



**Gruppo Naturalistico Bellona**  
**Sezione Astronomia**

# ESOPIANETI

**cosa sappiamo dei mondi oltre il sistema solare**

**19/04/2024**

**Museo di Storia Naturale e  
Archeologia di Montebelluna**





# CREDITS:

<https://exoplanets.nasa.gov/news/1350/are-we-alone-in-the-universe-revisiting-the-drake-equation/>

[https://chandra.harvard.edu/edu/formal/variable\\_stars/bg\\_info.html](https://chandra.harvard.edu/edu/formal/variable_stars/bg_info.html)

<https://exoplanets.nasa.gov/>

<https://science.nasa.gov/ems/>

[www.gnbellona.it](http://www.gnbellona.it)

Gruppo Naturalistico Bellona  
Sezione Astronomia





Gruppo Naturalistico Bellona  
Sezione Astronomia

# Verified Certificate

This is to certify that

**Massimiliano Sartor**

successfully completed and received a passing grade in

**SPU30x: Super-Earths and Life**

a course of study offered by HarvardX, an online learning initiative of Harvard University.

HarvardX

**Dimitar Sasselov**

Professor of Astronomy

*Harvard University*



Verified Certificate  
Issued December 25, 2023

Valid Certificate ID  
9a4497fc4e77461d8237825c2ab0315c



# formula di Drake (1961)

$$N = R_* \times f_p \times n_e \times f_e \times f_i \times f_c \times L$$

The number of technologically advanced civilizations in the Milky Way galaxy

The rate of formation of stars in the galaxy

The fraction of those stars with planetary systems

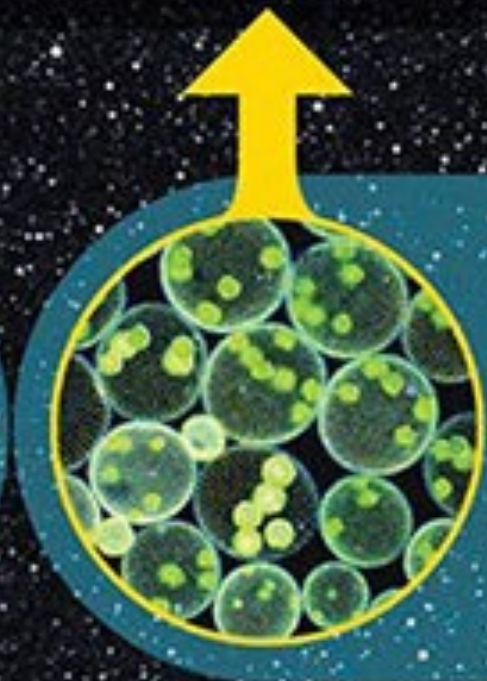
The number of planets, per solar system, with an environment suitable for life

The fraction of suitable planets on which life actually appears

The fraction of life-bearing planets on which intelligent life emerges

The fraction of civilizations that develop a technology that releases detectable signs of their existence into space

The length of time such civilizations release detectable signals into space



$A$

$=$

$N_{ast}$

$\times$

$f_{bt}$

The number of technological species that have formed over the history of the observable universe

The number of habitable planets in a given volume of the universe

The likelihood of a technological species arising on one of these planets

Frank & Sullivan (2016)



# formula di Drake (1961)

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The likelihood of a technological species arising on one of these planets



NELLA NOSTRA GALASSIA, LA **VIA LATTEA** CI SONO CIRCA  
100 MILIARDI DI STELLE

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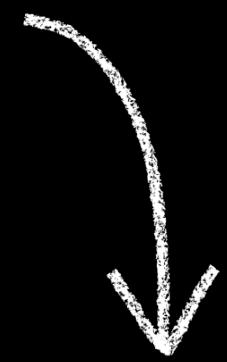




IN UN GRANNELLO  
DI SABBIA



NELL'UNIVERSO



1.000.000.000.000.000,000.000.000

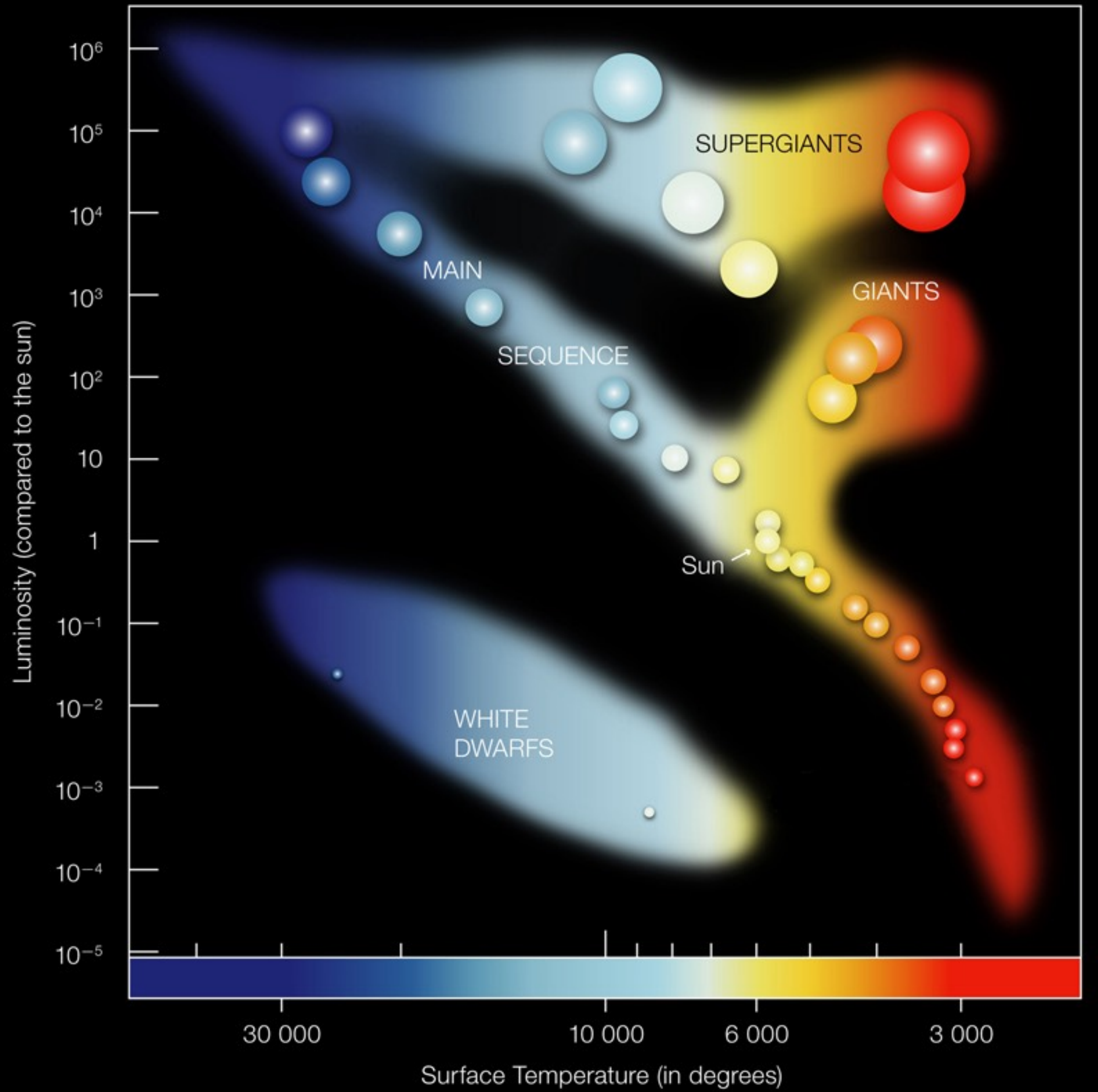


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... SI FA PRESTO A DIRE STELLA...

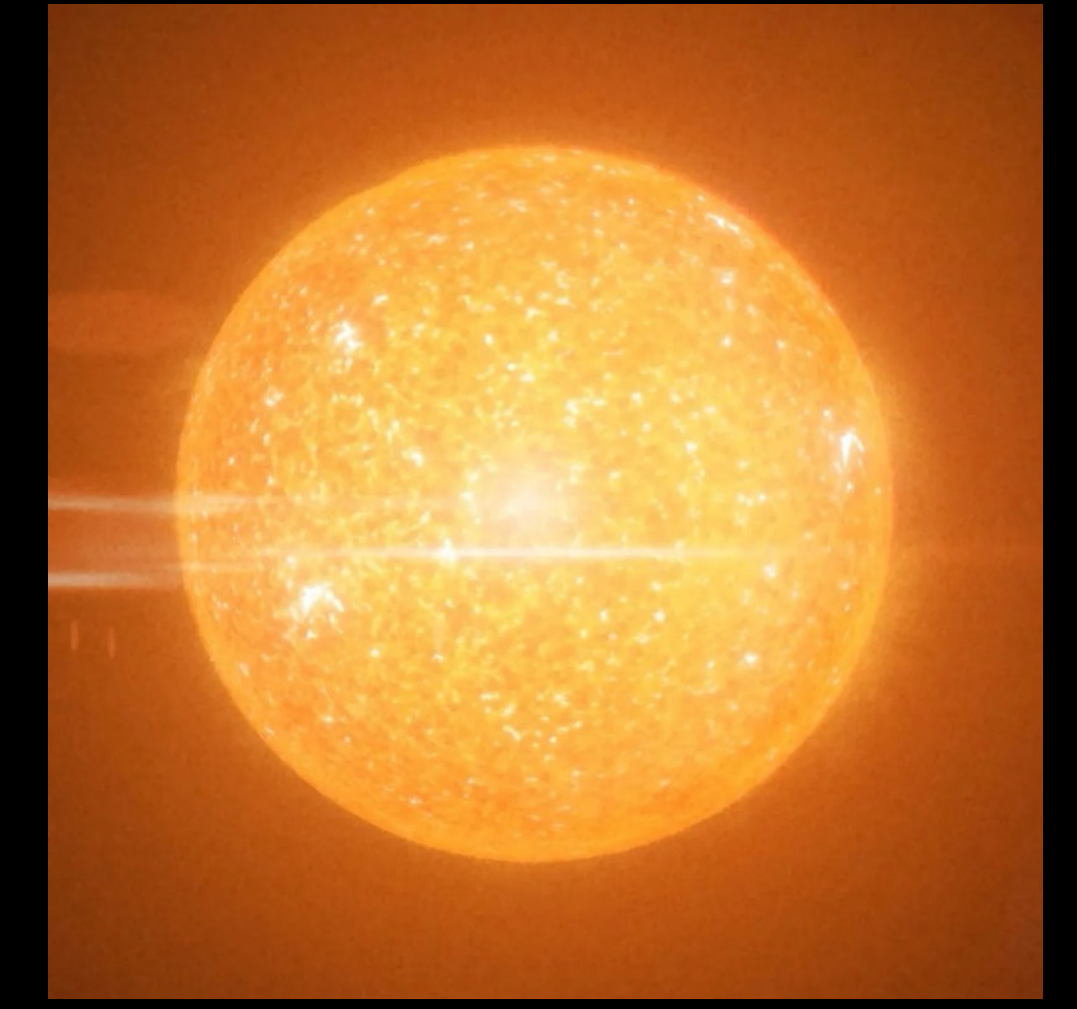
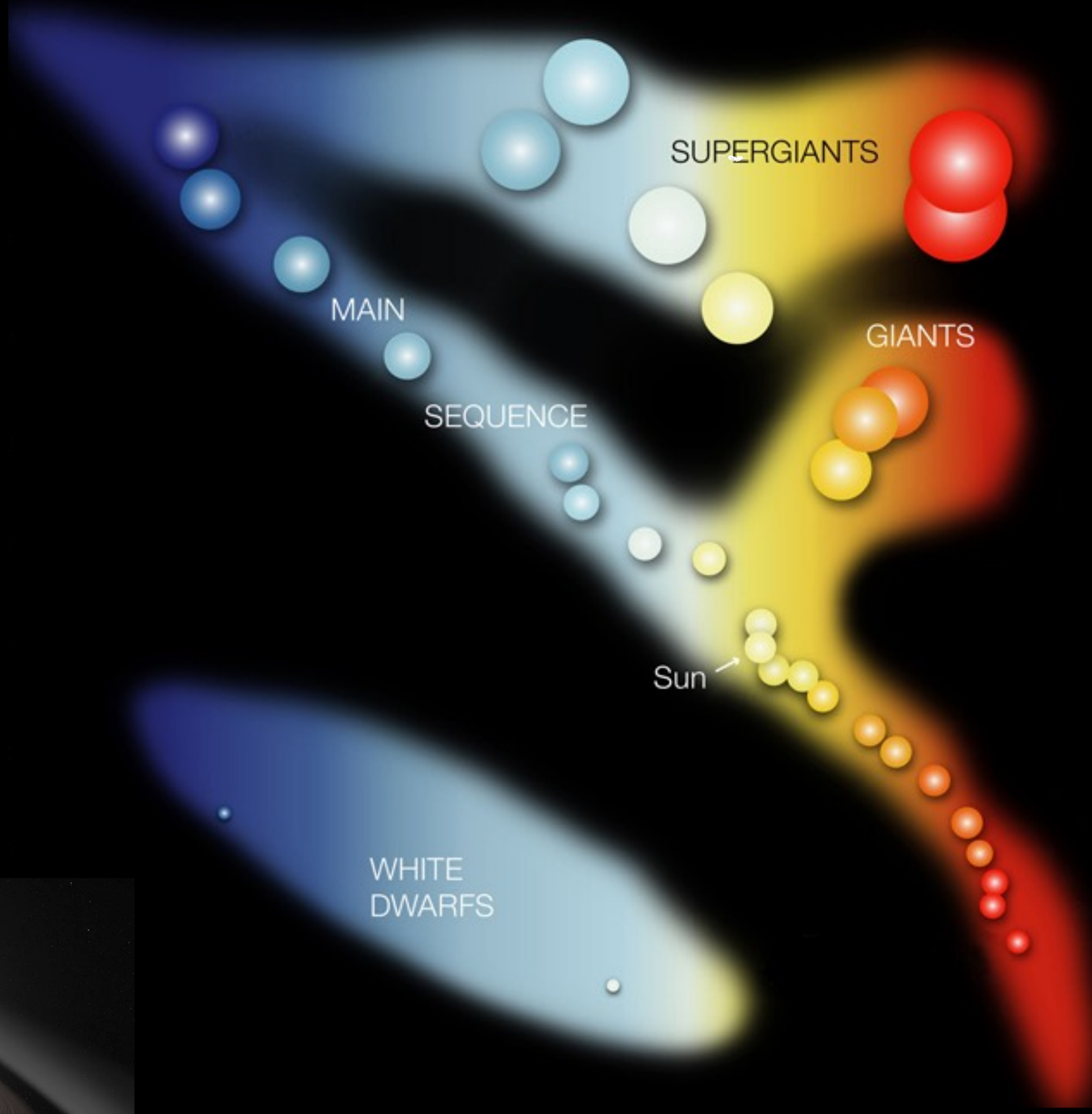
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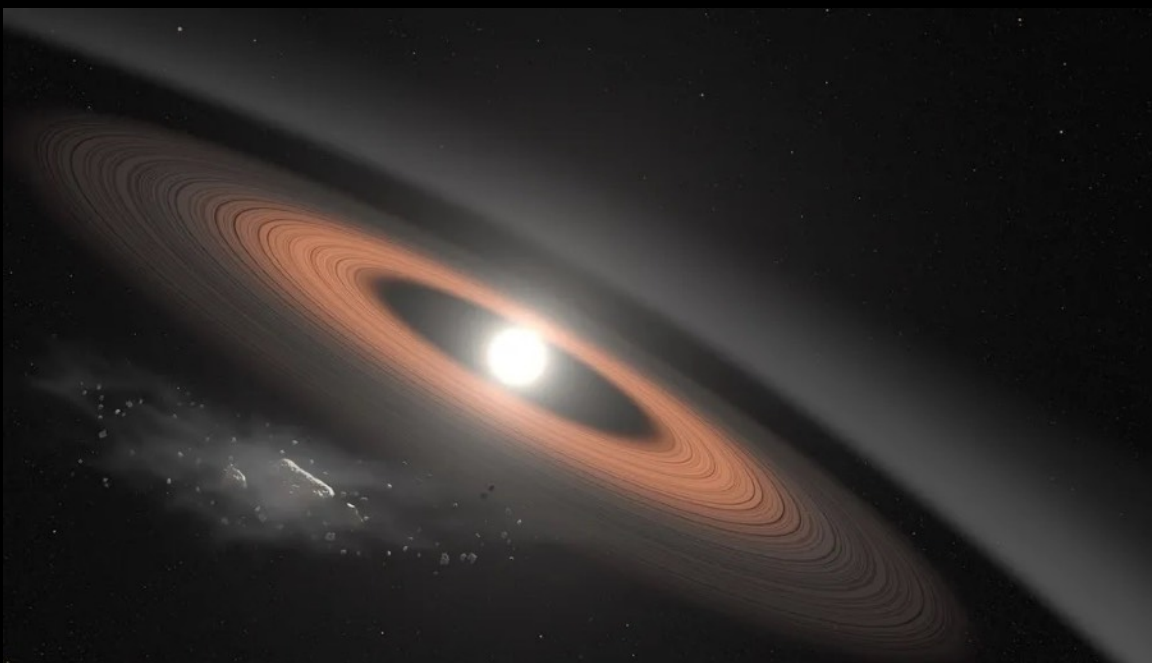
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GIGANTI  
ROSSE

