



Council of the
European Union

Brussels, 25 June 2024
(OR. en)

11541/24

ESPACE 64
INTER-REP 70

COVER NOTE

Subject: SPECULOOS project and recent results from James Webb Space
Telescope observations
- Powerpoint presentation (Space WP meeting 25.06.2024)

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TRAPPIST-1 : the small star and the 7 earths

Emmanuël Jehin

STAR Institute (Université de Liège, FNRS)



Credits: NASA

Bruxelles 25/06/24

A long history with Space Sciences



AMOS



Raphael Liégeois



Other Liège specialties...

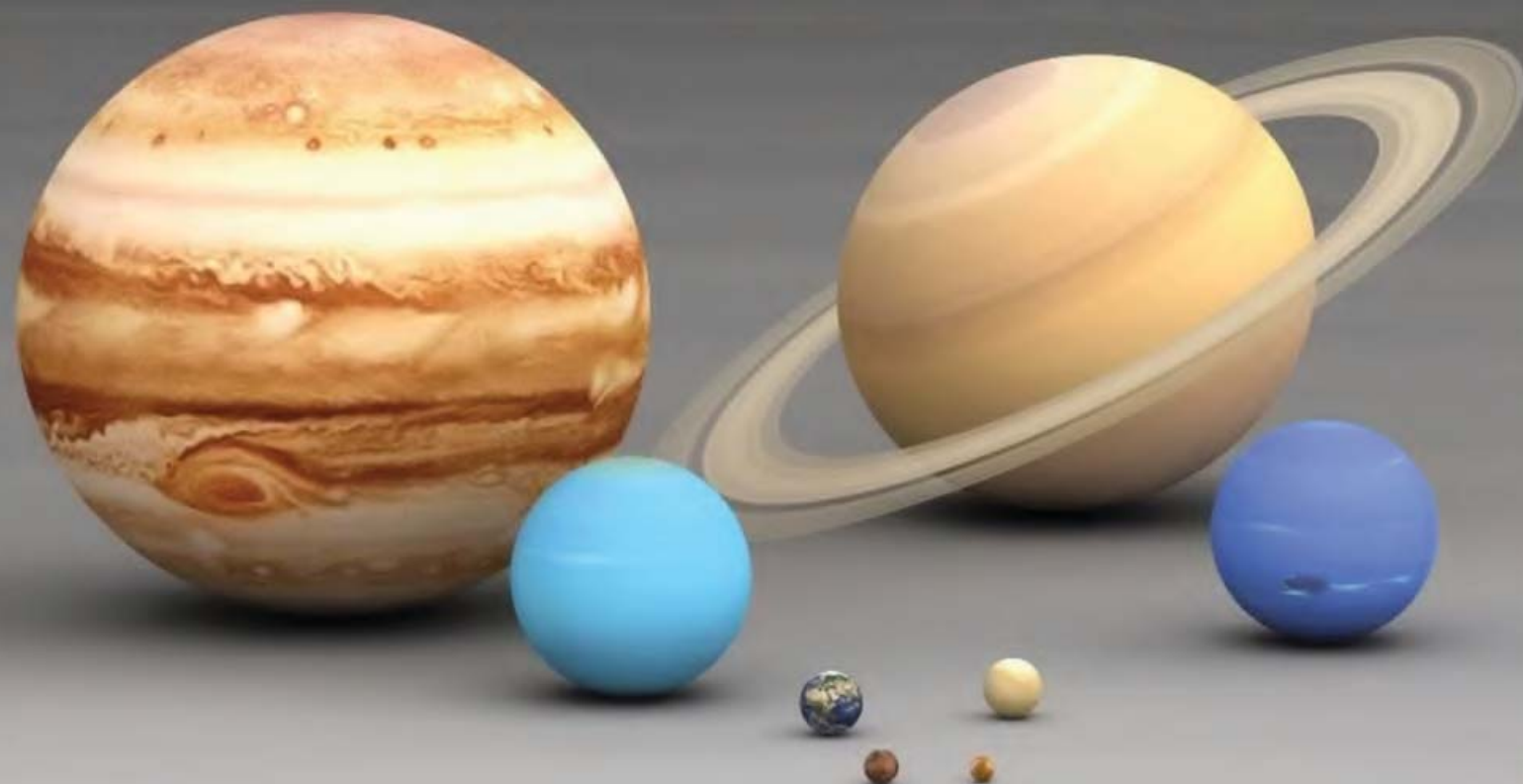


Waffles... and boulets !



