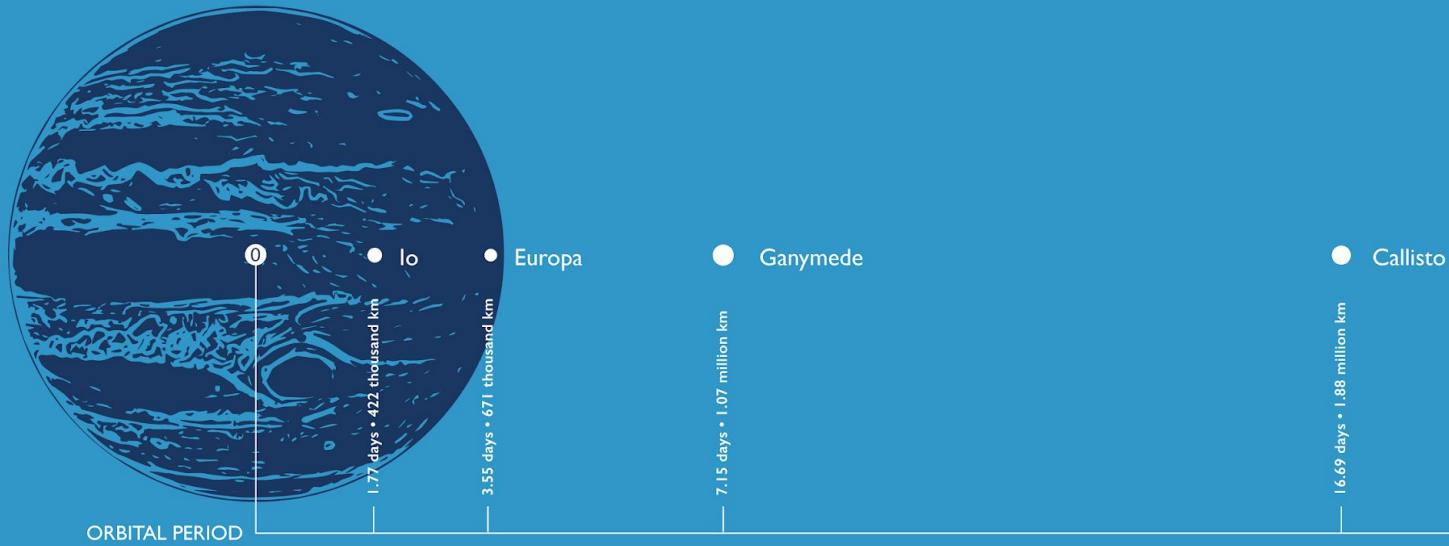
VOTED BEST "HAB ZONE" VACATION WITHIN 12 PARSECS OF EARTH

You can download these posters!

