

Astronomy Outreach: Exoplanets

Presented by:

Anitha Raj Rajkumar

PhD Candidate

Universidad de Atacama, Chile

Contents:

- How big the space is..
- Introduction to exoplanets
- Detection methods
- Characterize the atmosphere

Space outside the Earth

Is big.. Very big indeed!

Comparison of the stellar
objects in solar system and
other stellar objects.



Video Credit: <https://www.youtube.com/watch?v=PDMKhmlWwIk&t=52s>

Ceres: Dwarf Planet
Callisto: Moon of Jupiter
Kepler-22 b: Exoplanet

Other solar systems

Now that you have seen how big the stellar objects are, what are the possibilities for the existence of other worlds?

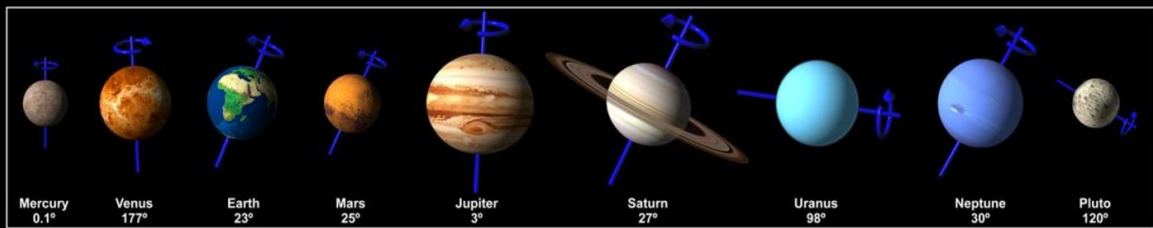
A lot!!!

Introduction to exoplanets

The planets which are outside our solar system are called extrasolar planets or exoplanets



The Planets in Our Solar System



Obliquity of the Nine Planets

© Copyright 1999 by Calvin J. Hamilton

But do they all look the same?



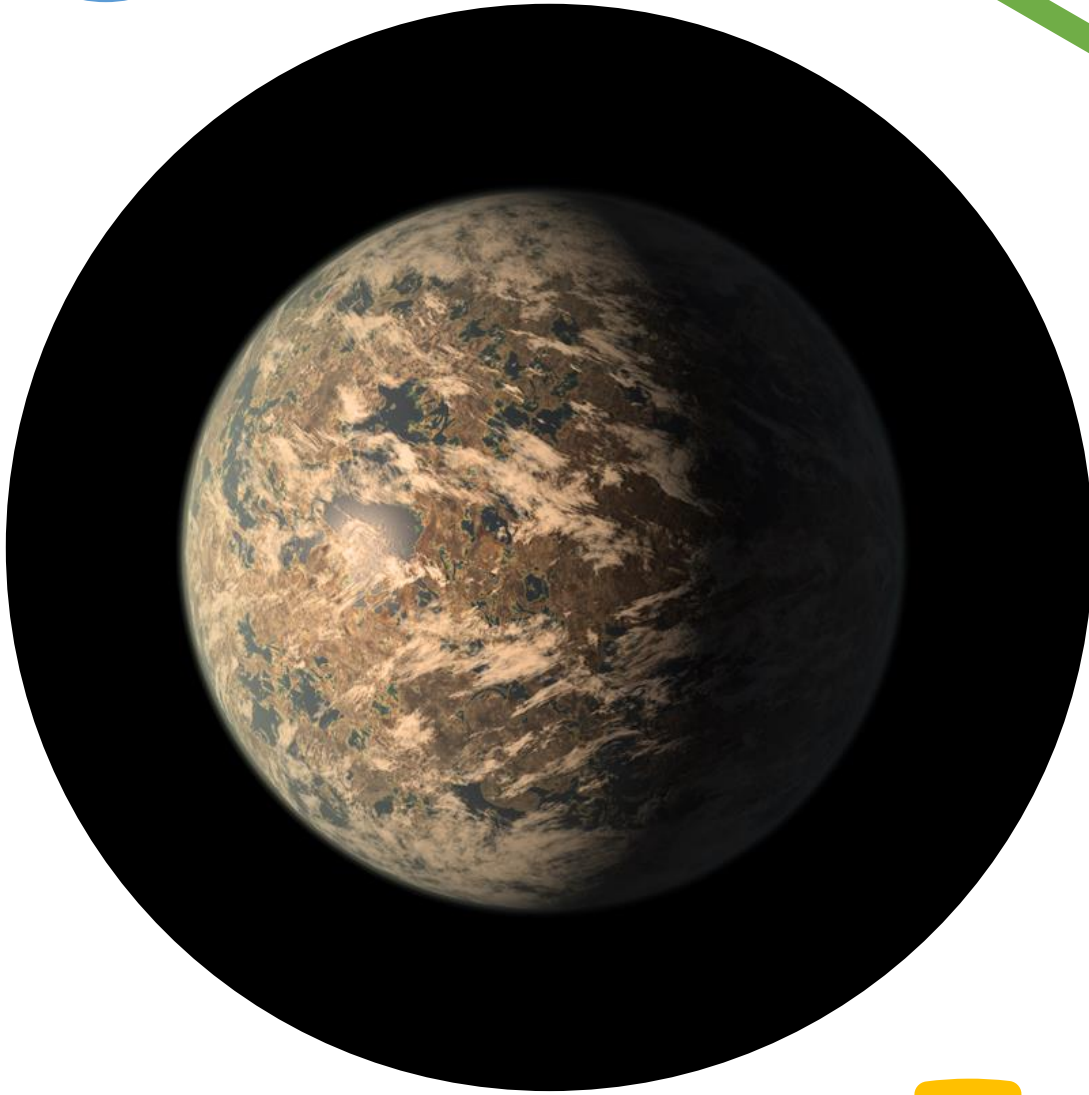
Different kinds of exoplanets

1. Terrestrial

e.g., Trappist-1e

Between half of Earth's size to twice its radius are considered terrestrial, and others may be even smaller