Are we alone in the Universe ?





Our world... a planet among others

Is our Blue Planet unique ?



A rocky planet with water (70%)

Credits: NASA

... hosts a complex biosphere



Where are the Martians ?



Credits: NASA



« Mars Attack » (Tim Burton, 1996)

Habitability conditions for a planet ?



Astro-biology

« The habitable zone »



Aim to the stars...



The Milky Way... our Galaxy

~300 billion stars!

1995: The discovery of the first

A Jupiter-mass companion to a solar-type star **Exoplanet !**

Michel Mayor & Didier Queloz

Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star's radial velocity. The companion lies only about eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a gas-giant planet that has migrated to this location through orbital evolution, or from the radiative stripping of a brown dwarf.



51 Peg : a hot jupiter close to its sun



Didier Queloz and Michel Mayor
!! NOBEL PRIZE 2019 !!

The hunt of exoplanets was open !

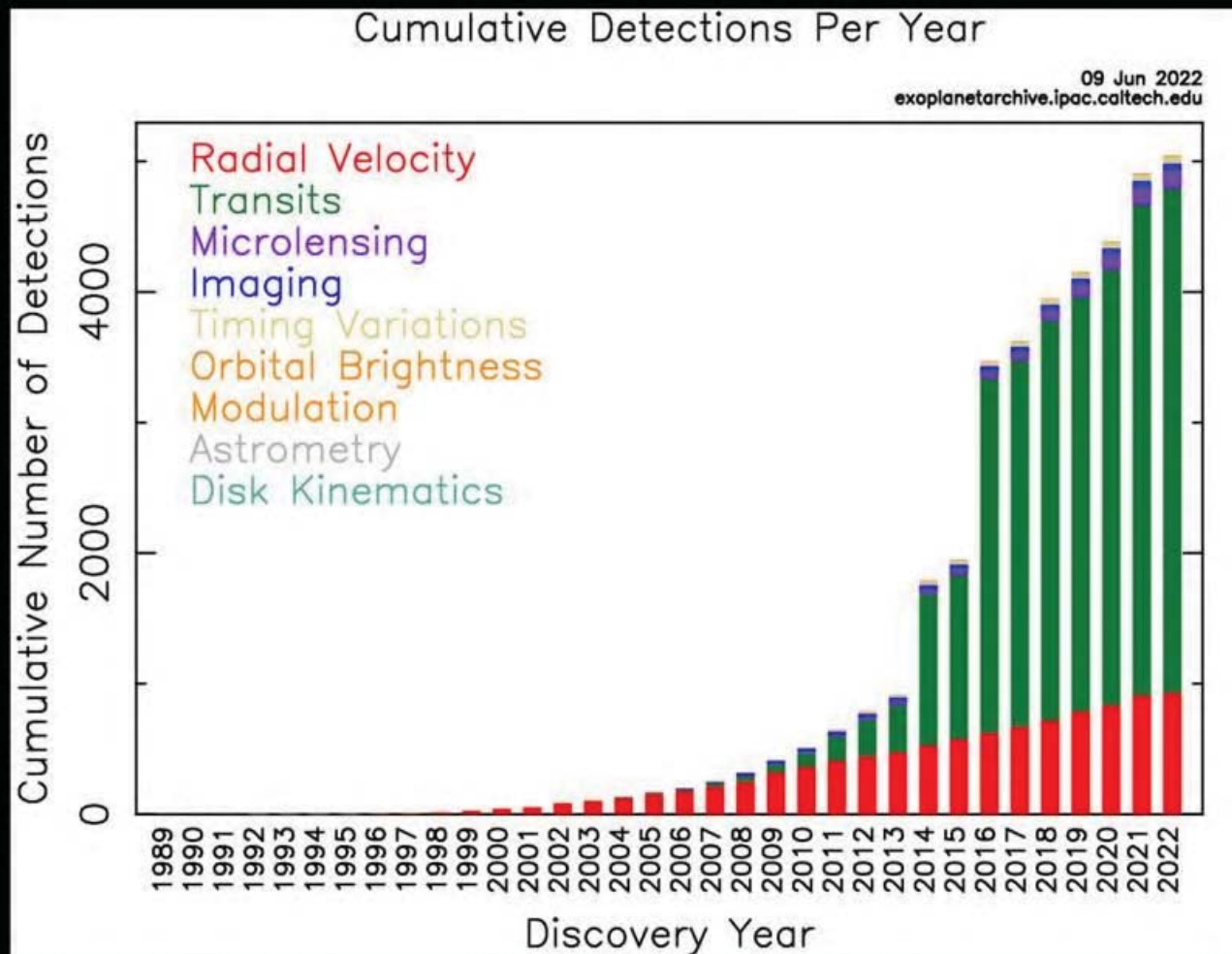


on the ground and in Space...

5339 exoplanets and 937 systems



And this is only the beginning...



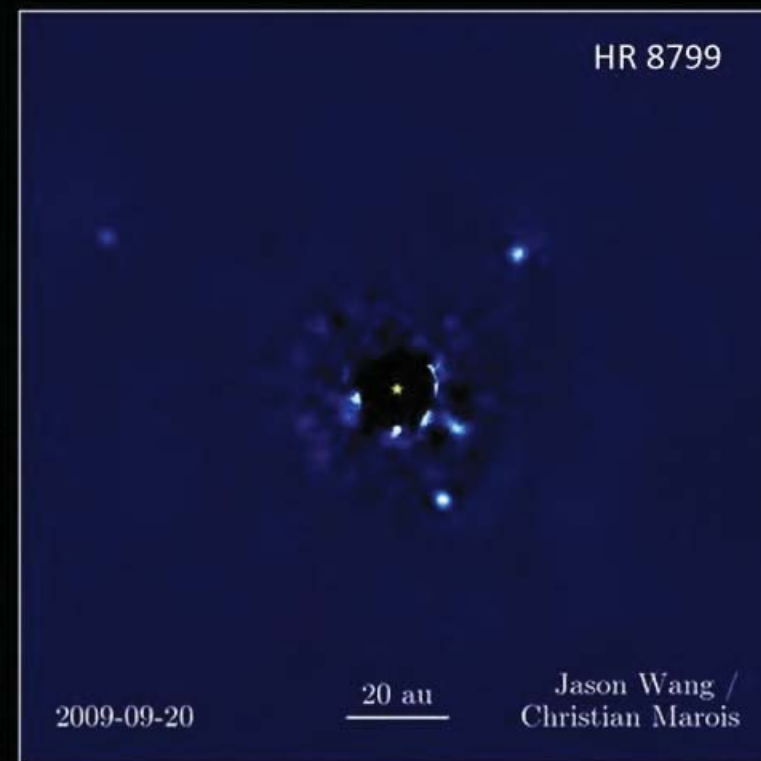
How to detect exoplanets ?



The exoplanet is lost in the star light!