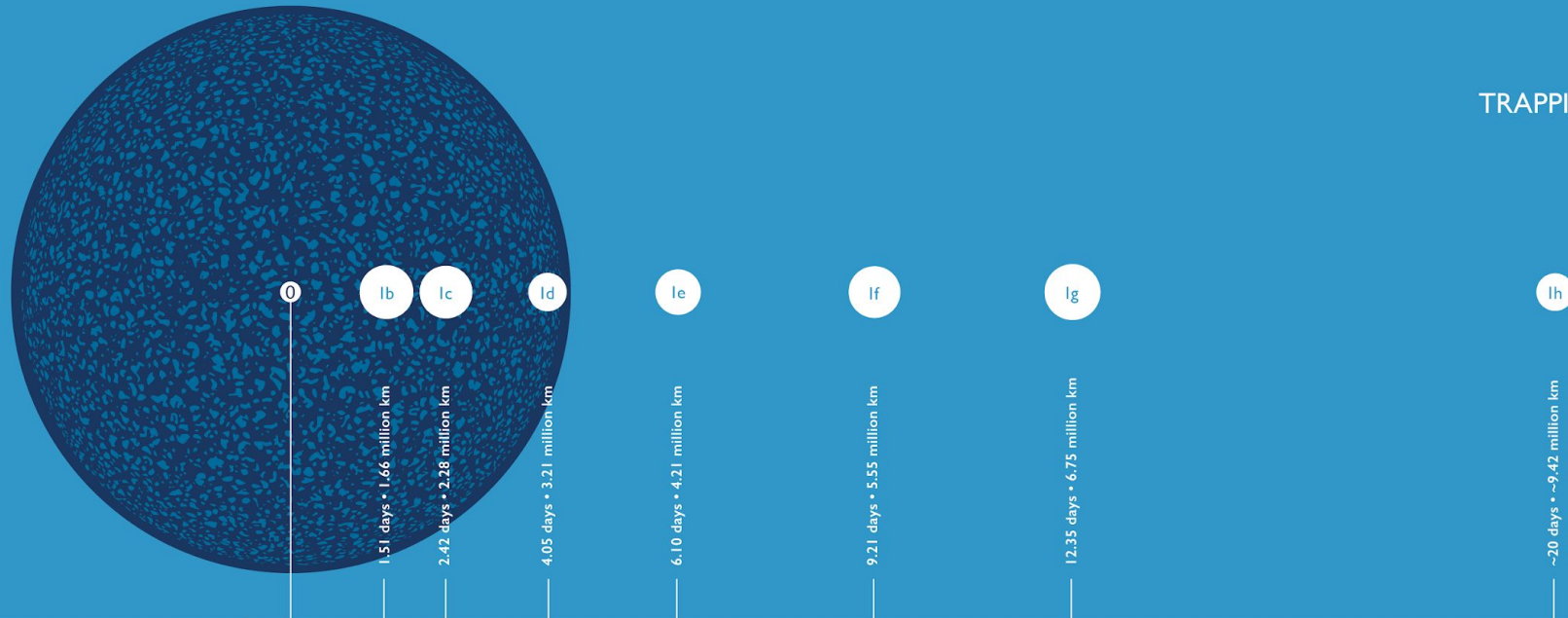
<https://exoplanets.nasa.gov/alien-worlds/exoplanet-travel-bureau/>