Current discoveries: 192



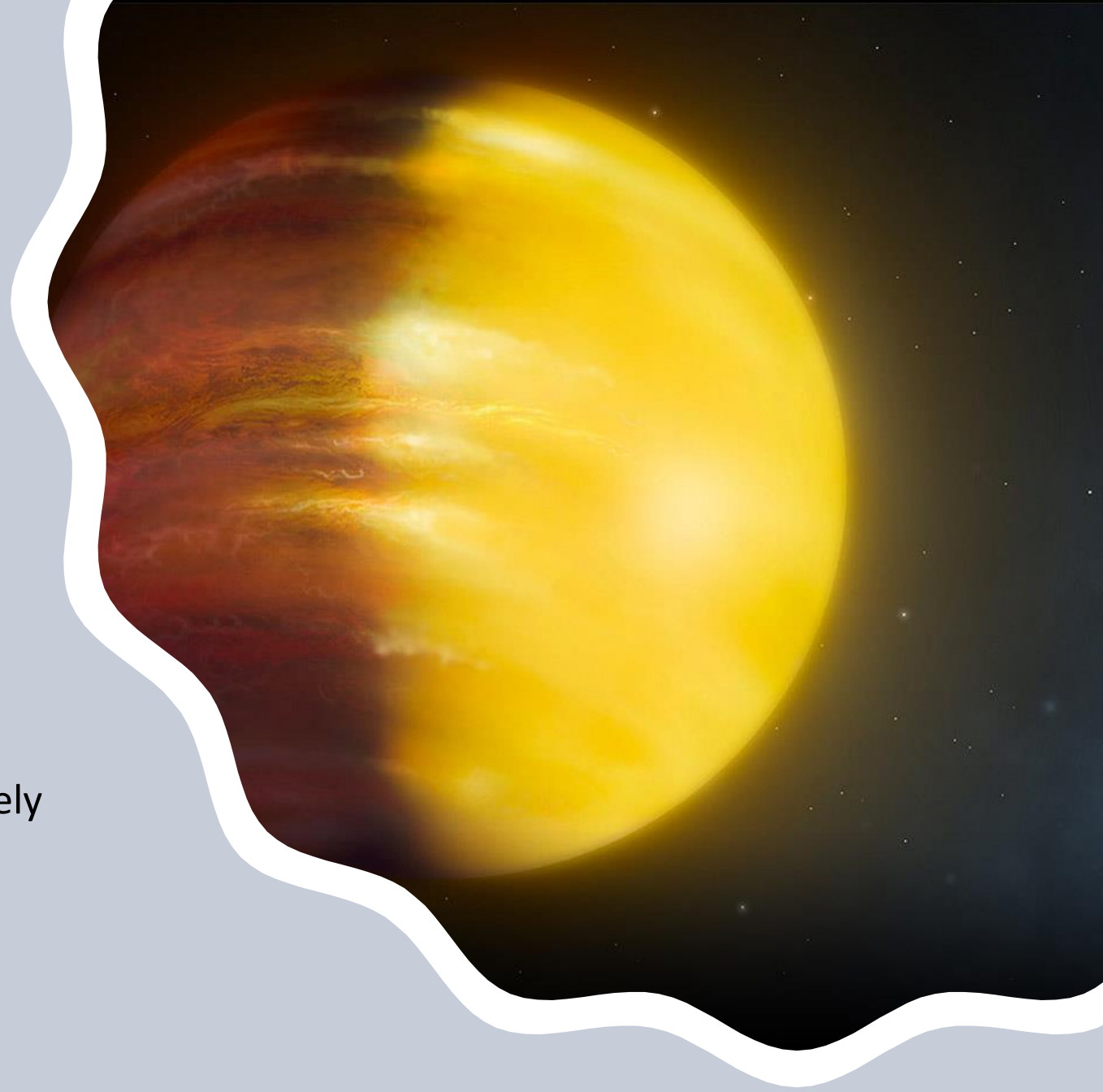
2. Gas giant

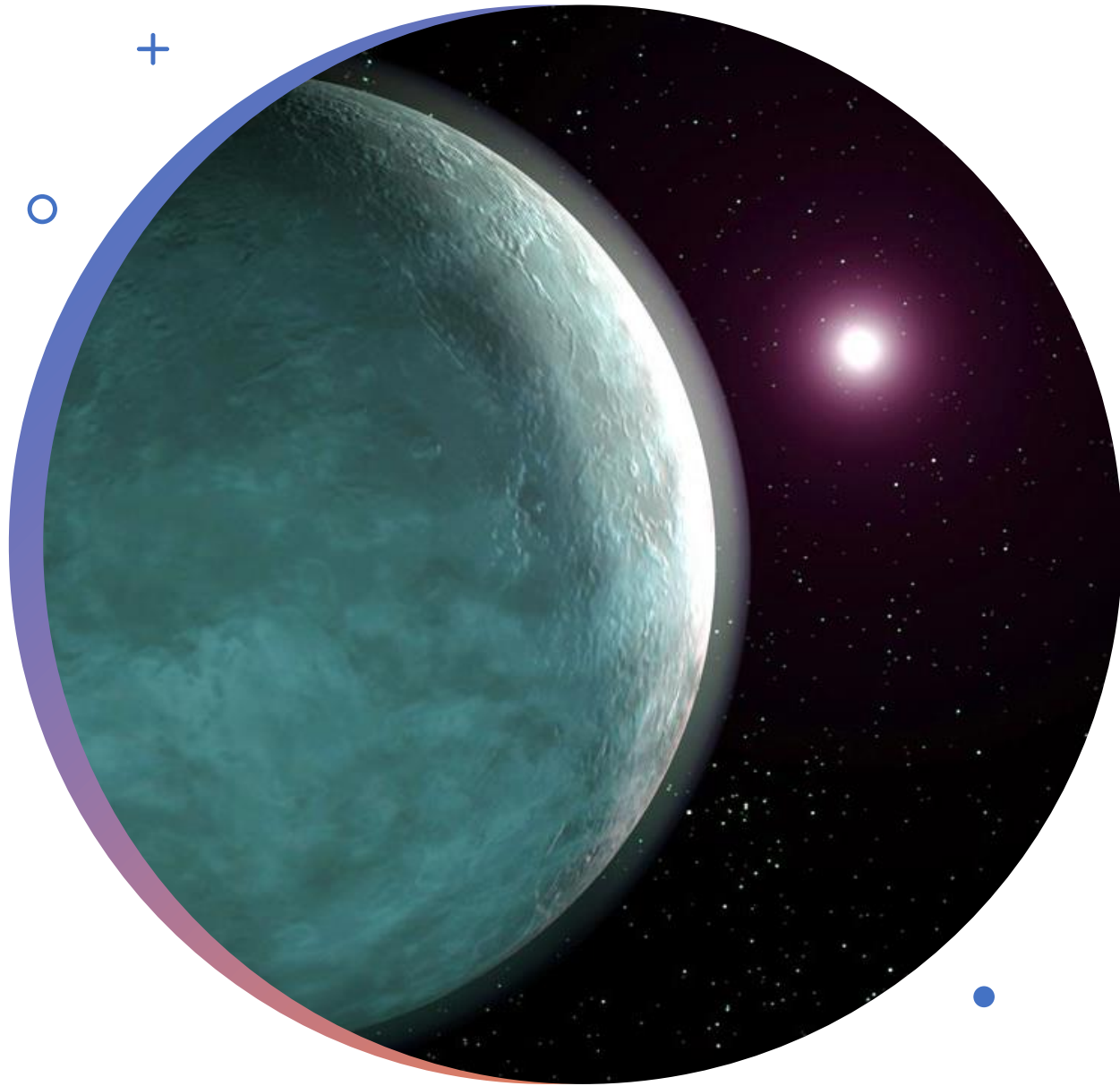
e.g., 51 Pegasi b

Mostly composed of hydrogen and/or
helium

Current discoveries: 1,613

They orbit their parent star very close approximately
less than 1 au





3. Neptunian

e.g., kepler 1655 b