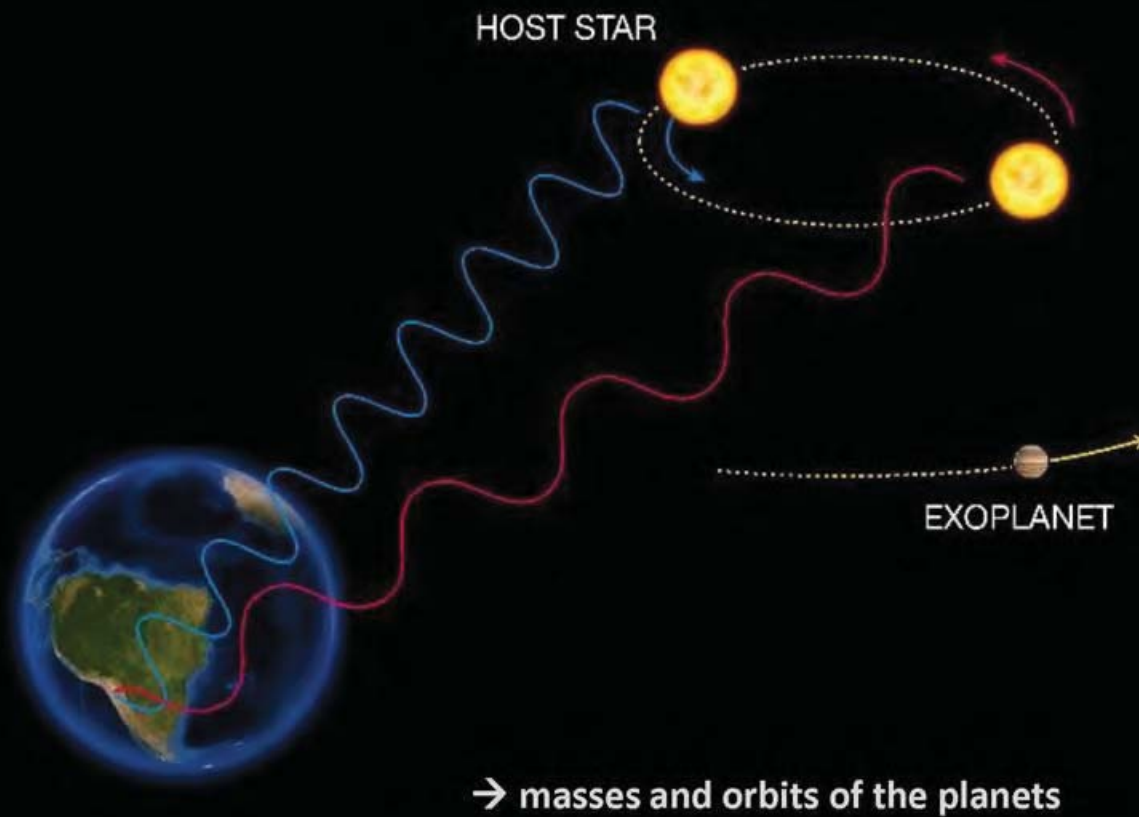


Direct imaging

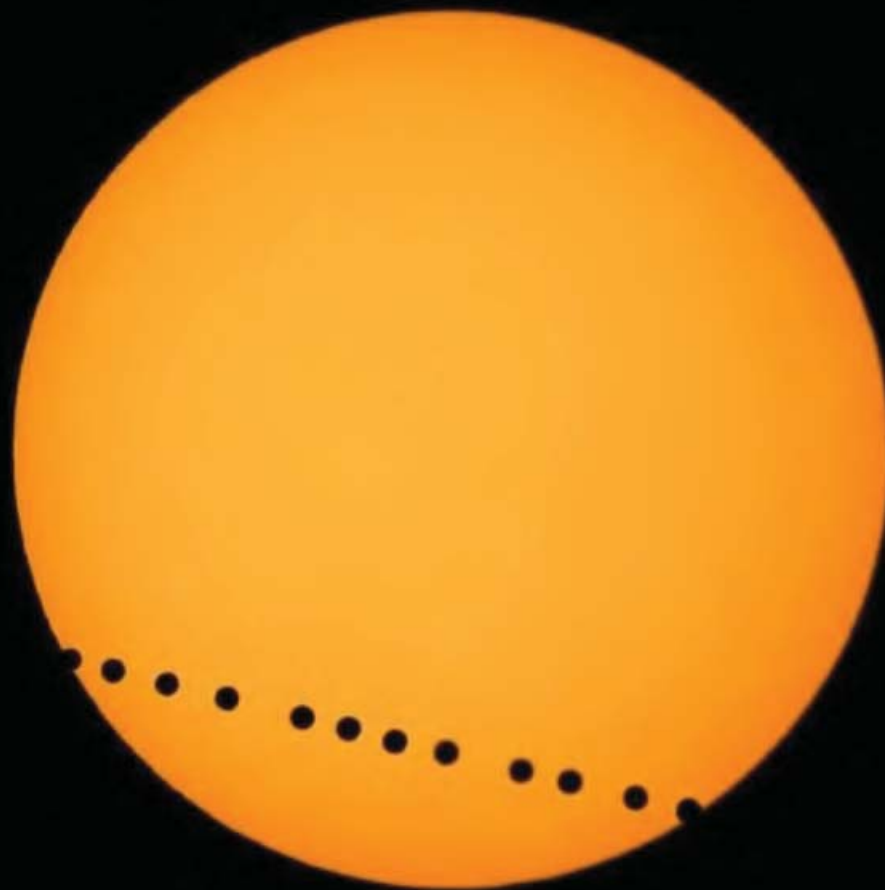


Gemini Observatory/AURA