JUPITER System



TRAPPIST-1 System



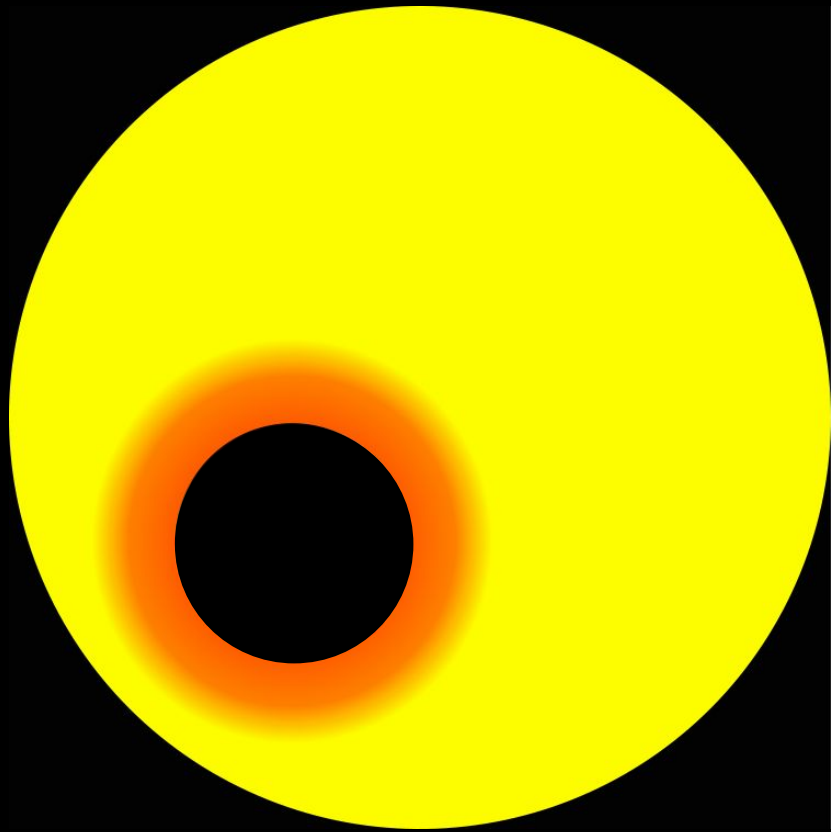
TRAPPIST-1

Comparing sizes and orbital periods.

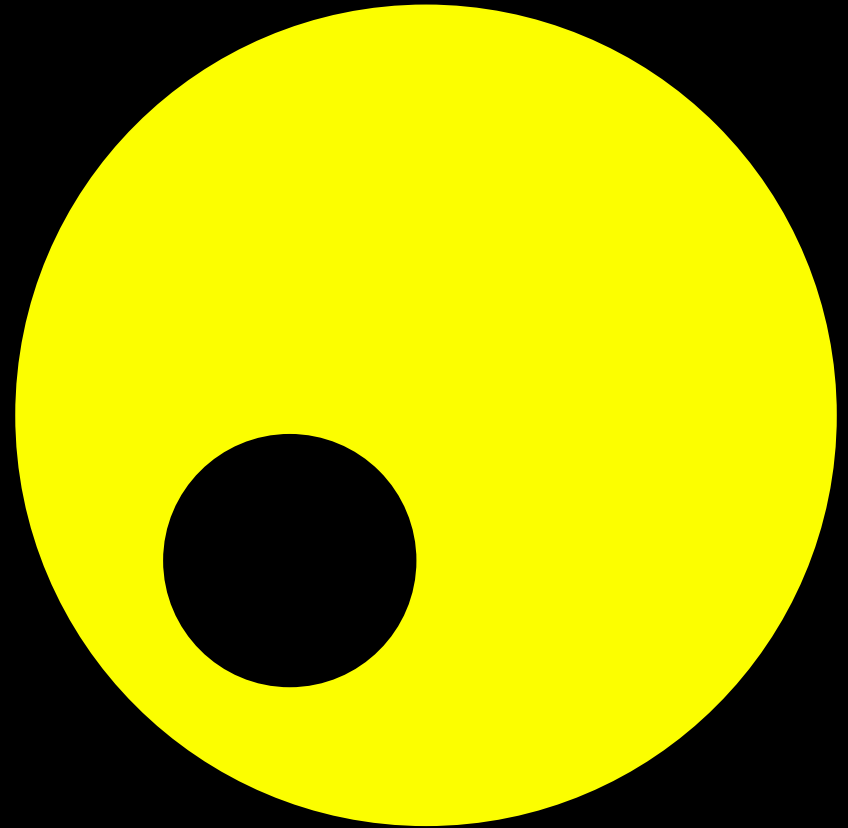
All sizes scaled to Jupiter.

TRAPPIST-1 is a system containing seven planets comparable to Earth. They orbit a small star called an ultra-cool dwarf. The distance of the planets to the star means that liquid water could likely persist on their surfaces. The system was found when the planets passed in front of the star, casting a shadow called a transit. This property means that we will be capable to investigate their climate and chemical composition, an essential step ahead of finding-out whether life has emerged there.

Does a Planet Have An Atmosphere?