NANE  
ROSSE

NANE  
BIANCHE



# LA ZONA ABITABILE



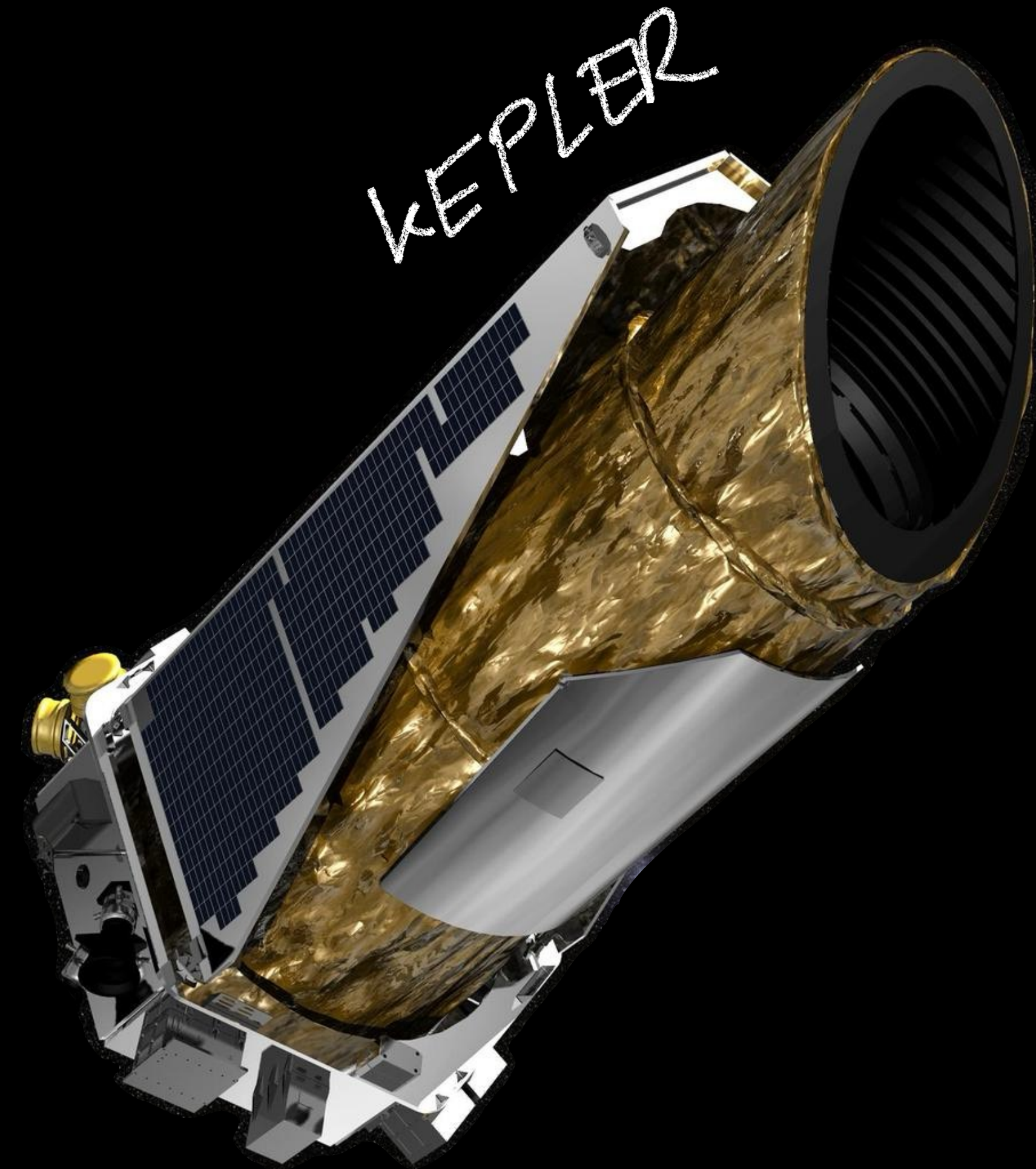
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	HABITABLE ZONE SIZE	X-RAY IRRADIANCE	RELATIVE ABUNDANCE	LONGEVITY
M		 400x		100 Billion Years
K		 25x		40 Billion Years
G		 1x		10 Billion Years



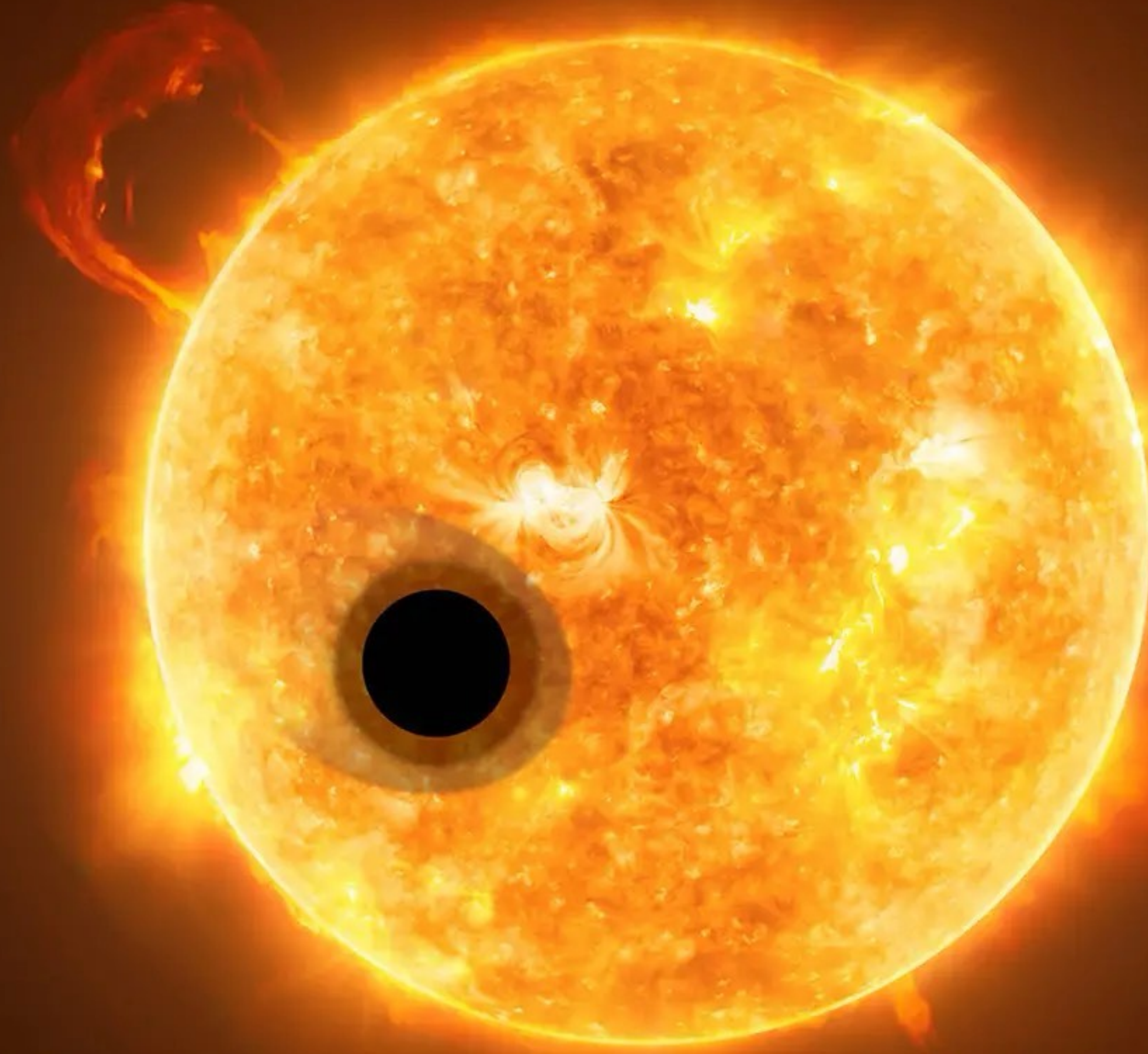
# Come troviamo gli esopianeti?

- METODO DEL TRANSITO
- METODO DI WOBBLE
- IMMAGINE DIRETTA
- MICROLENSING





# METODO DEL TRANSITO

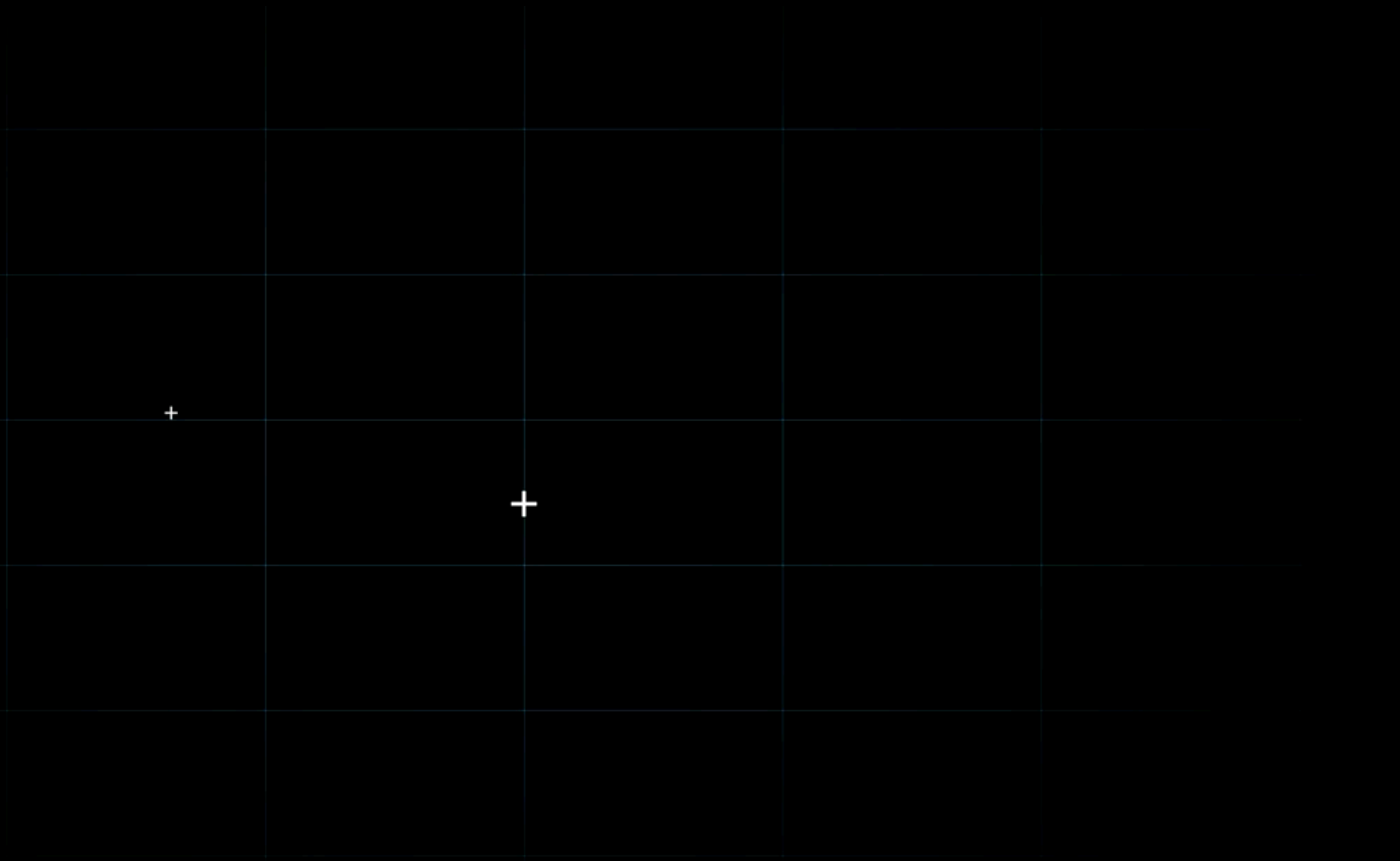


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# METODO DEL TRANSITO

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# METODO DEL TRANSITO + SPETTROSCOPIA