The radial velocity method

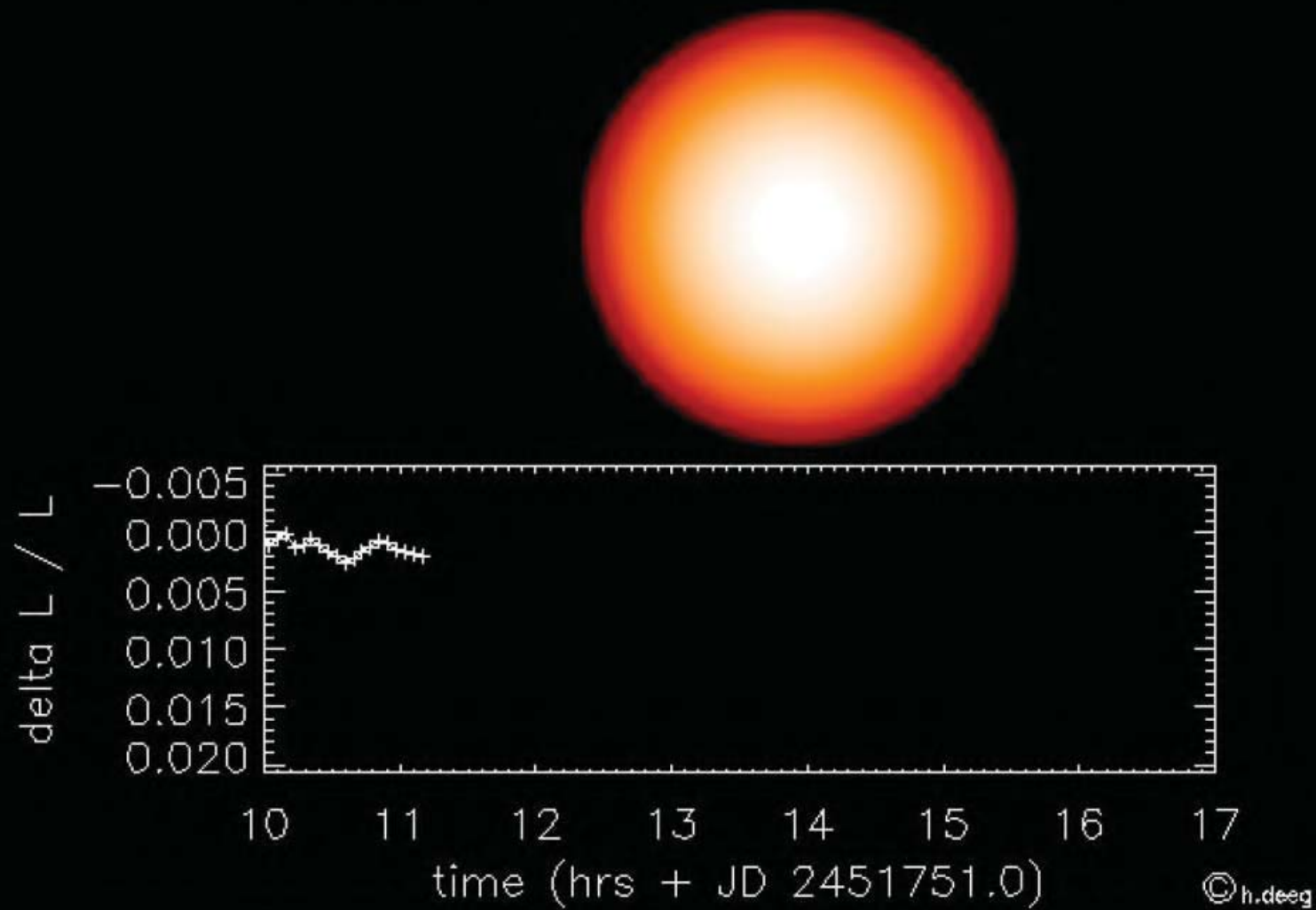


The transit method



The transit of Vénus in front of the Sun (2012)