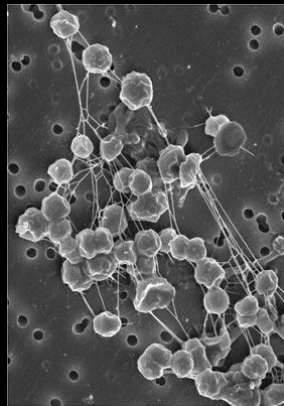
vs



We can look for life like the Earth's

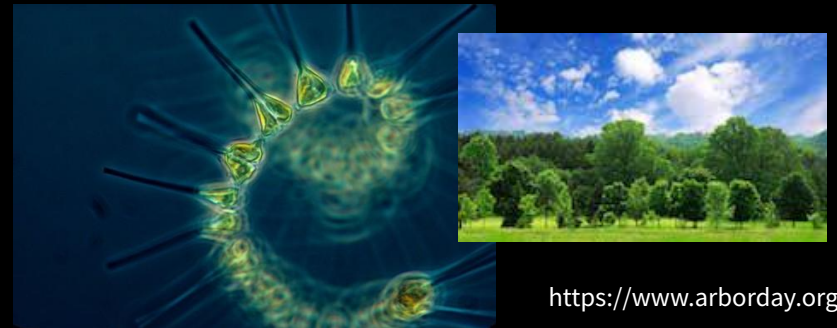
(in the future)

Methanogens -> Methane



<https://microbewiki.kenyon.edu/index.php/>

Photosynthesis -> Oxygen

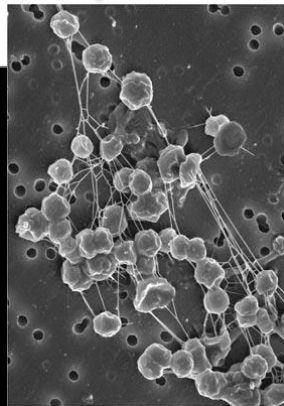
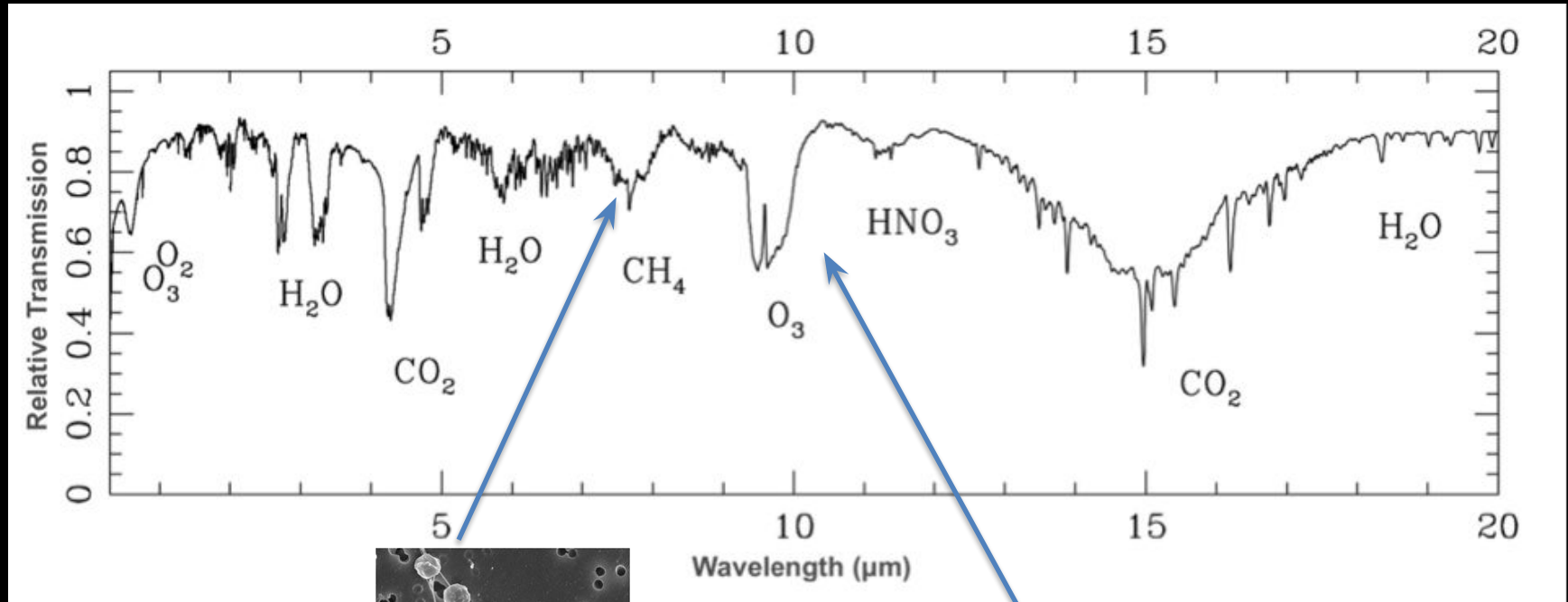