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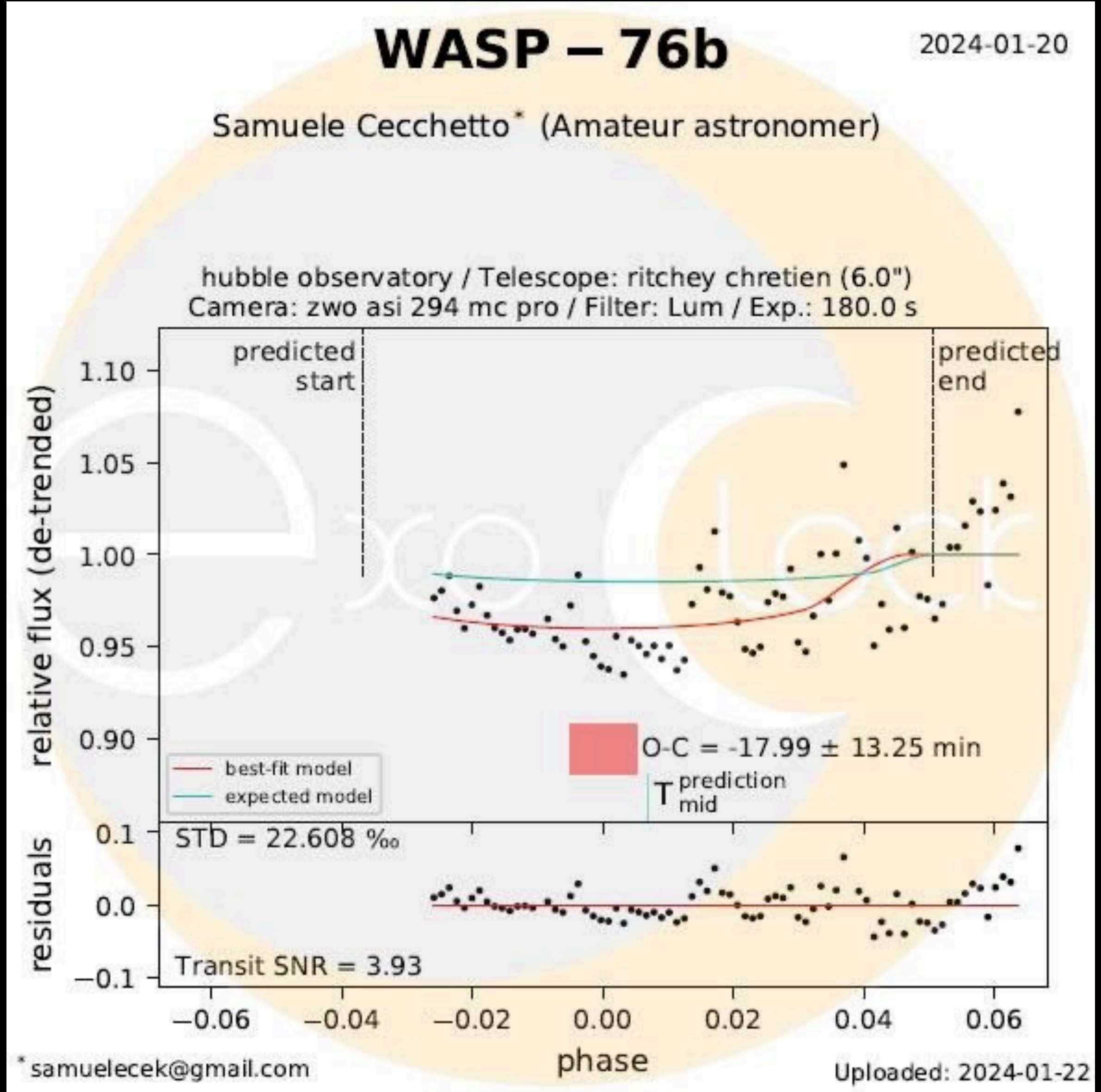
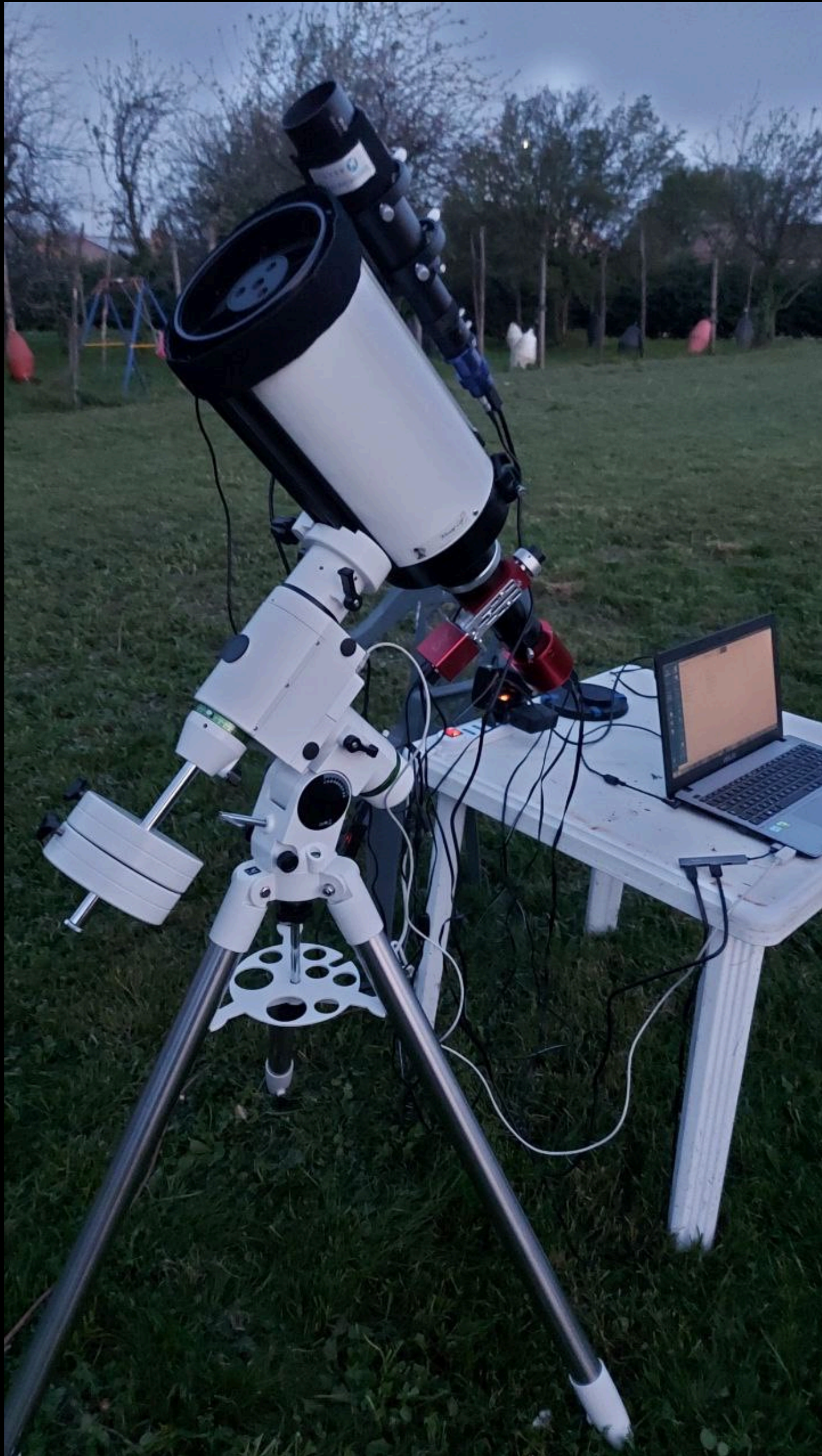




MA COSA PUO' FARE UN ASTROFILO ?

✓ SAMUELE

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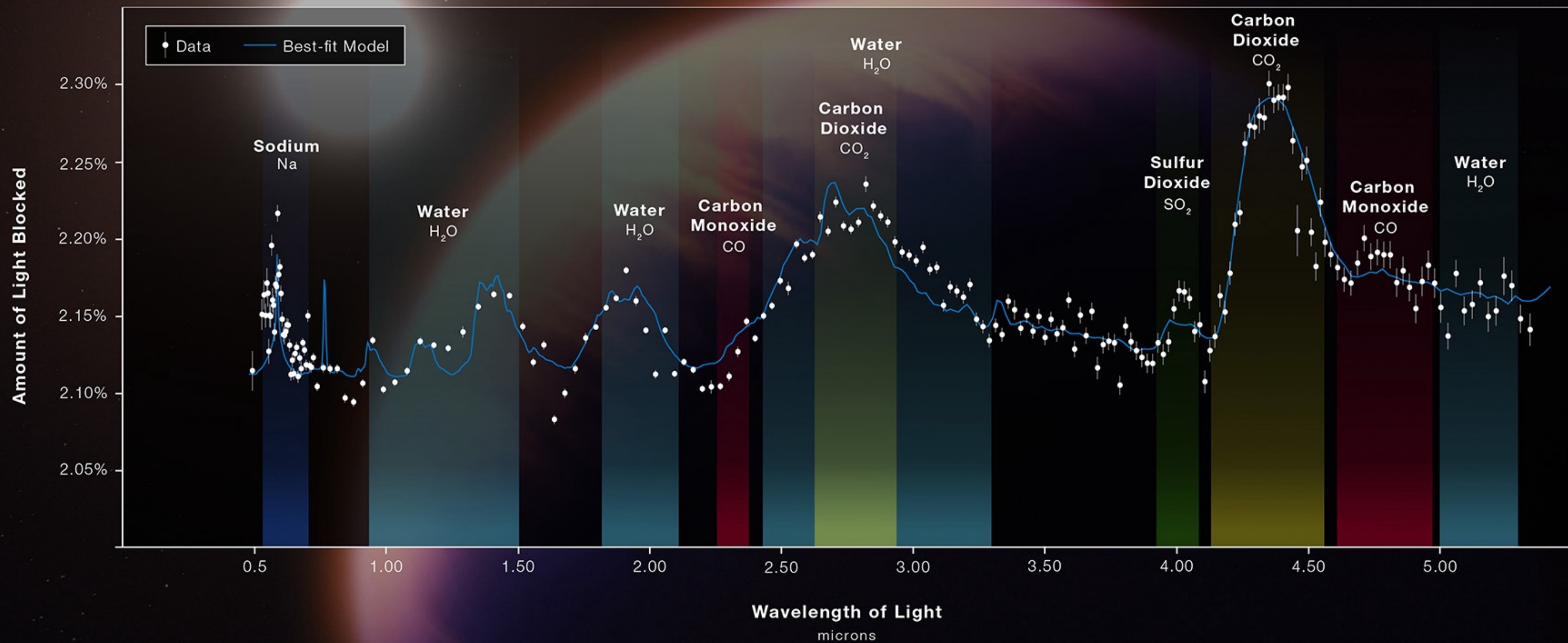


# JAMES WEBB

## HOT GAS GIANT EXOPLANET WASP-39 b

# ATMOSPHERE COMPOSITION

NIRSpec PRISM



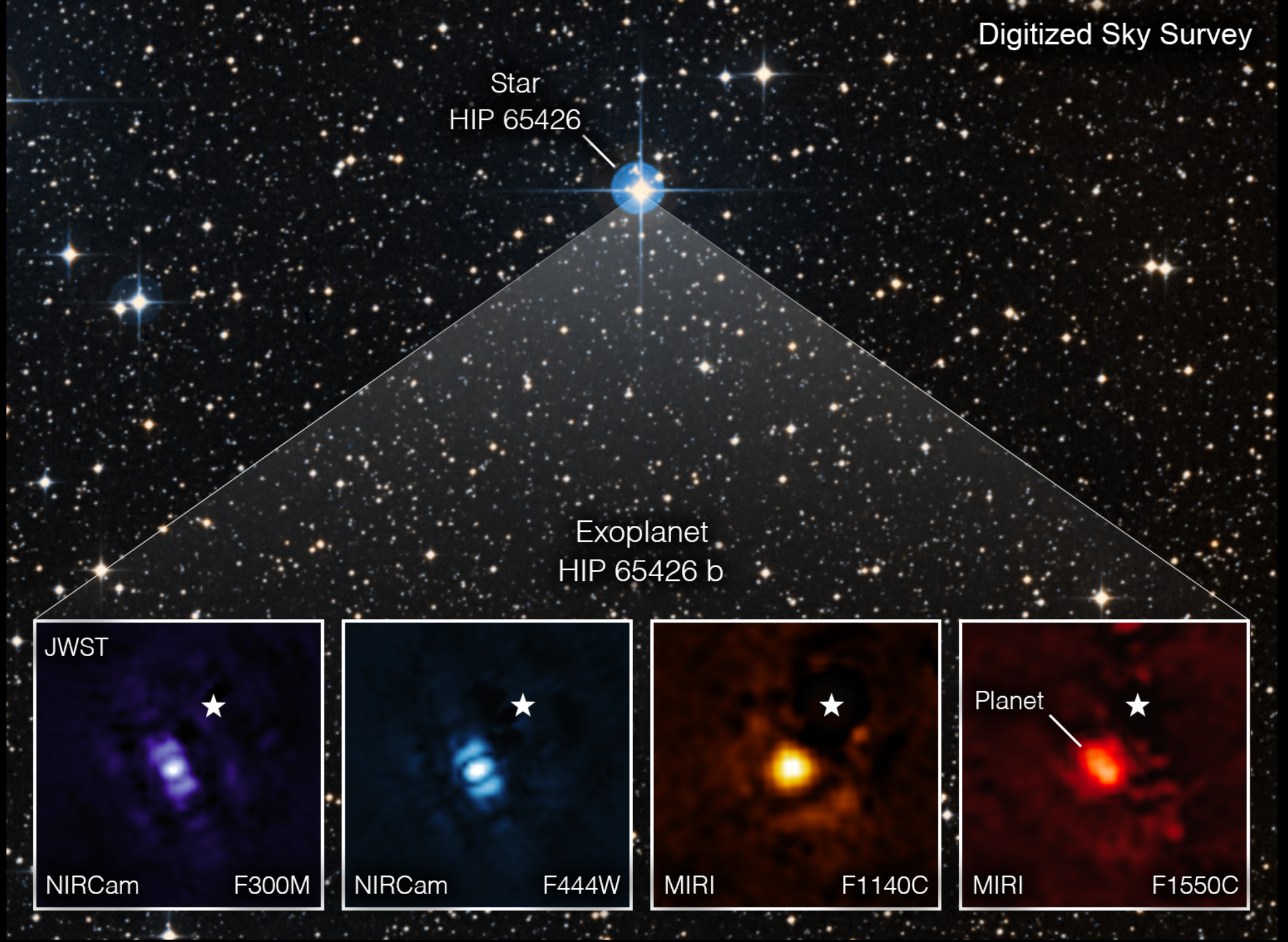
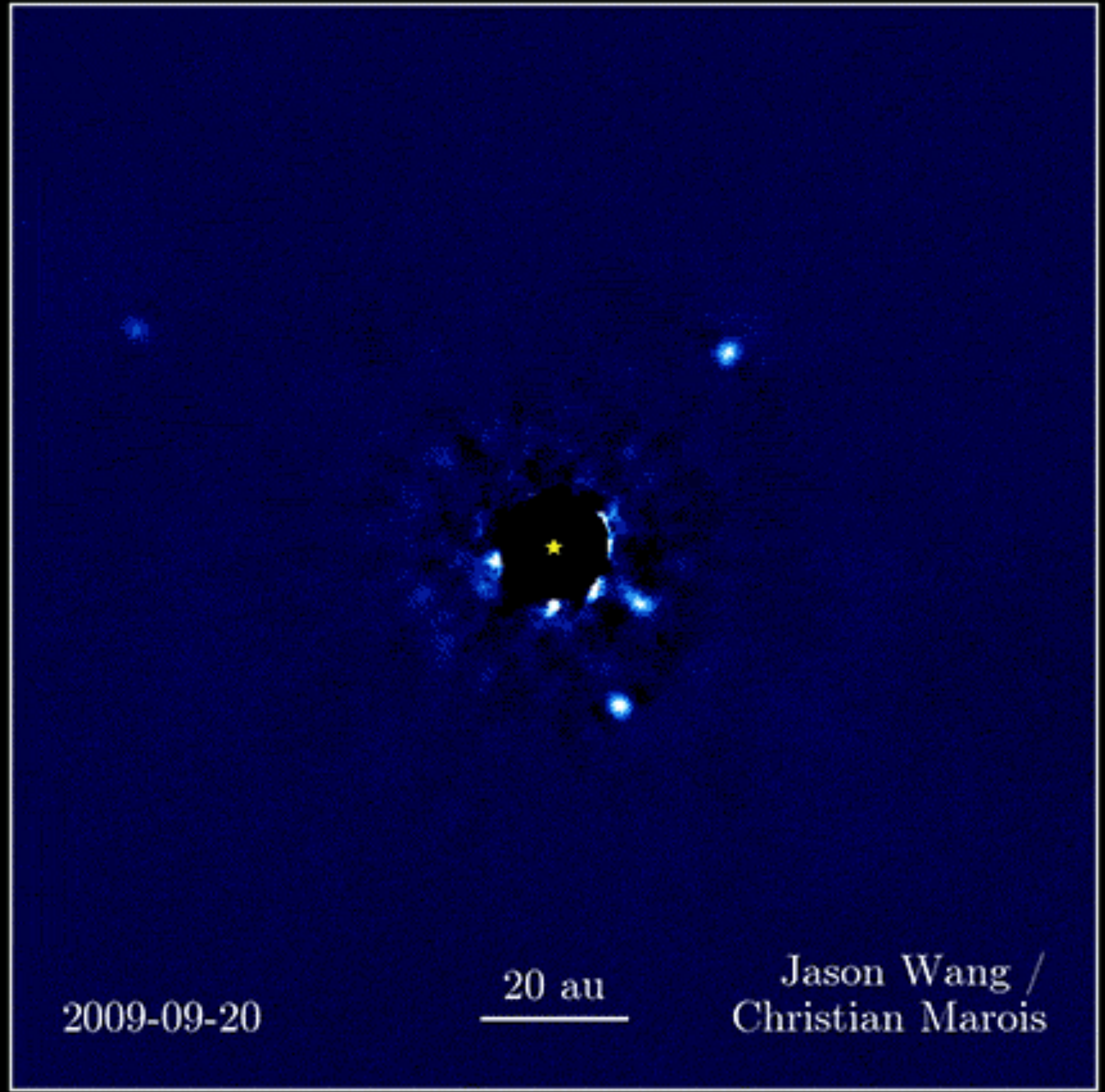
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**WEBB**  
SPACE TELESCOPE