The exoplanet transit lightcurves



TRAPPIST : TRAnsiting Planets and PlanetesImals Small Telescope



Credits: E. Jehin

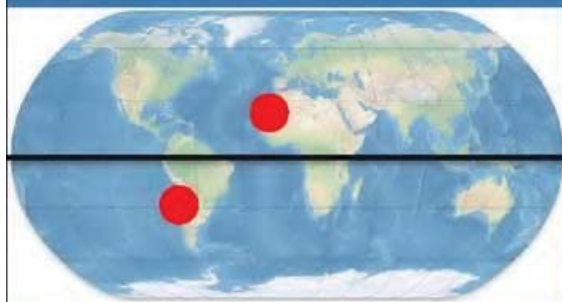
TRAPPIST-Sud at La Silla (ESO)

2010 (Chili)



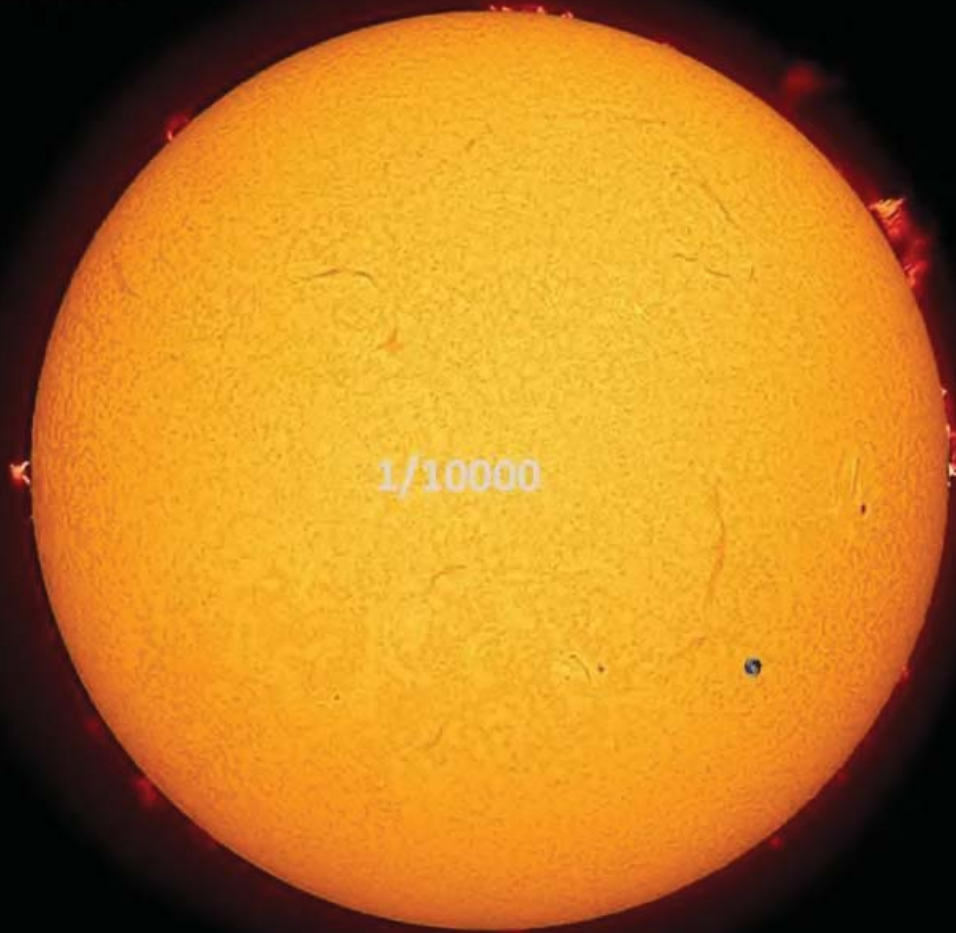


TRAPPIST-North 2015 (Morroco)