Neptunian planets typically have
hydrogen and helium-dominated
atmospheres with cores of rock and
heavier metals

Current discoveries: 1,808

4. Super-Earths

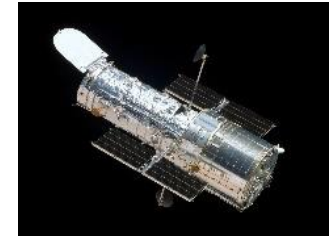
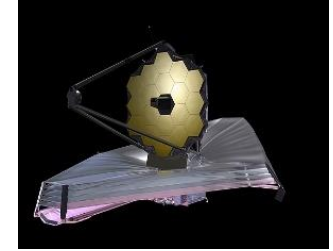
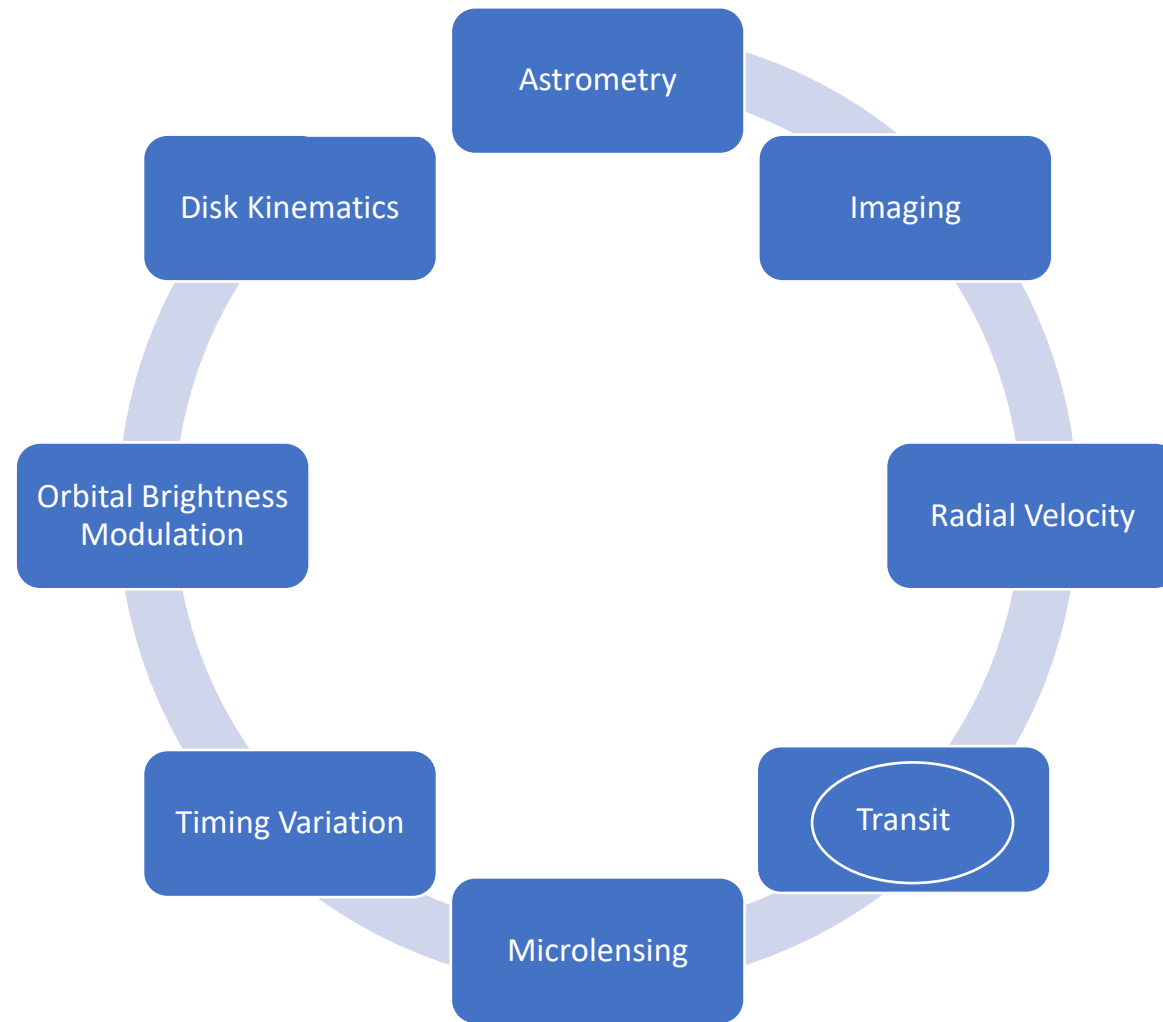
e.g., Barnard's Star b