JAMES WEBB 



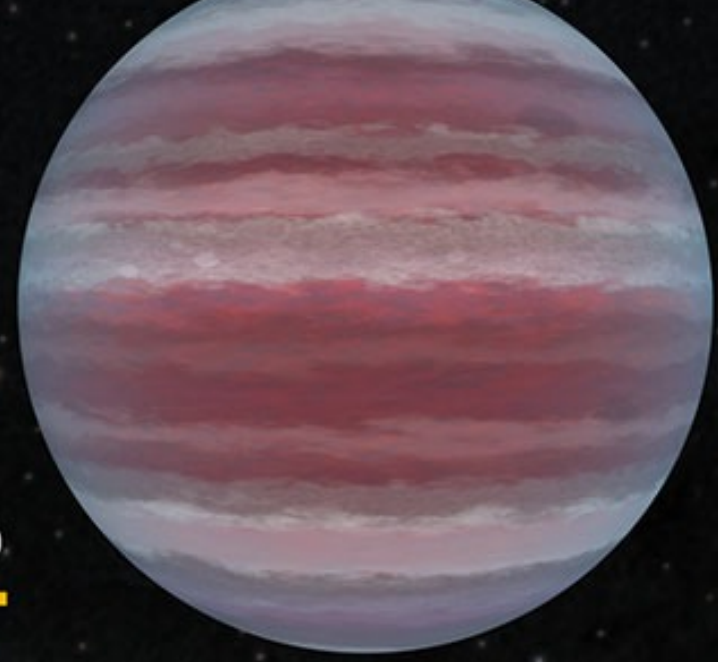
 KECK OBSERVATORY

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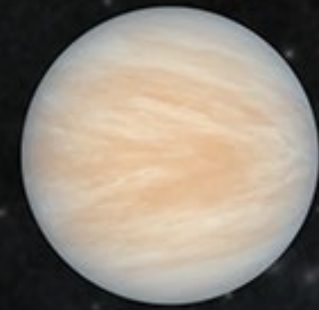
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**Sezione Astronomia**

QUINDI?  
COSA ABBIAMO TROVATO?



**30%**  
**GAS GIANT**

The size of Saturn or Jupiter (the largest planet in our solar system), or many times bigger. They can be hotter than some stars!



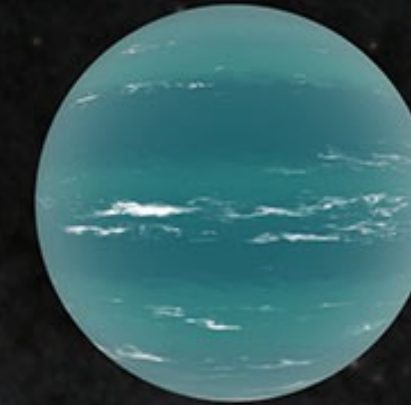
**31%**  
**SUPER-EARTH**

Planets in this size range between Earth and Neptune don't exist in our solar system. Super-Earths, a reference to larger size, might be rocky worlds like Earth, while mini-Neptunes are likely shrouded in puffy atmospheres.



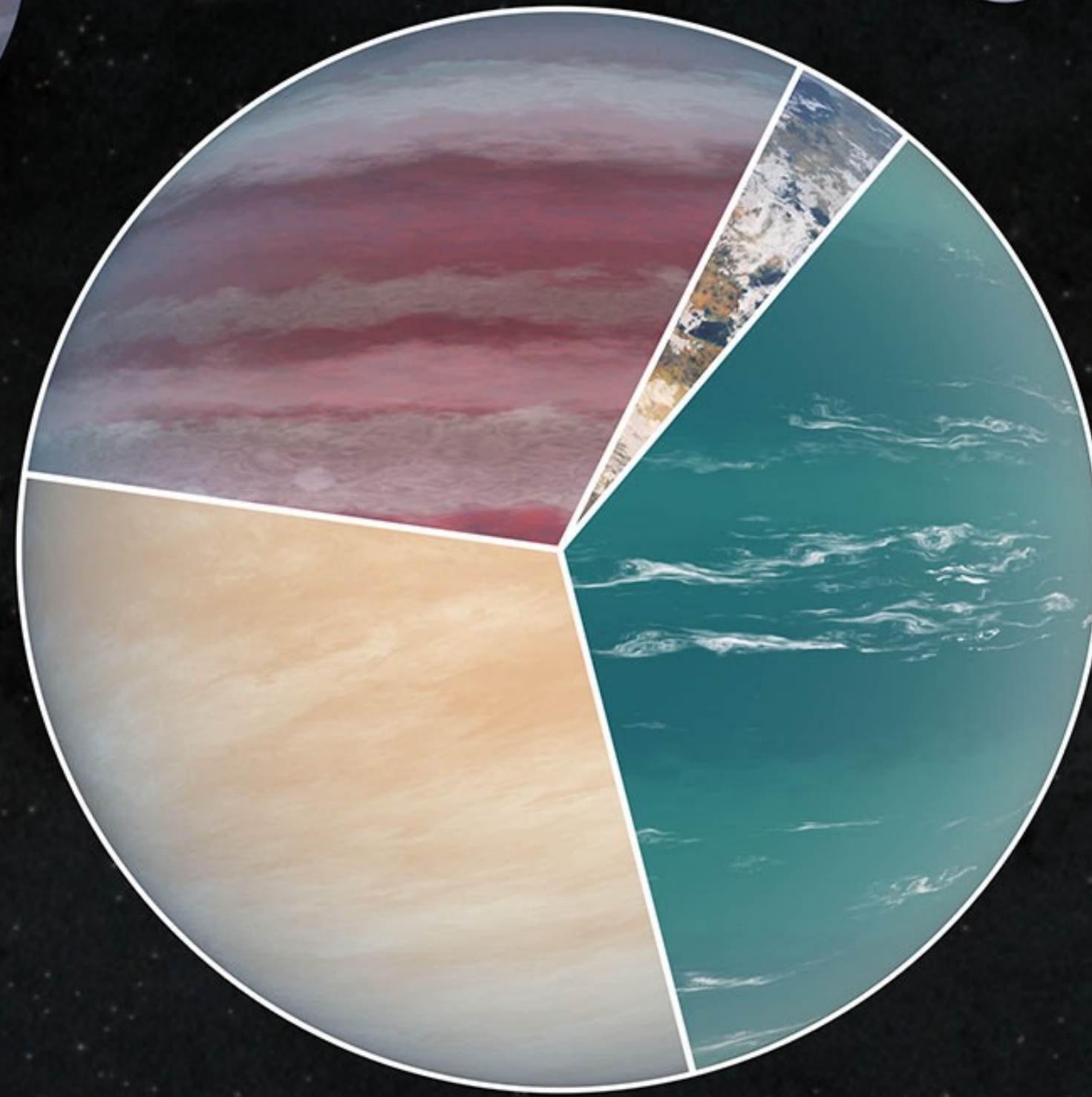
**4%**  
**TERRESTRIAL**

Small, rocky planets. Around the size of our home planet, or a little smaller.



**35%**  
**NEPTUNE-LIKE**

Similar in size to Neptune and Uranus. They can be ice giants, or much warmer. "Warm" Neptunes are more rare.



**5000+**  
**PLANETS FOUND**

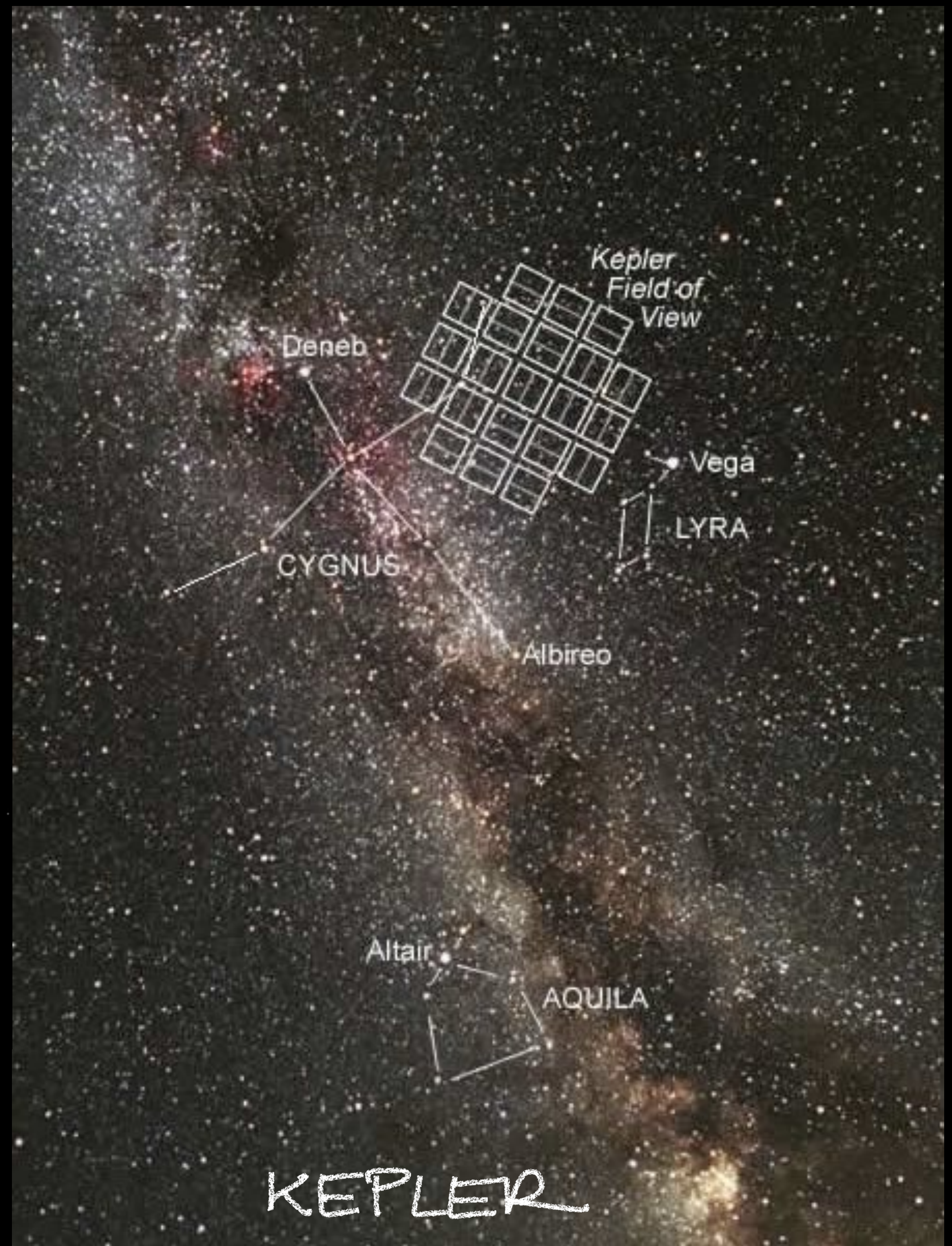
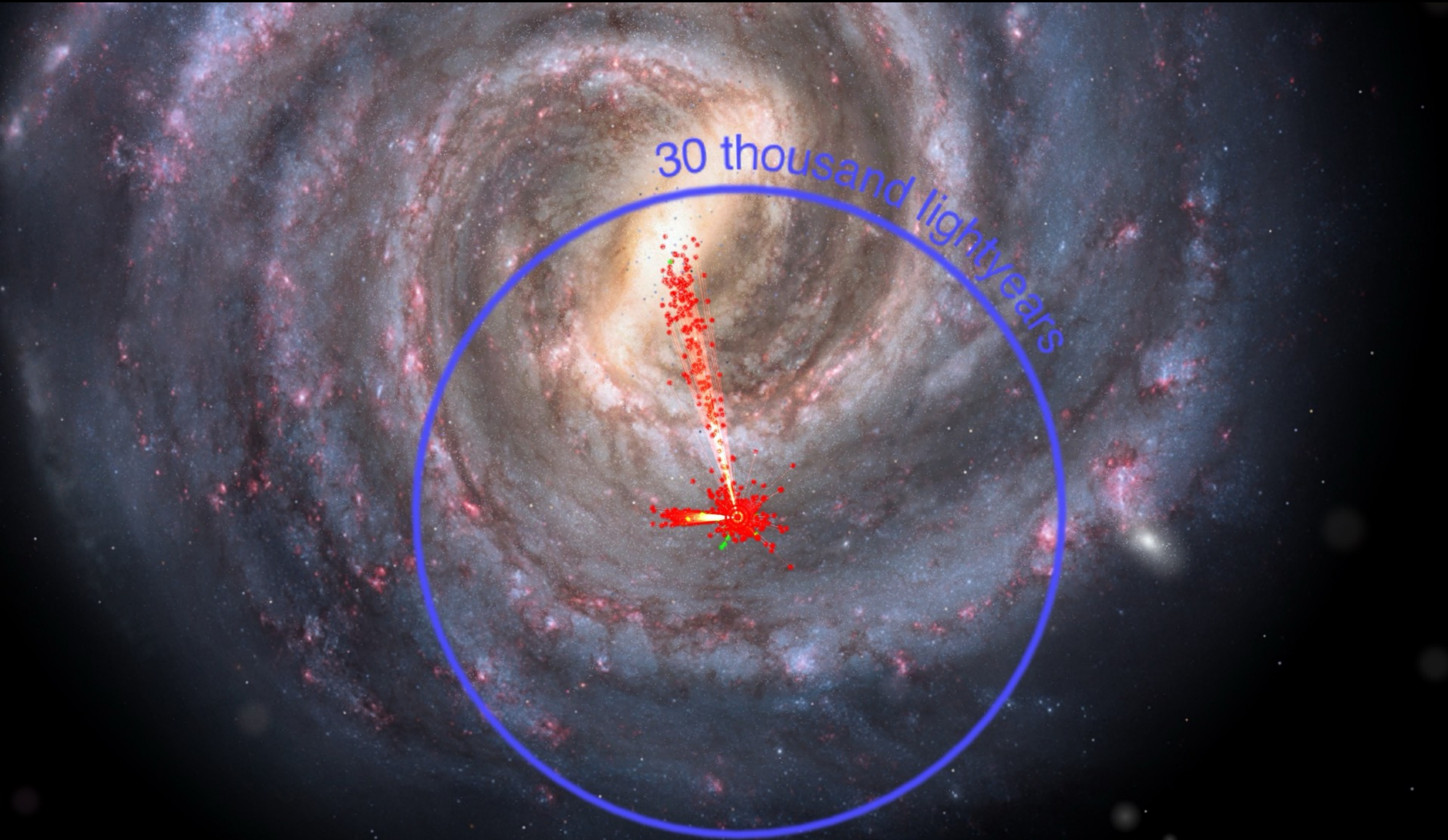
↑  
I PIU' PROMETTENTI  
PER LA RICERCA DI  
VITA

↑ GRAVITA' = ATMOSFERA / ACQUA  
↑ MAGGIORE STABILITA'

DOVE SONO?