<http://earthsky.org/>

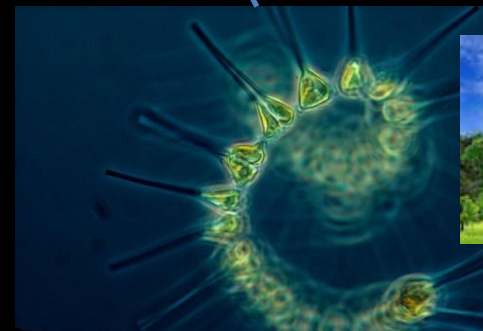
<https://www.arboday.org>

We can look for life like the Earth's

(in the future)



<https://microbewiki.kenyon.edu/index.php/>



<http://earthsky.org/>



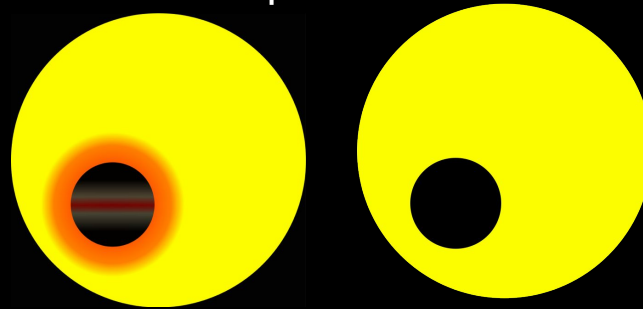
<https://www.arborday.org>

Webb Will be A Stepping Stone for Life-Detection!

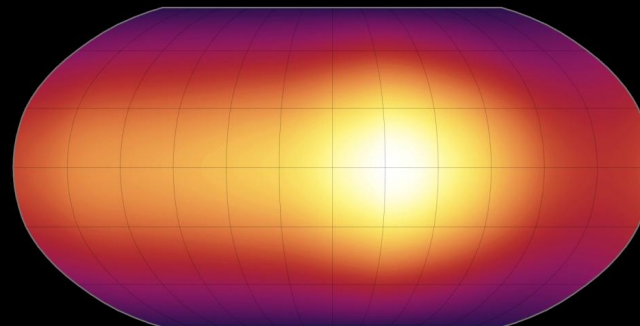
1. Learn What Planets Are Made Of & how they form



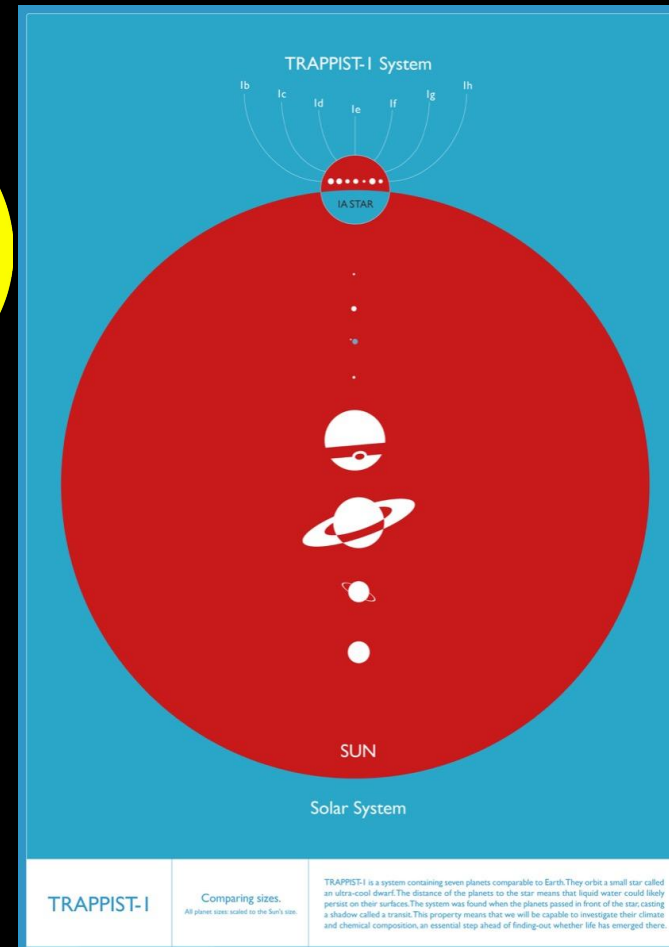
2. Which rocky planets have atmospheres?