They are between twice the size of Earth and up to 10 times its mass

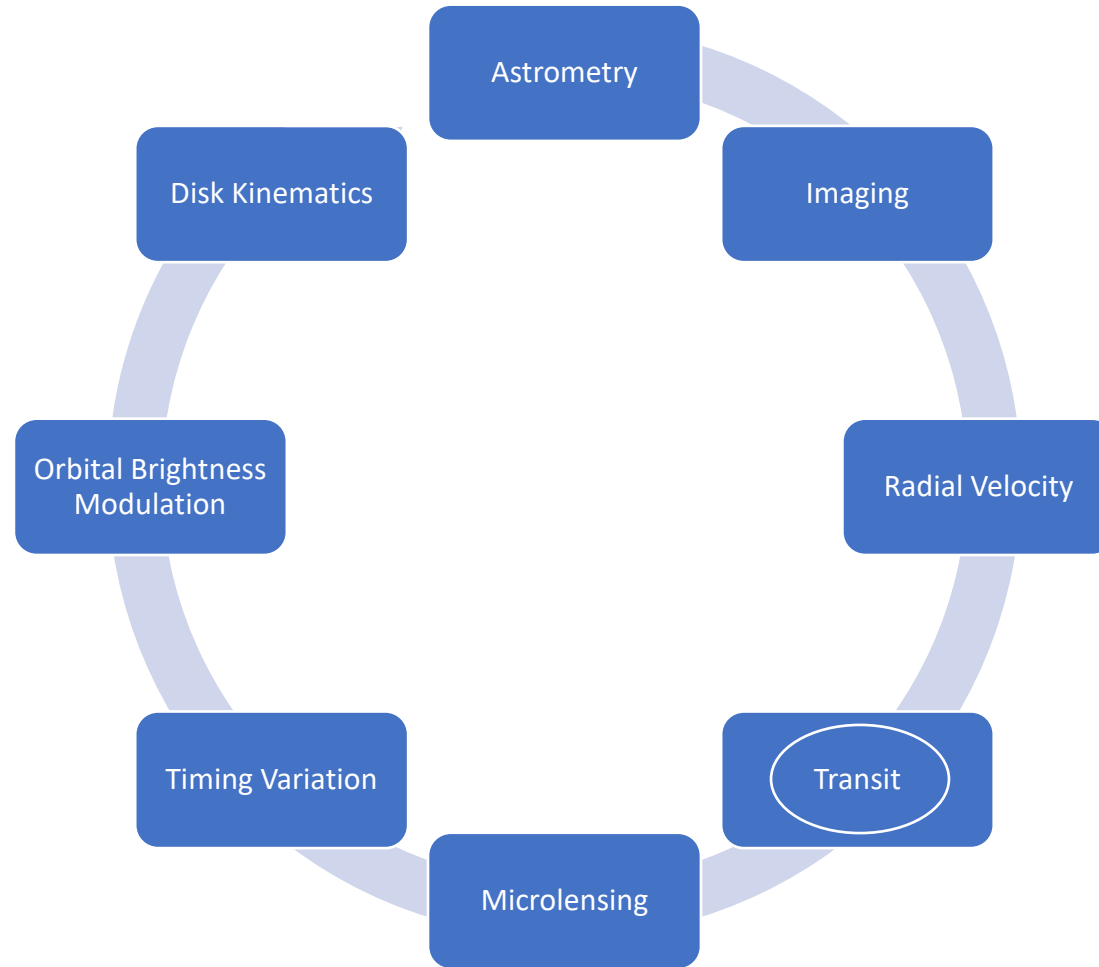
Current discoveries: 1,593



Methods to Detect an Exoplanet



Methods to Detect an Exoplanet

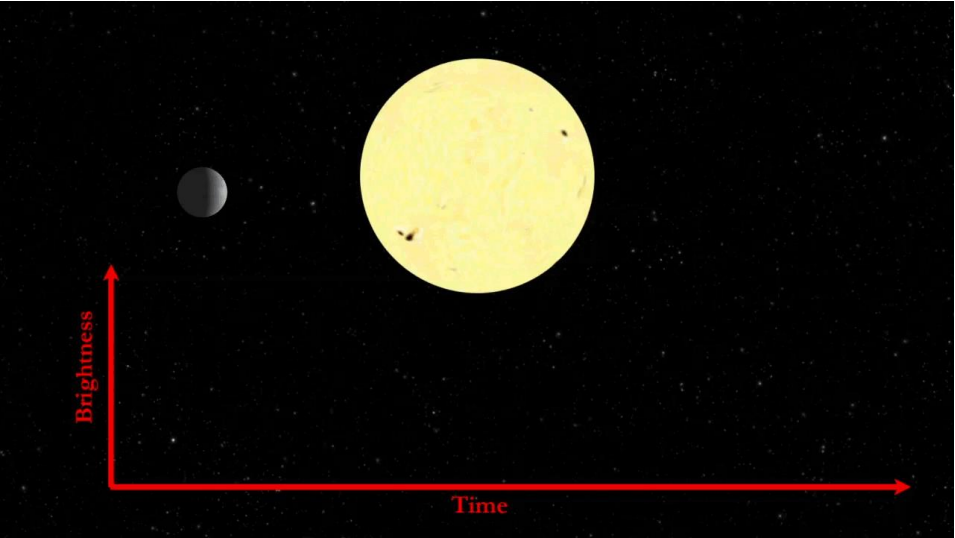
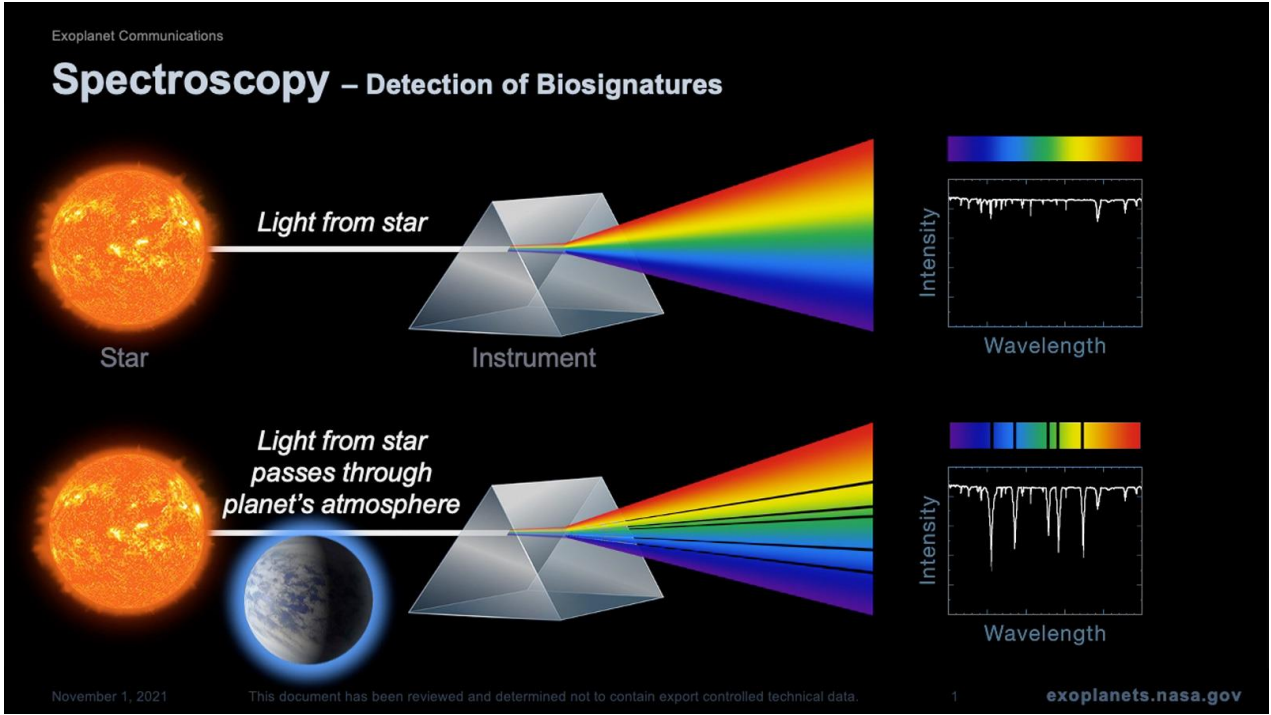


Transit Method

- It provides accurate constraints on planetary and stellar radii, orbital inclination, transit timing measurements and Stellar density.