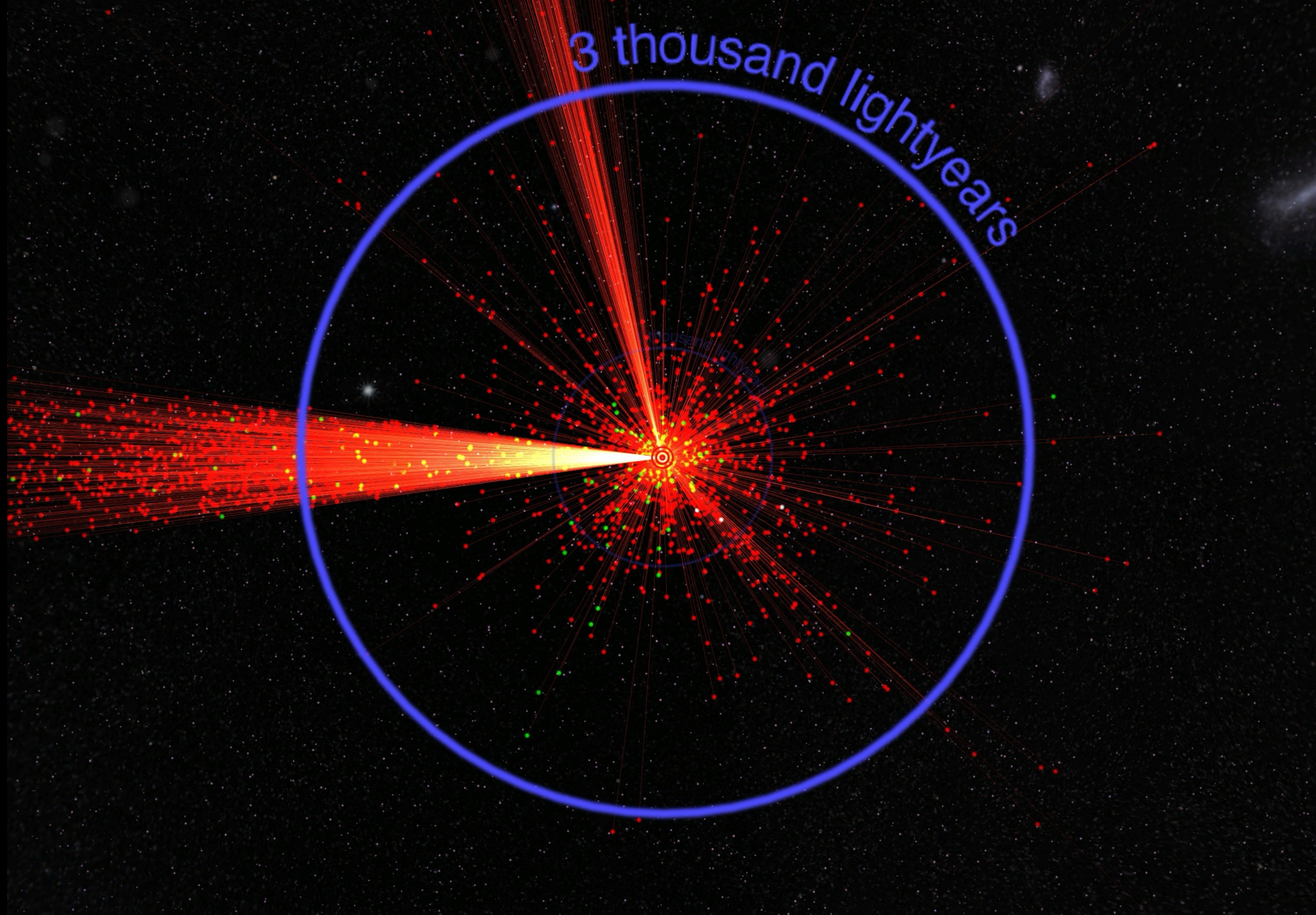


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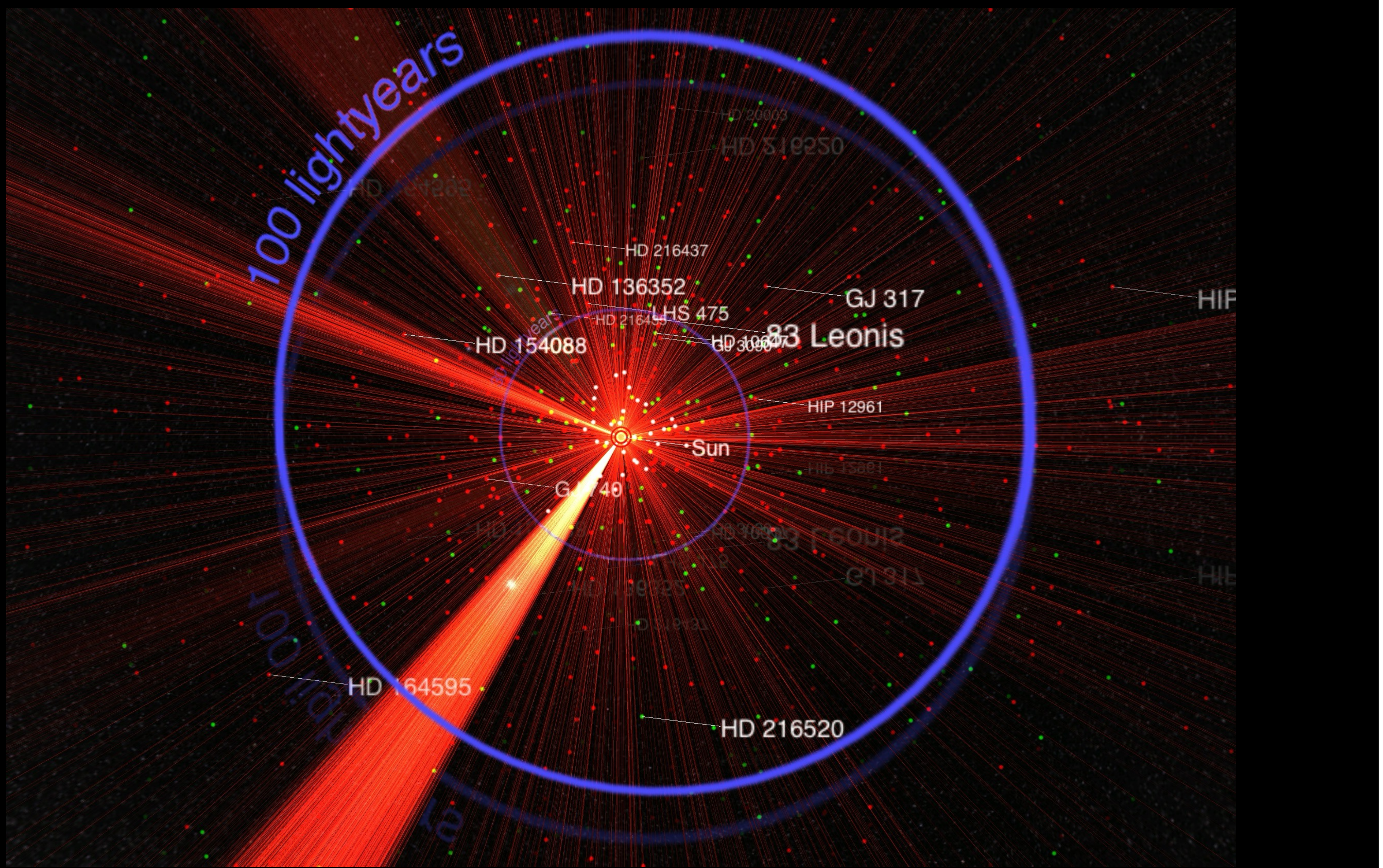


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# Kepler-22 System

## Solar System

Habitable Zone



Kepler-22b

Mercury



Venus



Earth



Mars

Planets and orbits to scale



ORBITAL RADIUS	0.812 AU	ORBITAL PERIOD	289.9 days	ORBITAL ECCENTRICITY	< 0.72
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Planet Comparison

Kepler-22 b Earth

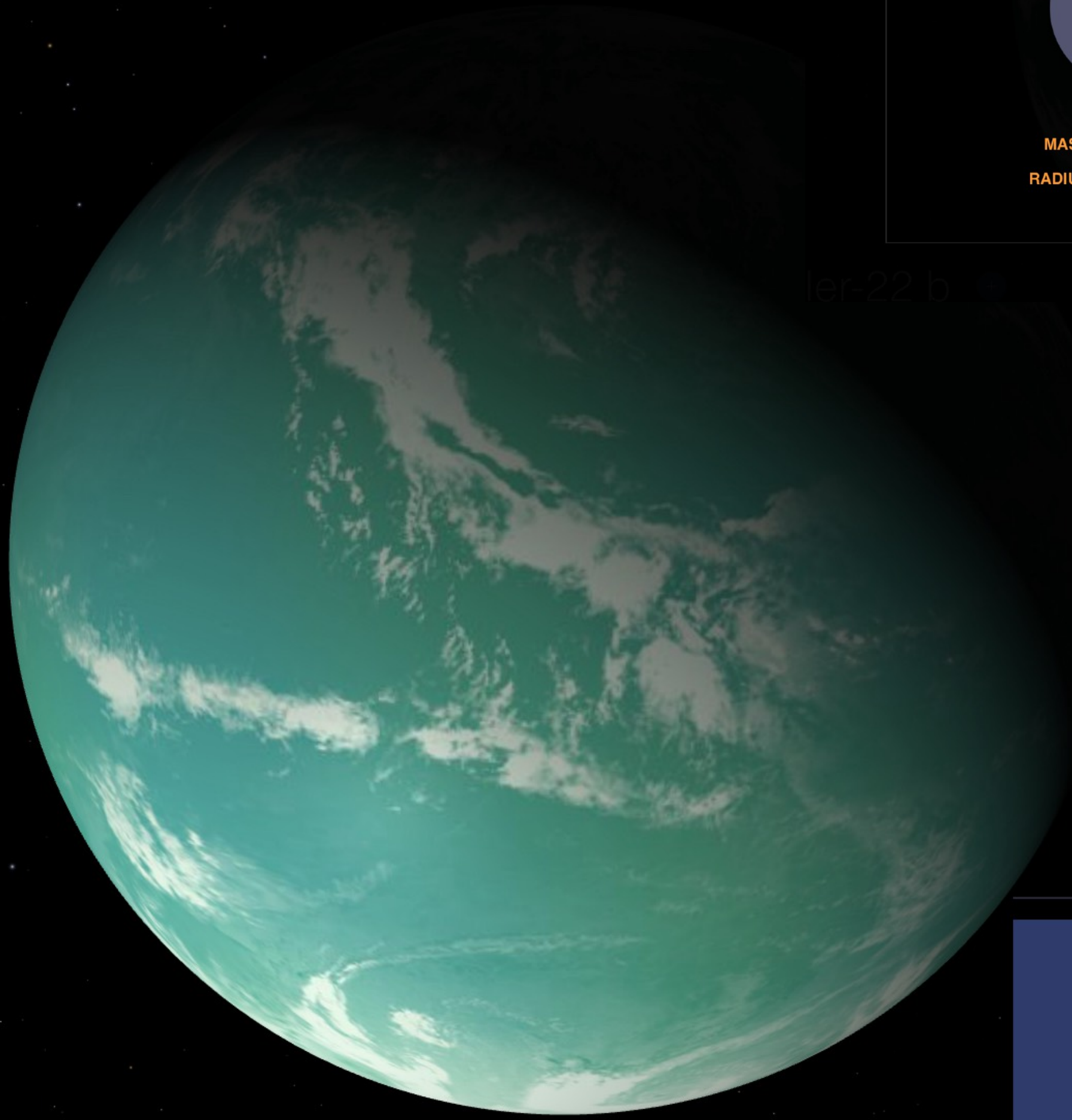
MASS 9.1 Earths  
RADIUS 2.1 x Earth

Star Comparison

Kepler-22 Our Sun

MASS 0.86 x Our Sun  
RADIUS 0.87 x Our Sun

You are  
635 light-years  
from Earth



# Kepler-22 b +

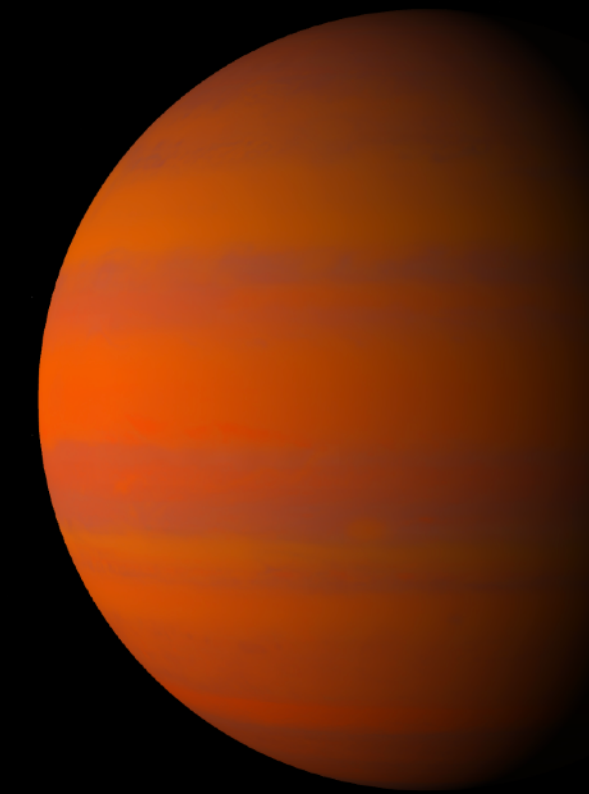
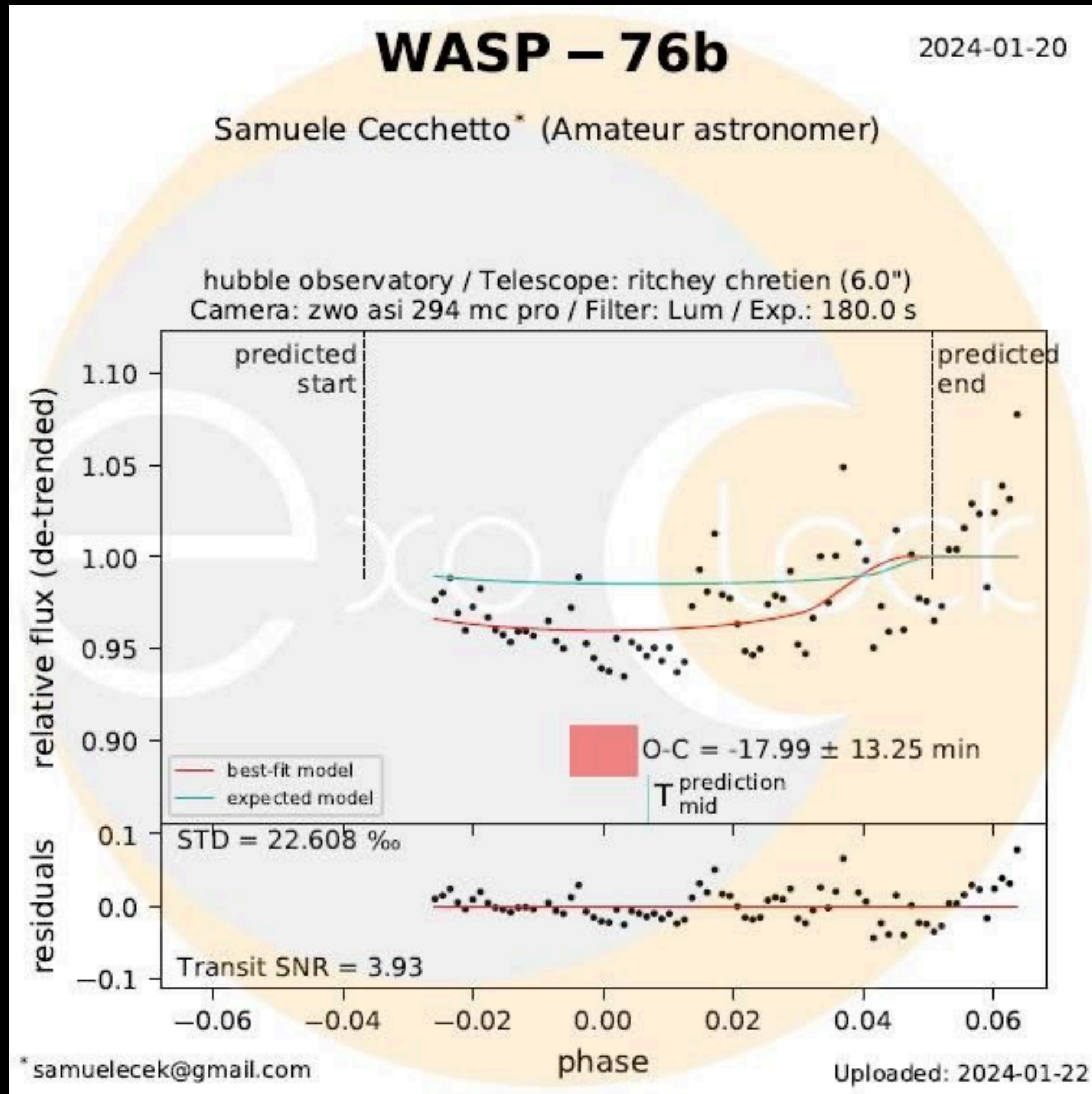
A potentially rocky world, larger than Earth