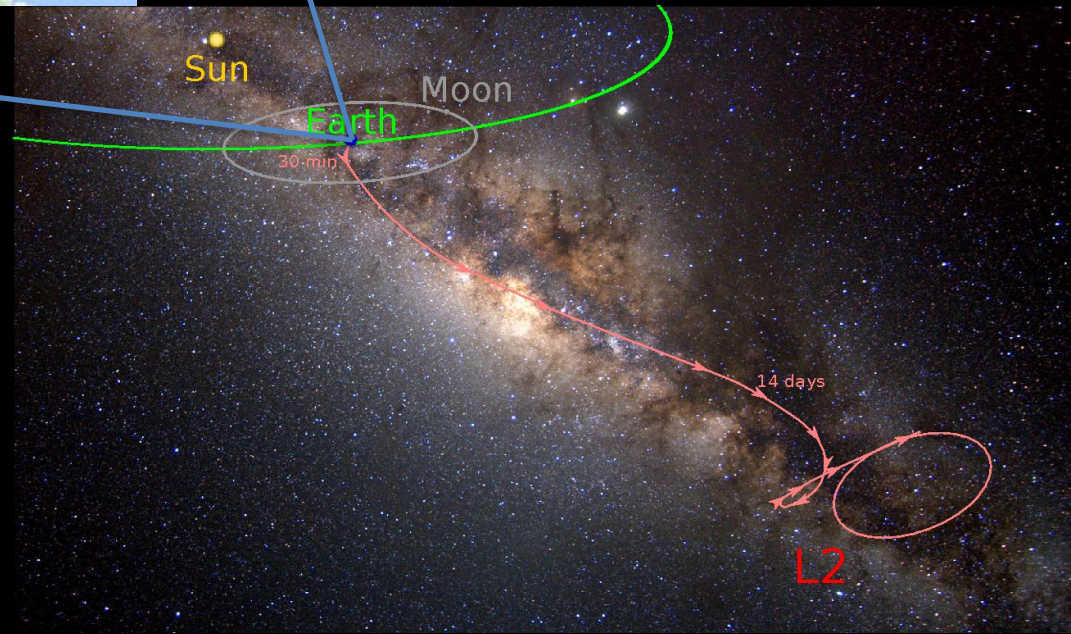
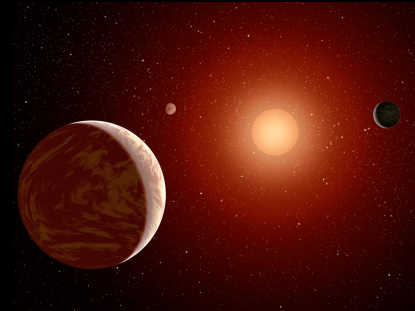


3. Learn How Atmospheres Distribute Heat



4. The Future:
Look for Earth-like life!





The Webb Telescope Lagrangian Points



TEEN ASTRONOMY

Café – To Go!