- This method can allow for a planet's atmosphere to be investigated through transmission spectroscopy

Transmission Spectroscopy

As light from the star passes through the planet's atmosphere, the resulting spectra can provide clues to the existing chemical composition of the atmosphere.





What's Next?



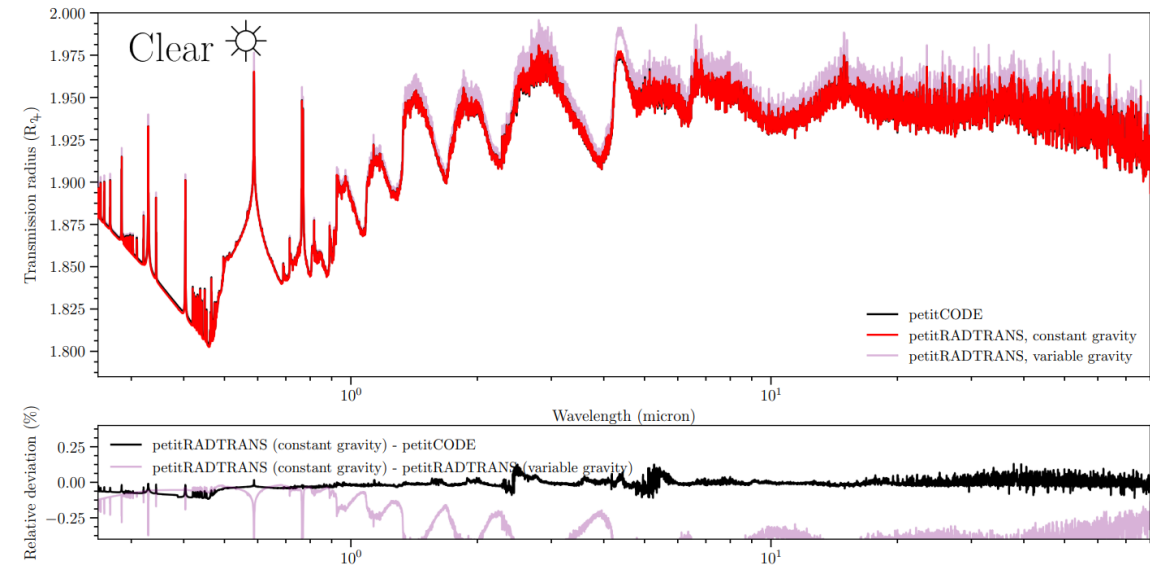
Characterizing the exoplanetary atmosphere

Why is it important to characterize the atmosphere?