VIEW

Planet System Star

COMPARE





You are  
634 light-years  
from Earth

WASP-76 b +

A giant planet composed mainly of gas

VIEW

Planet   System   Star

COMPARE

<b>ORBITAL RADIUS</b> 0.033 AU	<b>ORBITAL PERIOD</b> 1.8 days	<b>ORBITAL ECCENTRICITY</b> 0
--------------------------------	--------------------------------	-------------------------------

### Planet Comparison

WASP-76 b    Jupiter

**MASS** 0.92 Jupiters  
**RADIUS** 1.83 x Jupiter

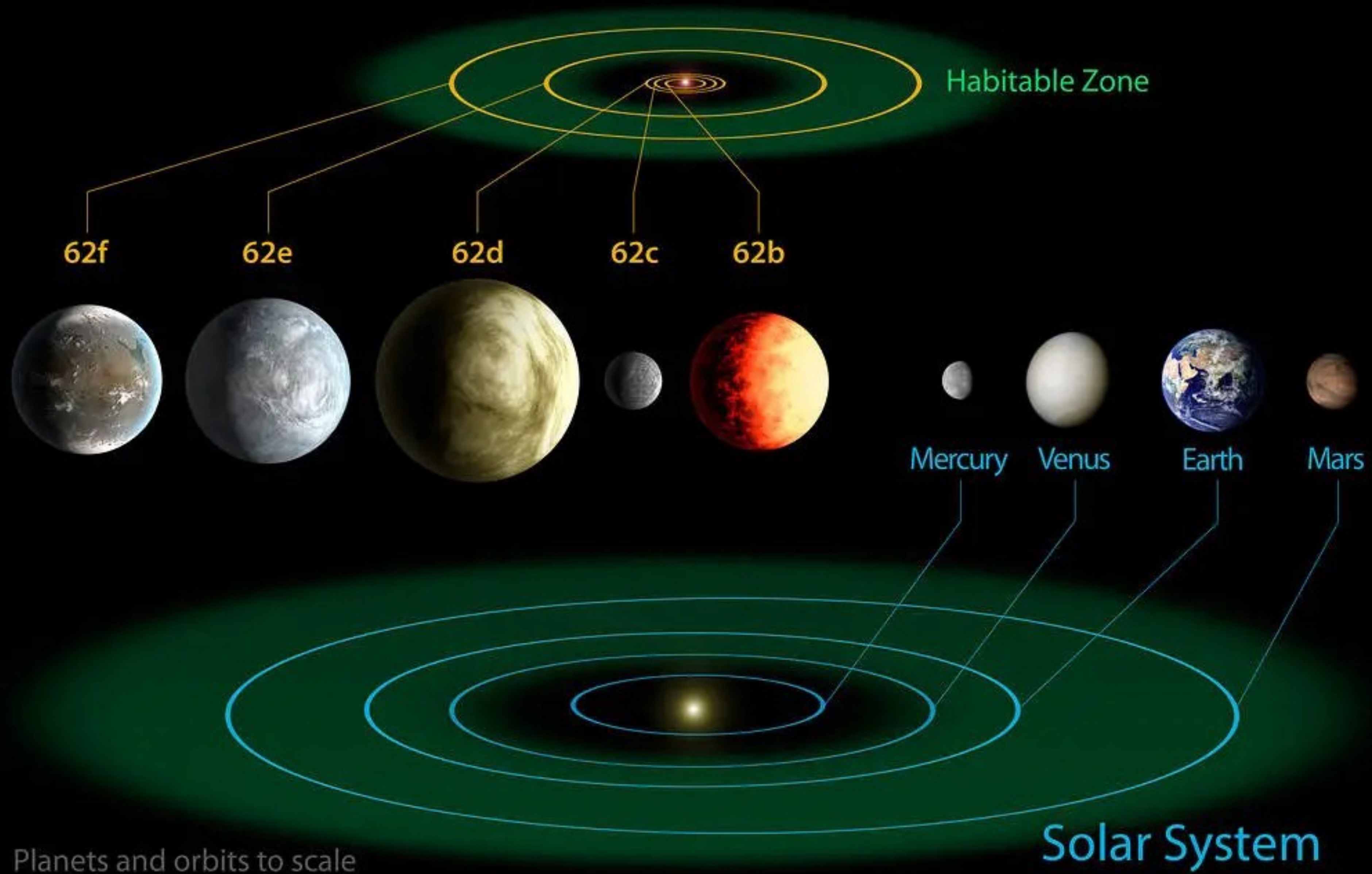
### Star Comparison

WASP-76    Our Sun

**MASS** 1.46 x Our Sun  
**RADIUS** 1.73 x Our Sun



# Kepler-62 System

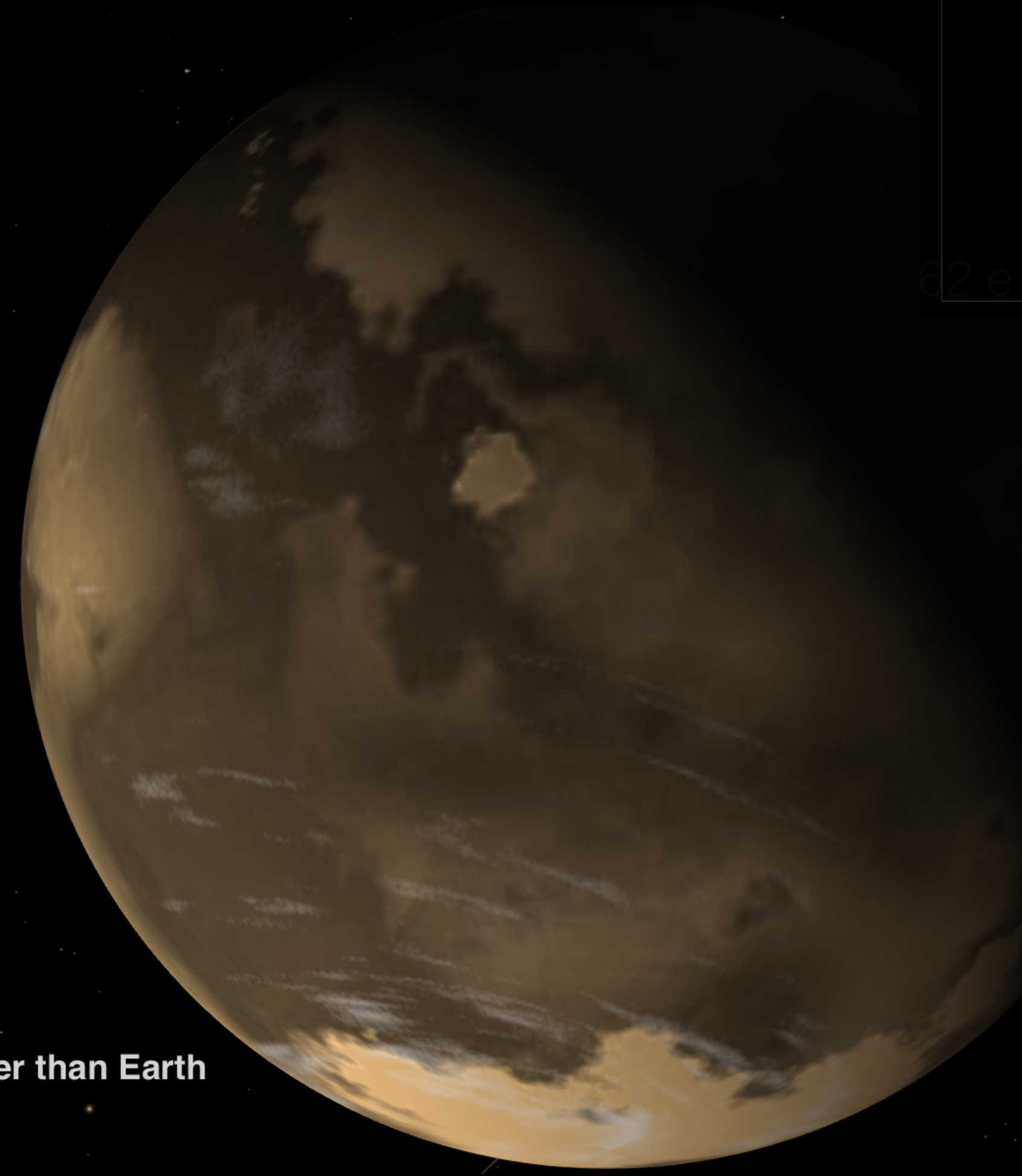


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ORBITAL RADIUS	0.427 AU	ORBITAL PERIOD	122.4 days	ORBITAL ECCENTRICITY	0
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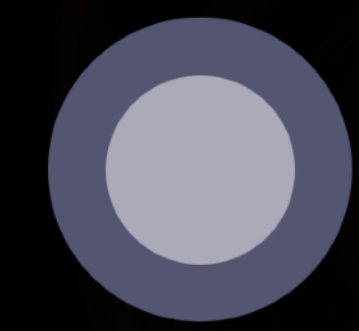
You are  
981 light-years  
from Earth

Kepler-62 e

A potentially rocky world, larger than Earth

Planet Comparison

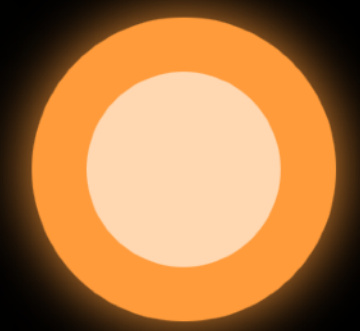
Kepler-62 e Earth



MASS 36 Earths  
RADIUS 1.61 x Earth

Star Comparison

Kepler-62 Our Sun



MASS 0.69 x Our Sun  
RADIUS 0.64 x Our Sun

VIEW

Planet System Star

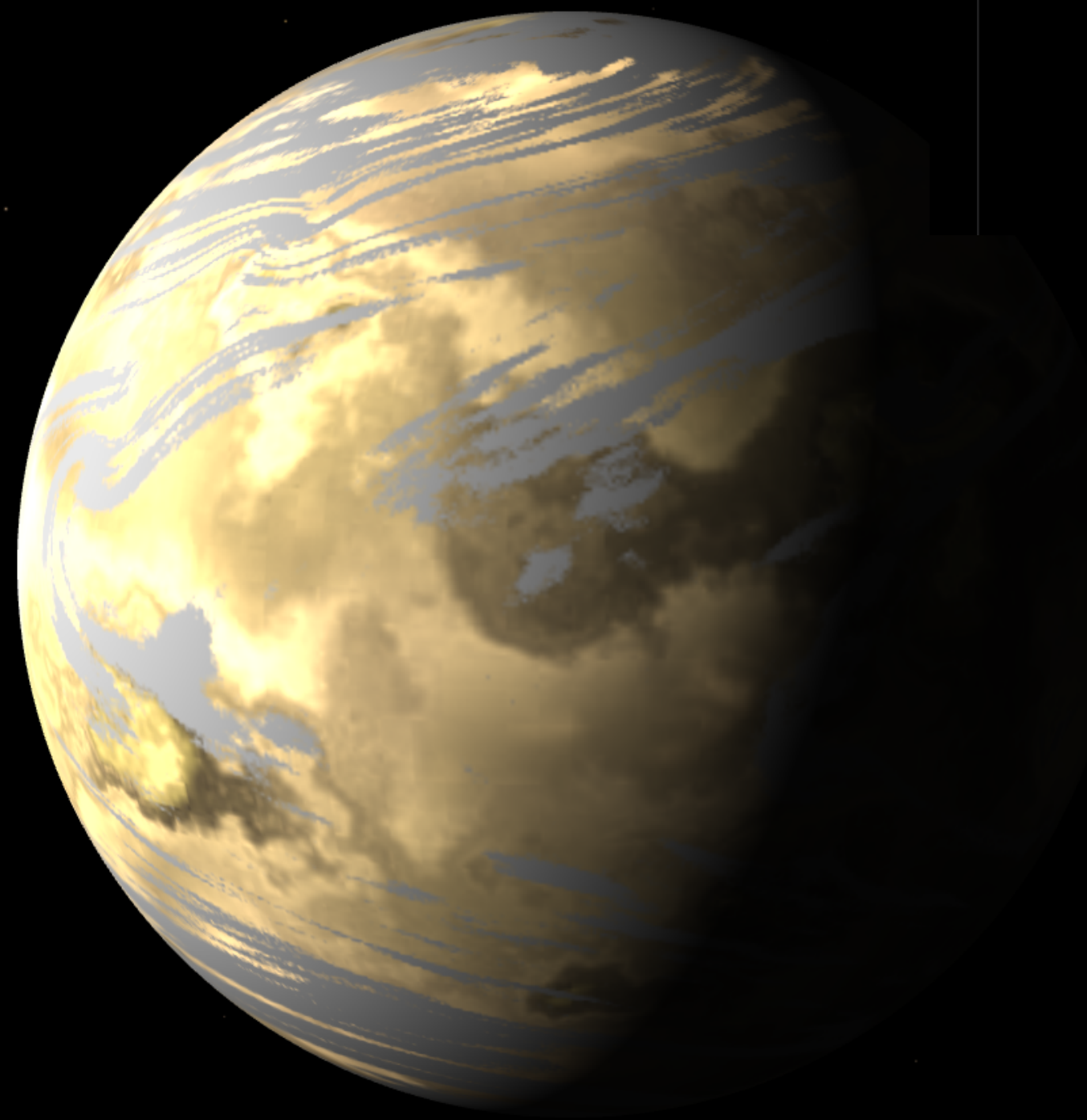
COMPARE



You are  
981 light-years  
from Earth

# Kepler-62 f +

A potentially rocky world, larger than Earth



ORBITAL RADIUS	0.718 AU	ORBITAL PERIOD	267.3 days	ORBITAL ECCENTRICITY	0
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**Planet Comparison**