The ultracool red dwarfs

on 02-07-2013

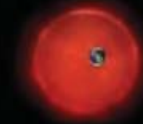


1/10000



Michael Gillon

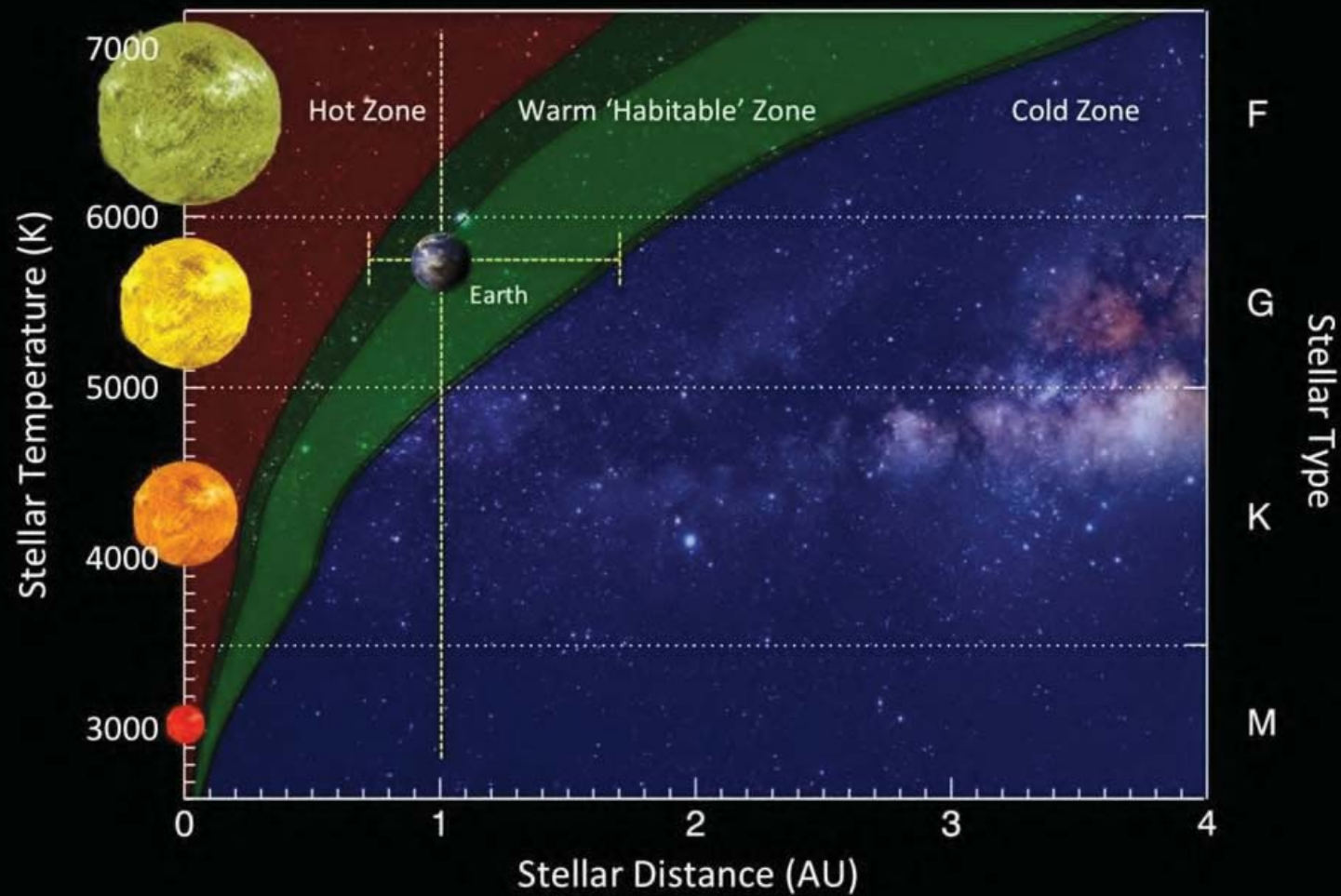
1/100



10x smaller

© 2013 John Chumack www.galactic