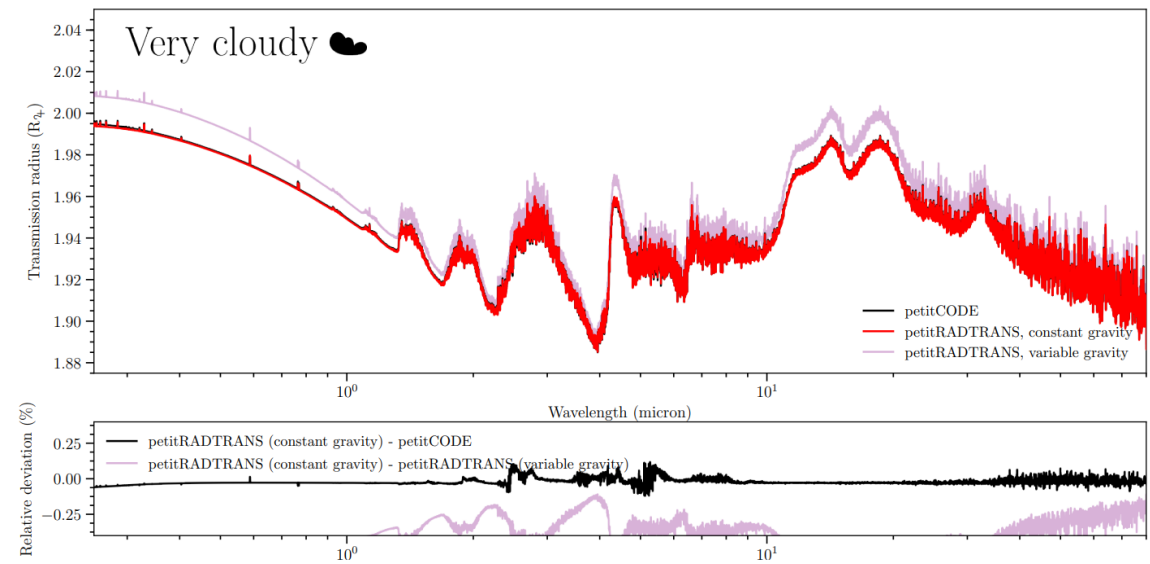
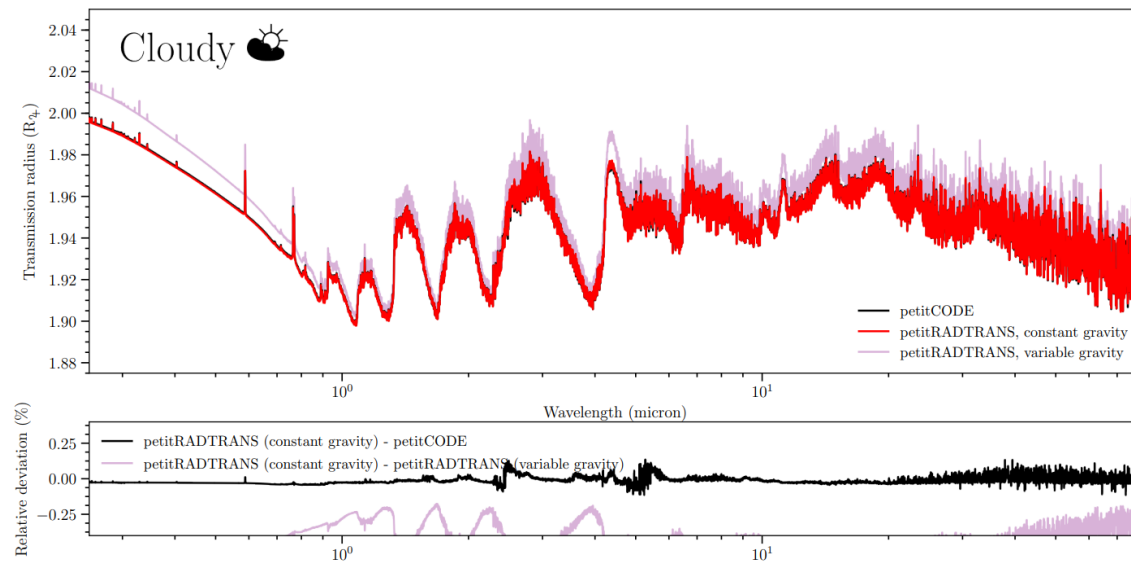
Presence of clouds and hazes

What could it tell us?

Whether the exoplanet can bare life in it or not!

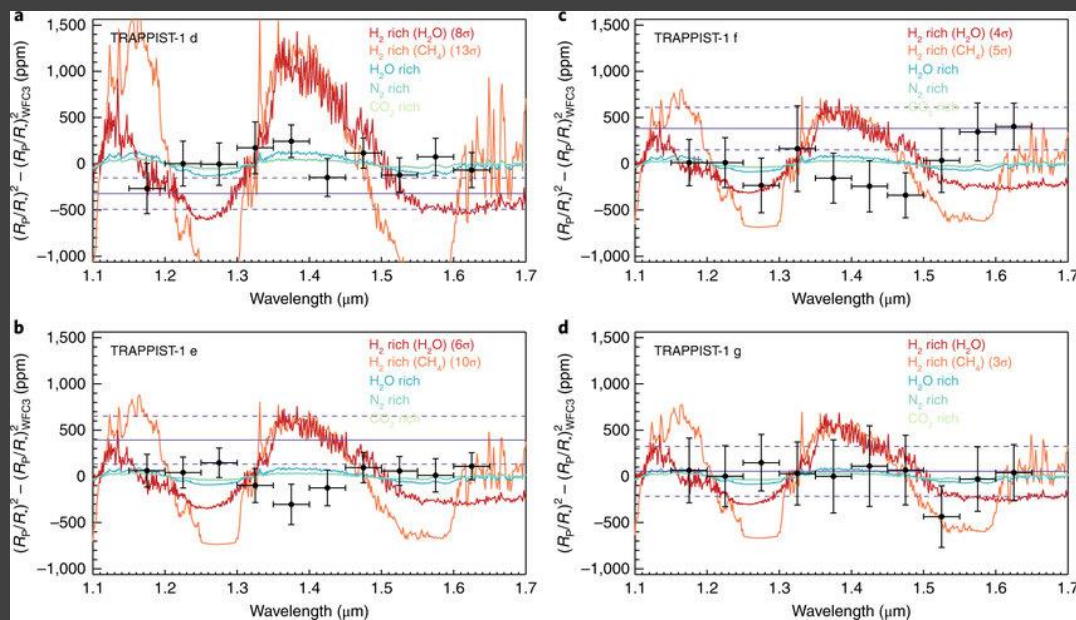


TrES-4 b [Molliere et al. (2019)]