Kepler-62 f Earth

MASS 35 Earths  
RADIUS 1.41 x Earth

**Star Comparison**

Kepler-62 Our Sun

MASS 0.69 x Our Sun  
RADIUS 0.64 x Our Sun

VIEW

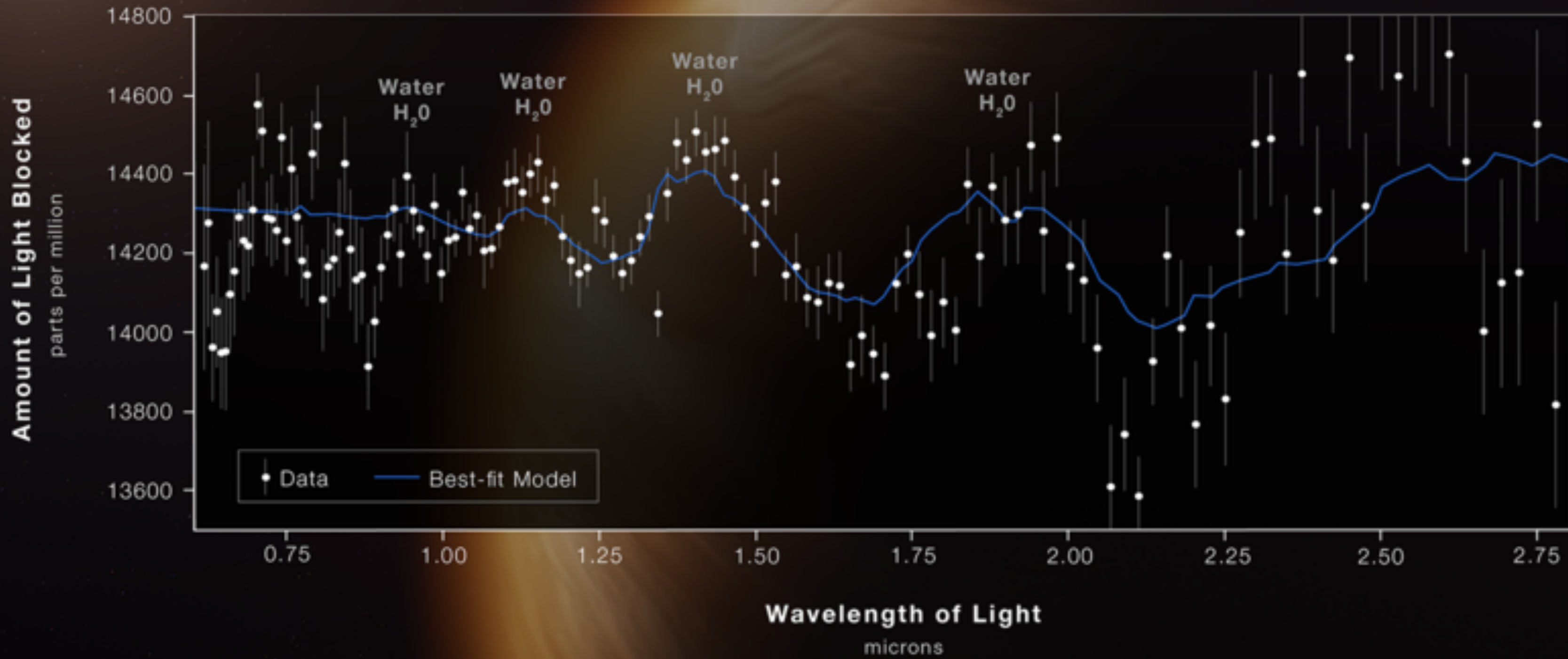
Planet System Star

COMPARE ⬆



# HOT GAS GIANT EXOPLANET WASP-96 b ATMOSPHERE COMPOSITION

NIRISS | Single-Object Slitless Spectroscopy

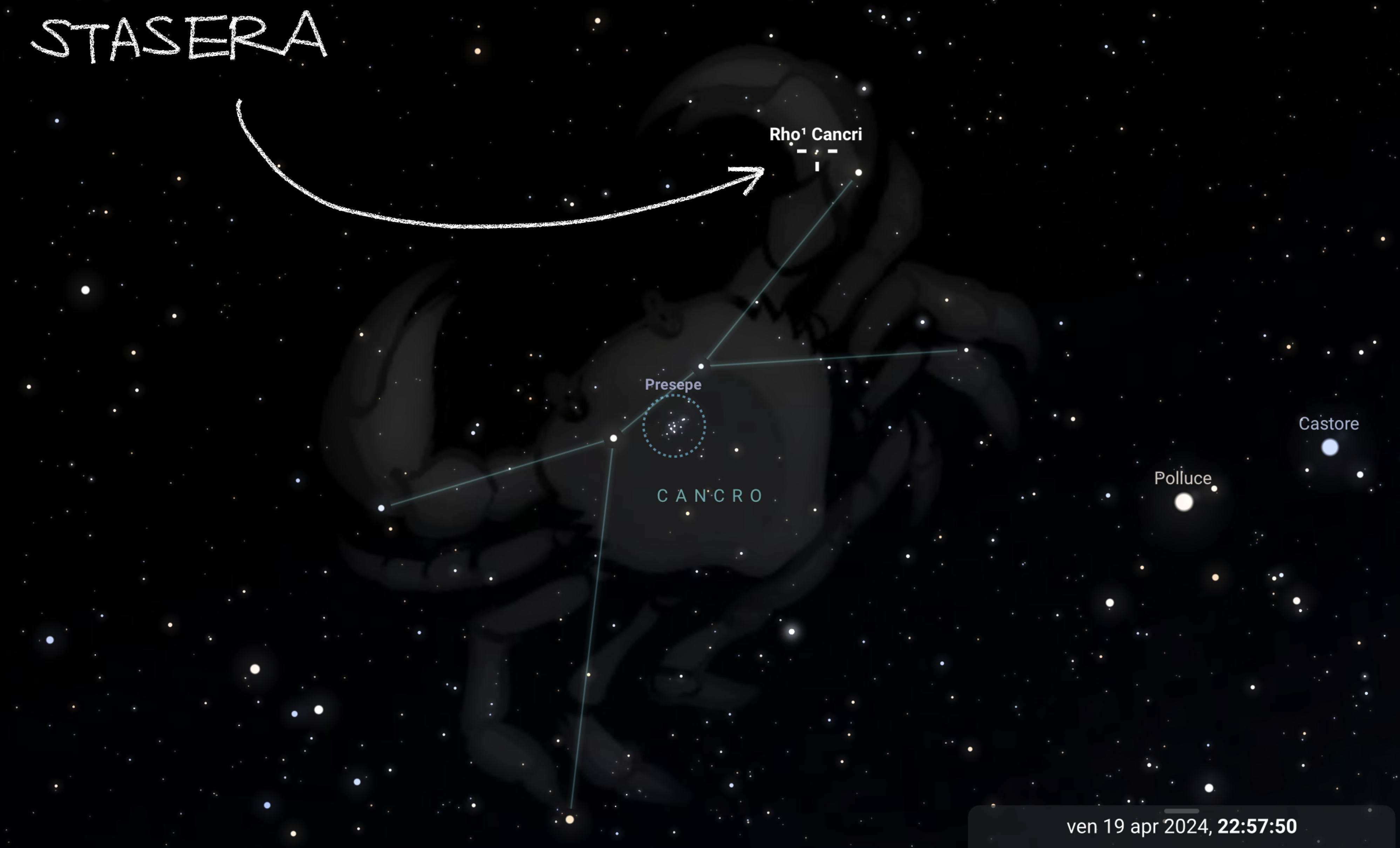


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**WEBB**  
SPACE TELESCOPE




# STASERA




 **Rho¹ Cancri**  
Stella ad alto movimento  
corretto

 Centro

ven 19 apr 2024, 22:57:50





● Chiaro di luna



Habitable Zone

You are  
41 light-years  
from Earth

# Copernicus

5 planets orbiting a K-type star, 41 light-years from Earth.

Uranus

Jupiter

Mars

Venus

Mercury  
Copernicus  
Earth

55 Cancri f

Saturn

55 Cancri d

VIEW



Planet



System



Star

COMPARE TO OUR SOLAR SYSTEM



**DISCOVERED** 1996

**PLANET TYPE** Gas Giant

55 Cancri b is a gas giant exoplanet that orbits a K-type star. Its mass is 0.8306 Jupiters, it takes 14.7 days to complete one orbit of its star, and is 0.1134 AU from its star. Its discovery was announced in 1996.

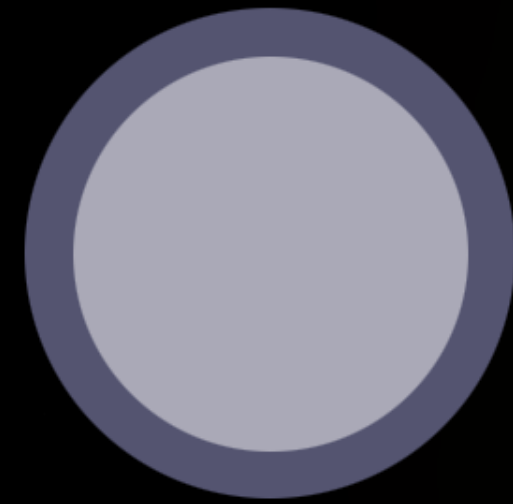
**ORBITAL RADIUS** 0.1134 AU

**ORBITAL PERIOD** 14.7 days

**ORBITAL ECCENTRICITY** 0

### Planet Comparison

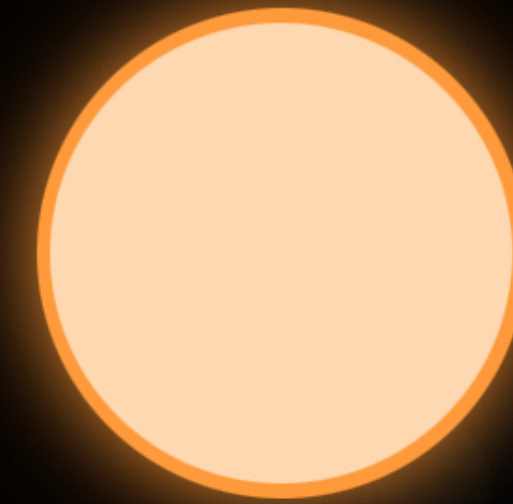
55 Cancri b Jupiter



**MASS** 0.8306 Jupiters  
**RADIUS** 1.24 x Jupiter (estimate)

### Star Comparison

55\_Cnc Our Sun



**MASS** 0.91 x Our Sun  
**RADIUS** 0.94 x Our Sun





**DISCOVERED** 2004

**PLANET TYPE** Gas Giant

55 Cancri c is a gas giant exoplanet that orbits a K-type star. Its mass is 0.1714 Jupiters, it takes 44.4 days to complete one orbit of its star, and is 0.2373 AU from its star. Its discovery was announced in 2004.

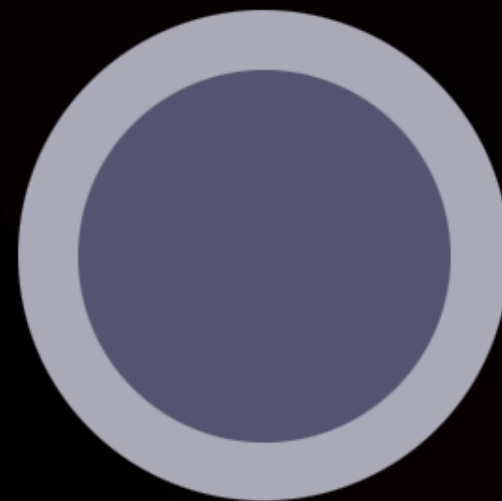
**ORBITAL RADIUS** 0.2373 AU

**ORBITAL PERIOD** 44.4 days

**ORBITAL ECCENTRICITY** 0.03

### Planet Comparison

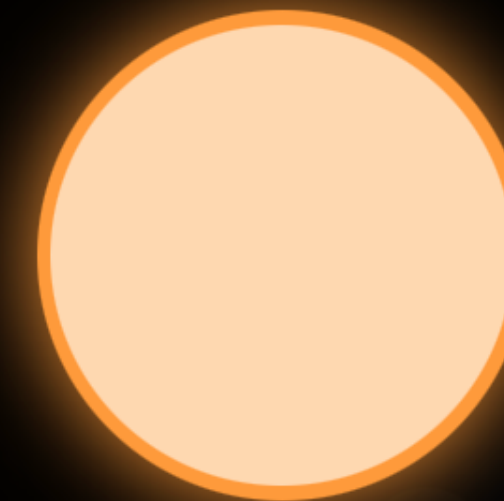
55 Cancri c Jupiter



**MASS** 0.1714 Jupiters  
**RADIUS** 0.76 x Jupiter (estimate)

### Star Comparison

55\_Cnc Our Sun



**MASS** 0.91 x Our Sun  
**RADIUS** 0.94 x Our Sun



# NEW EXOPLANET

**DISCOVERED** 2002

**PLANET TYPE** Gas Giant

55 Cancri d is a gas giant exoplanet that orbits a K-type star. Its mass is 3.878 Jupiters, it takes 15.3 years to complete one orbit of its star, and is 5.957 AU from its star. Its discovery was announced in 2002.

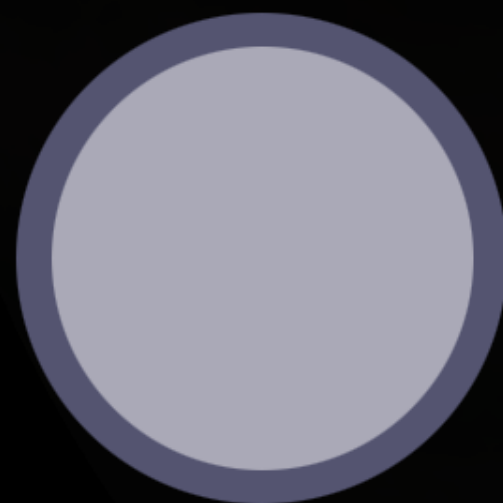
**ORBITAL RADIUS** 5.957 AU

**ORBITAL PERIOD** 15.3 years

**ORBITAL ECCENTRICITY** 0.13

## Planet Comparison

55 Cancri d    Jupiter

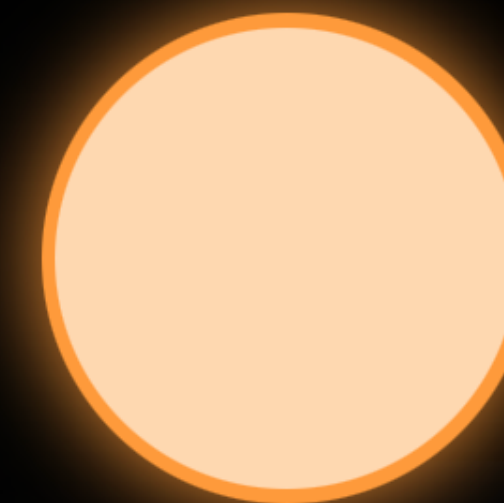


**MASS** 3.878 Jupiters  
**RADIUS** 1.16 x Jupiter (estimate)

composed mainly of gas

## Star Comparison

55\_Cnc    Our Sun



**MASS** 0.91 x Our Sun  
**RADIUS** 0.94 x Our Sun



**DISCOVERED** 2004

**PLANET TYPE** Super Earth

55 Cancri e, also known as Janssen, orbits a star called Copernicus only 41 light years away. The molten surface is completely uninhabitable, but above the burning horizon, Janssen's sister planet, Galileo, hangs in a dark sky. Silicates in the atmosphere would condense into clouds on the tidally-locked planet's darkside reflecting the lava below. So, the skies would sparkle.

55 Cancri e is a super-Earth exoplanet that orbits a G-type star similar to our Sun. Its mass is 8.08 Earths, it takes 0.7 days to complete one orbit of its star, and is 0.01544 AU from its star. Its discovery was announced in 2004.

*Exoplaneteers: The Friend is exploring 55 Cancri e, a lava world about 41 light-years away from Earth. This exoplanet is so close to its star that scientists believe it's covered in flowing lava seas. But while the lava across its surface might be daunting, silicates in the planet's atmosphere reflect that lava below, making the sky sparkle.*

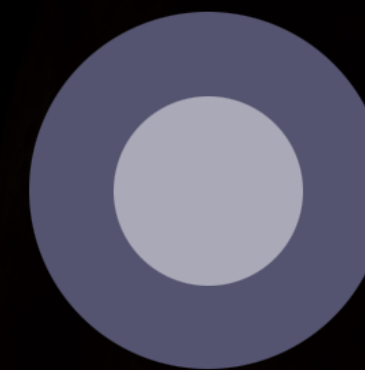
**ORBITAL RADIUS** 0.01544 AU

**ORBITAL PERIOD** 0.7 days

**ORBITAL ECCENTRICITY** 0.05

#### Planet Comparison

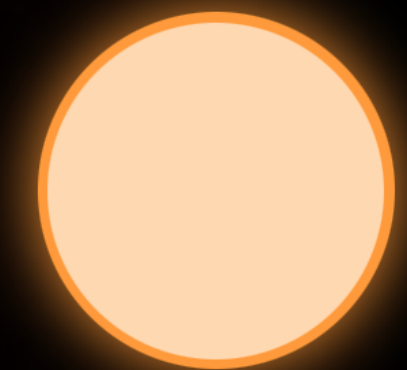
55 Cancri e Earth



**MASS** 7.99 Earths  
**RADIUS** 1.875 x Earth

#### Star Comparison

55\_Cnc Our Sun



**MASS** 0.91 x Our Sun  
**RADIUS** 0.94 x Our Sun



**DISCOVERED** 2007

**PLANET TYPE** Gas Giant

55 Cancri f is a gas giant exoplanet that orbits a K-type star. Its mass is 0.141 Jupiters, it takes 259.9 days to complete one orbit of its star, and is 0.7708 AU from its star. Its discovery was announced in 2007.

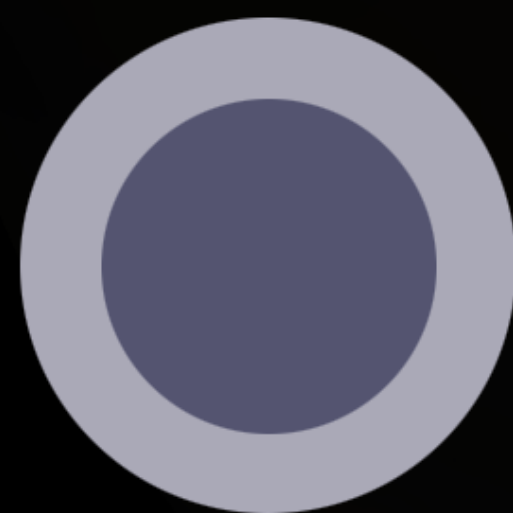
**ORBITAL RADIUS** 0.7708 AU

**ORBITAL PERIOD** 259.9 days

**ORBITAL ECCENTRICITY** 0.08

### Planet Comparison

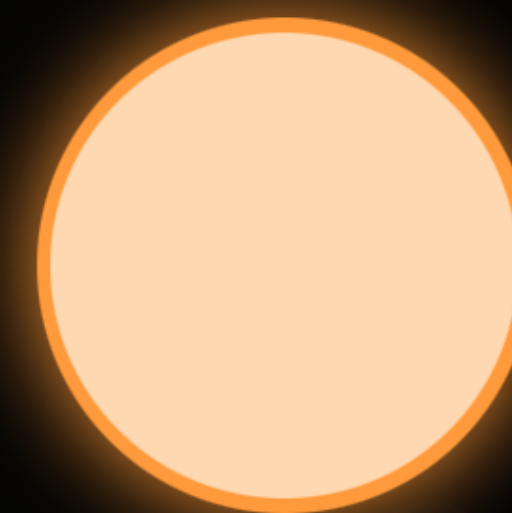
55 Cancri f Jupiter



**MASS** 0.141 Jupiters  
**RADIUS** 0.677 x Jupiter (estimate)

### Star Comparison

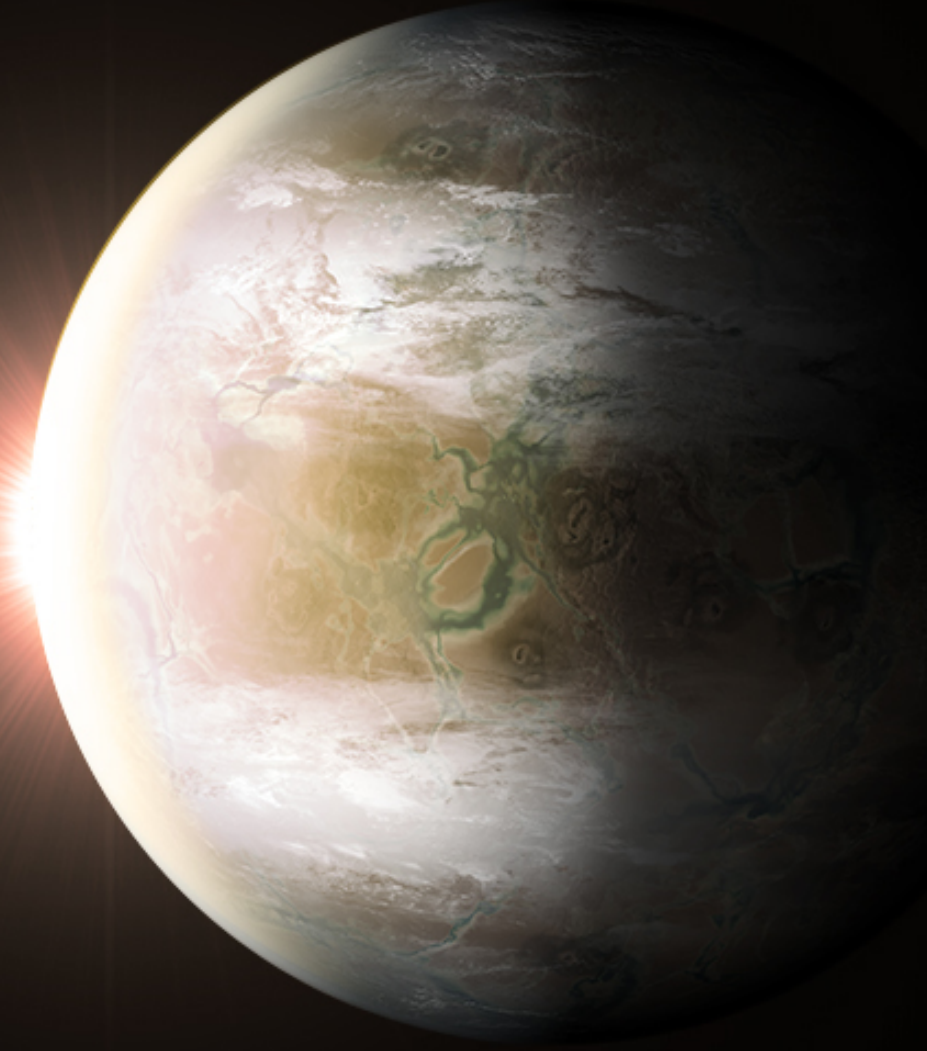
55\_Cnc Our Sun



**MASS** 0.91 x Our Sun  
**RADIUS** 0.94 x Our Sun



# THE FIRST **NEAR-EARTH-SIZE** PLANET DISCOVERED AROUND A **SUN-SIZE** STAR



## Kepler-452b

Discovered July 23, 2015

The first Earth-size planet discovered around a near solar twin, the discovery of Kepler-452b brings us closer than ever to finding an Earth-like planet.



### TEMPERATURE

Kepler-452b's temperature is **yet unknown**.



### ORBITAL PERIOD

Kepler-452b orbits its host star every **385 days**.

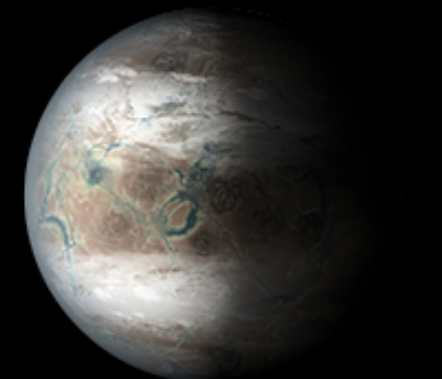


### DISTANCE FROM EARTH

Kepler-452b is **1,400 light years** from earth.

### PLANET COMPARISON

Kepler-452b



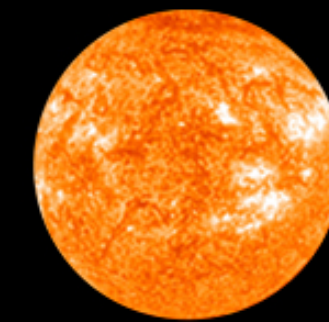
Earth



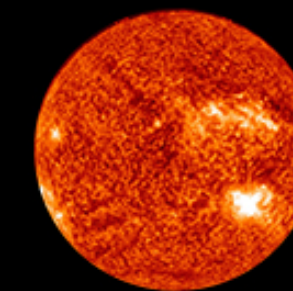
Kepler-452b is **60% larger** than Earth

### STAR COMPARISON

Kepler-452



Our Sun

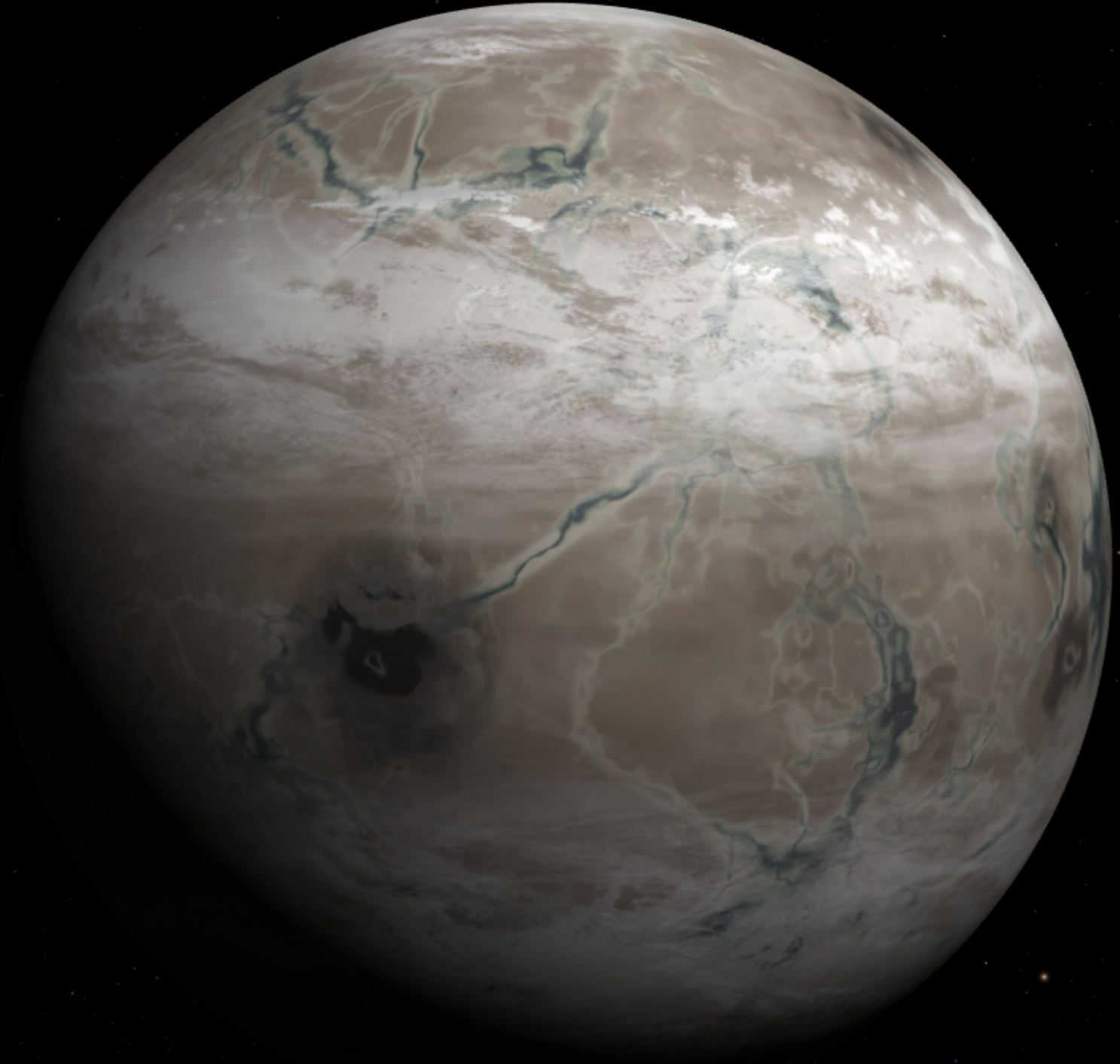


Kepler-452 is **10% larger** than our Sun.



Gruppo Naturalistico Bellona  
Sezione Astronomia

You are  
1,799 light-years  
from Earth



# Kepler-452 b +

A potentially rocky world, larger than Earth

VIEW

- Planet
- System
- Star

COMPARE ↕



**DISCOVERED** 2015

**PLANET TYPE** Super Earth

Kepler-452b is the first near-Earth-size world to be found in the habitable zone of star that is similar to our sun. Until its discovery in 2015, the Kepler telescope had only detected 12 Earth-size planets (smaller than twice the size of Earth) in the habitable zone of their smaller and cooler stars. Kepler-452b is the first planet orbiting a star about the same size and temperature as the sun.

When looking for planets that might support life, scientists start with the habitable zone. The habitable zone is a region around a star where temperatures are right for water—an essential ingredient for life as we know it—to pool on the surface. Scientists don't know if Kepler-452b can support life. What is known about the planet is that it is about 60 percent larger than Earth, placing it in a class of planets dubbed "super-Earths," with an orbit of 385 days. Scientists believe that Kepler-452b is about 6 billion years old, much older than Earth.

<b>ORBITAL RADIUS</b> 1.046 AU	<b>ORBITAL PERIOD</b> 384.8 days	<b>ORBITAL ECCENTRICITY</b> 0
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