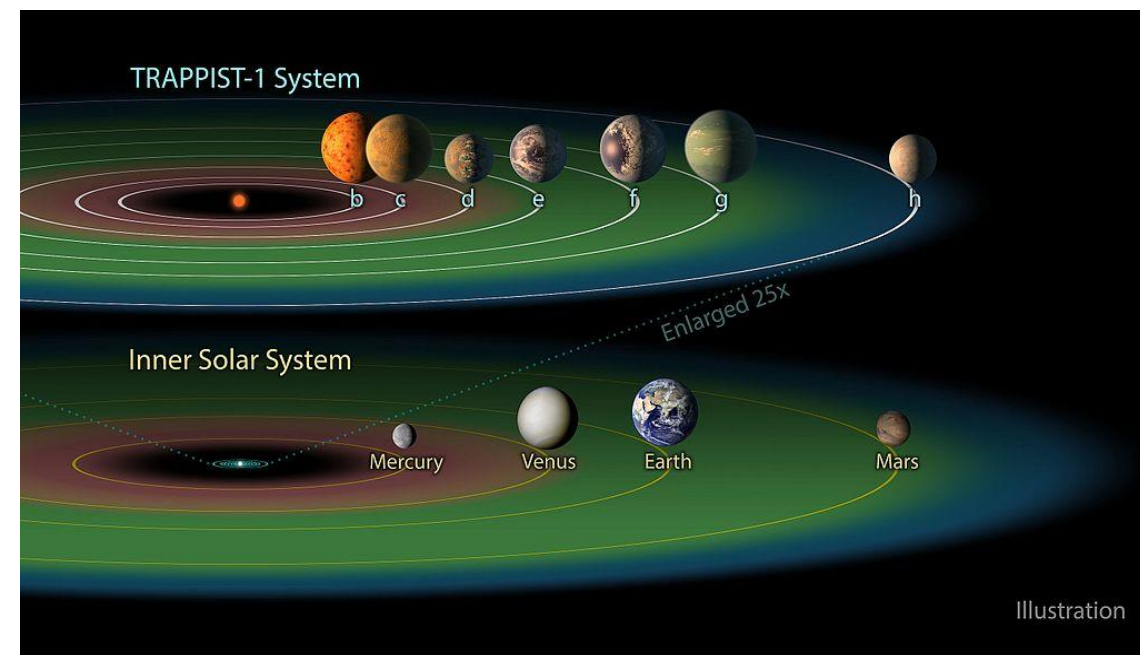
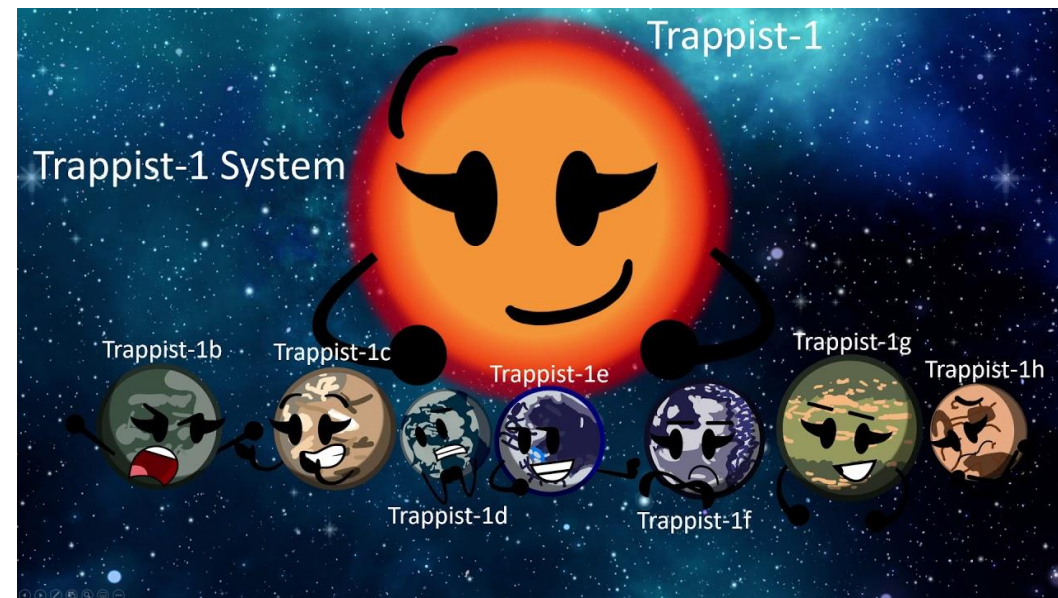


Few examples of different worlds

TRAPPIST-1 System



J. de Wit et al. 2018



Illustration

HELL PLANET



WASP-72 b

During the day, the temperature is
2400 deg C

It's Hotter than Hell



- Making the iron evaporates into the atmosphere to form metallic clouds.
- Then driven by strong wind (1600 Kmph) to cause rain.



Earth's Evil Twin

HD 189733b

Looks nice and Earthlike..

But it's not!

- It is a hot-Jupiter gas giant
- Day side: 1000 deg C
- Night side: 650 deg C
- It rains silicate glass sideways
- The blue color is thought to come from silicate particles in the planet's atmosphere
- Wind speed: 4350 mph (7000 km/hr)

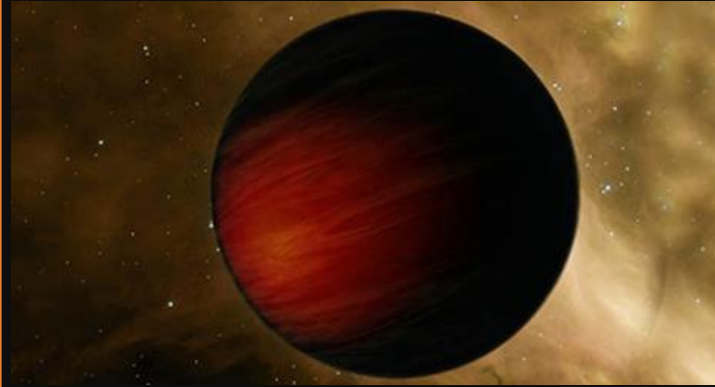


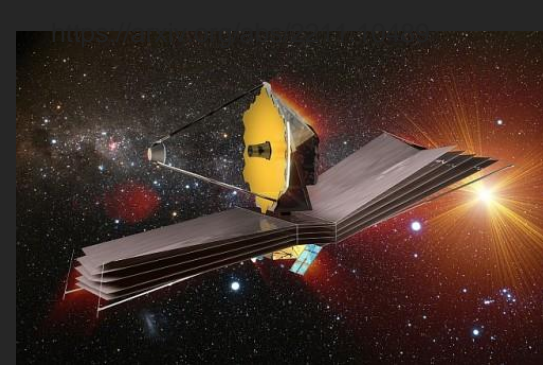
Darkest known exoplanet

TrEs-2b

Less than 1% of the sunlight falling on it

The researchers propose that light-absorbing chemicals such as vaporized sodium and potassium or gaseous titanium oxide in the planet's atmosphere could help explain why it is so dark. Still, none of these can fully explain why the world is as stealthily cloaked as it is.





Arxiv papers on the discovery:

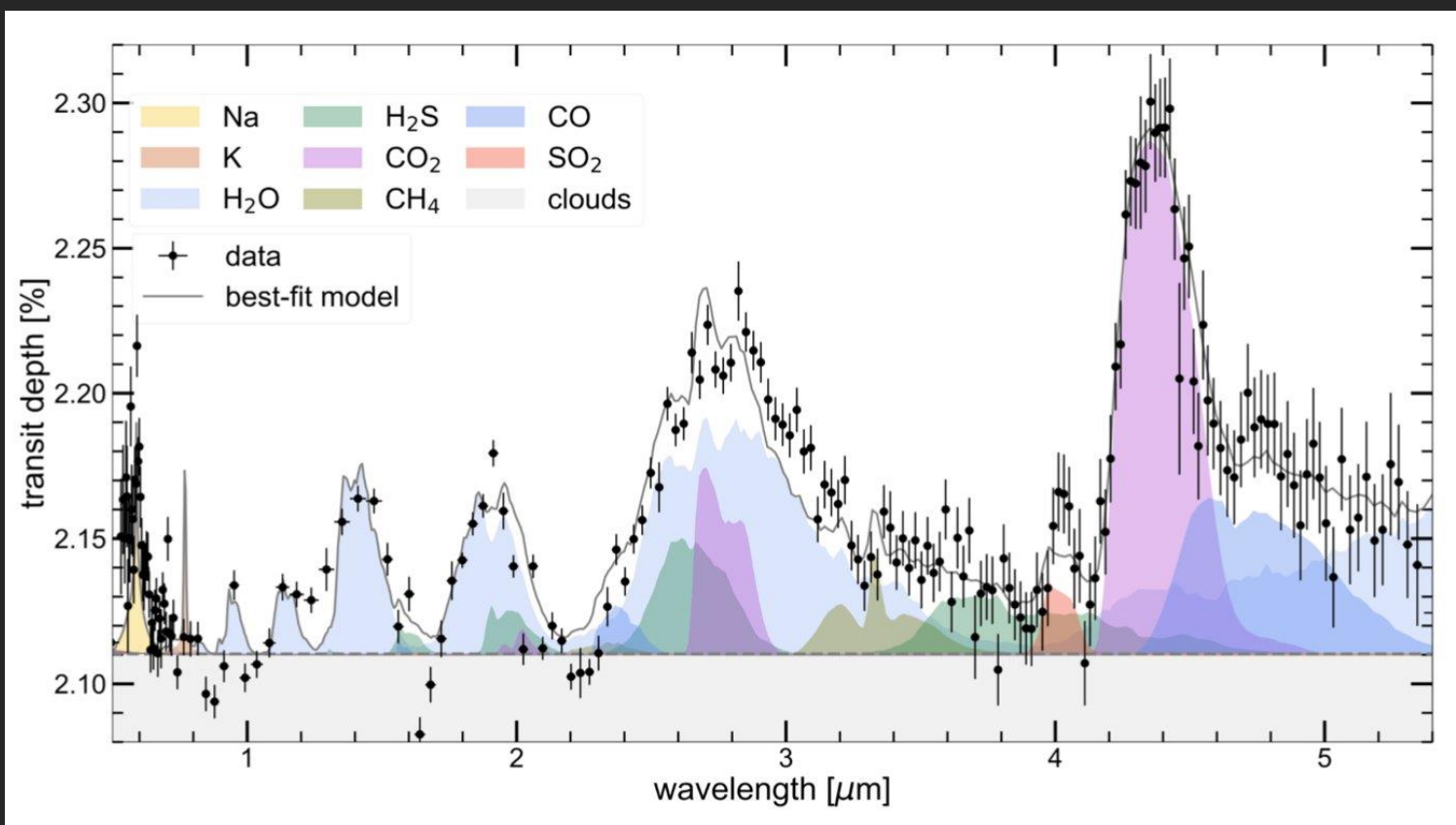
<https://arxiv.org/abs/2211.10488>

<https://arxiv.org/abs/2211.10487>

<https://arxiv.org/abs/2211.10489>

<https://arxiv.org/abs/2211.10493>

<https://arxiv.org/abs/2211.10490>



Rustamkulov et al.

Interesting results from JWST

WASP-39 b

- Hot-Jupiter gas giant
- H₂O and CO₂ abundance

"The Discovery of Photochemistry happening in this exoplanet's atmosphere "

SO₂



Photons from the star interact with abundant water molecules and results in forming Sulfur Dioxide molecules

Hubble Deep-space Image

Each dot is a galaxy!

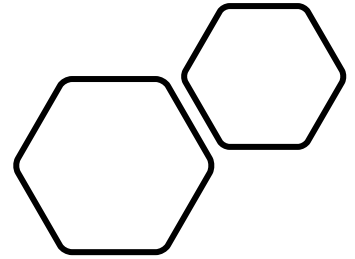


"Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam."

- Carl Sagan, 1934-1996



The Earth as imaged from the the Voyager 1 spacecraft, as it exited the solar system in 1990. Earth is nearly 4 billion miles away in this image.





Live your Life!

Our Earth is big; but the space is enormous!

The background of the slide is dark with a pattern of question marks in various shades of brown and grey. A large, semi-transparent grey question mark is positioned behind the text.

Thank you!!

Any questions?

References:

- <https://exoplanets.nasa.gov/what-is-an-exoplanet/planet-types/overview/>
- <https://www.space.com/12612-alien-planet-darkest-coal-black-kepler.html>
- <https://universemagazine.com/en/trappist-1-planets-capable-of-sustaining-life/>
- <https://object-cosmos.fandom.com/wiki/Lieopa>