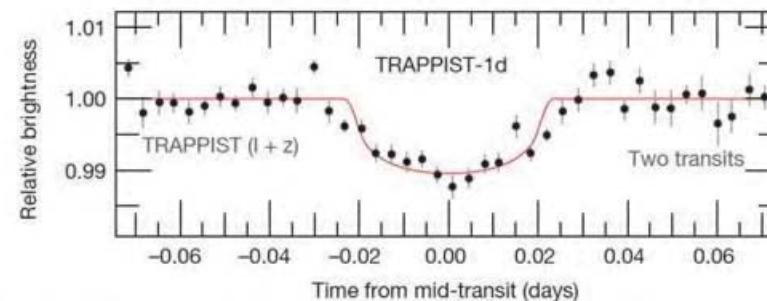
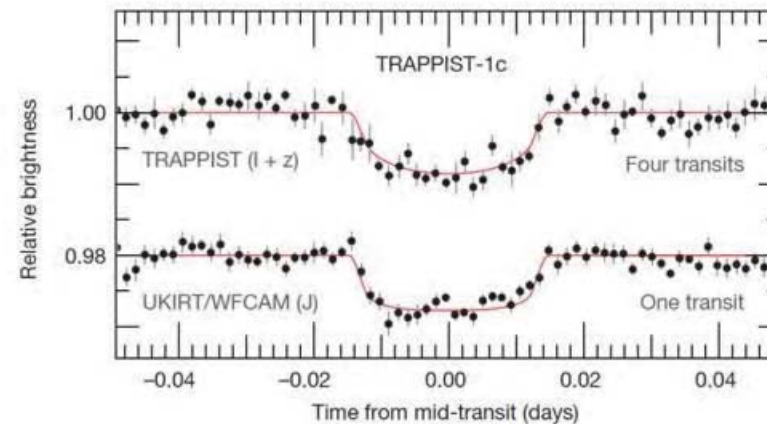
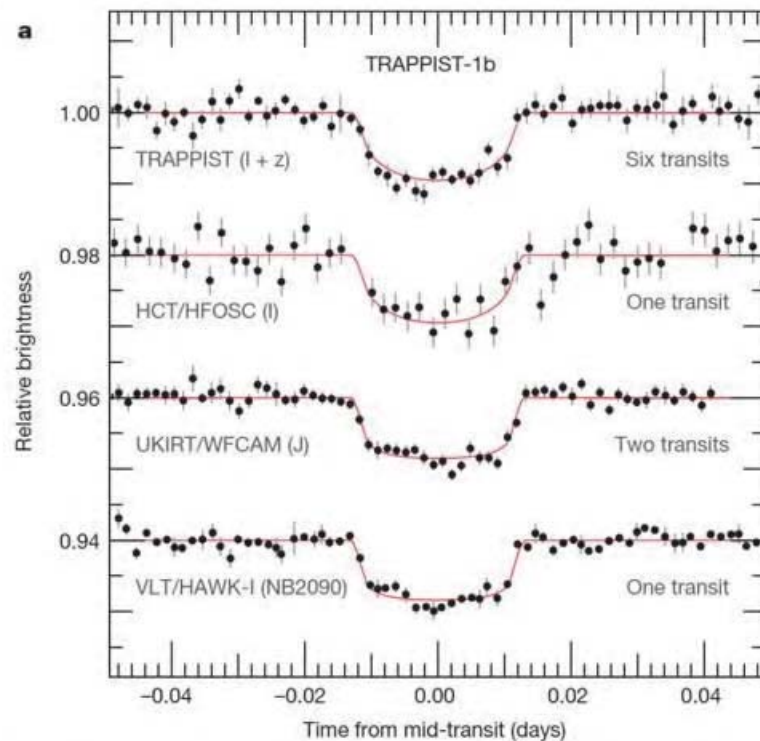
The habitable zone of red dwarfs



TRAPPIST-1: first transits

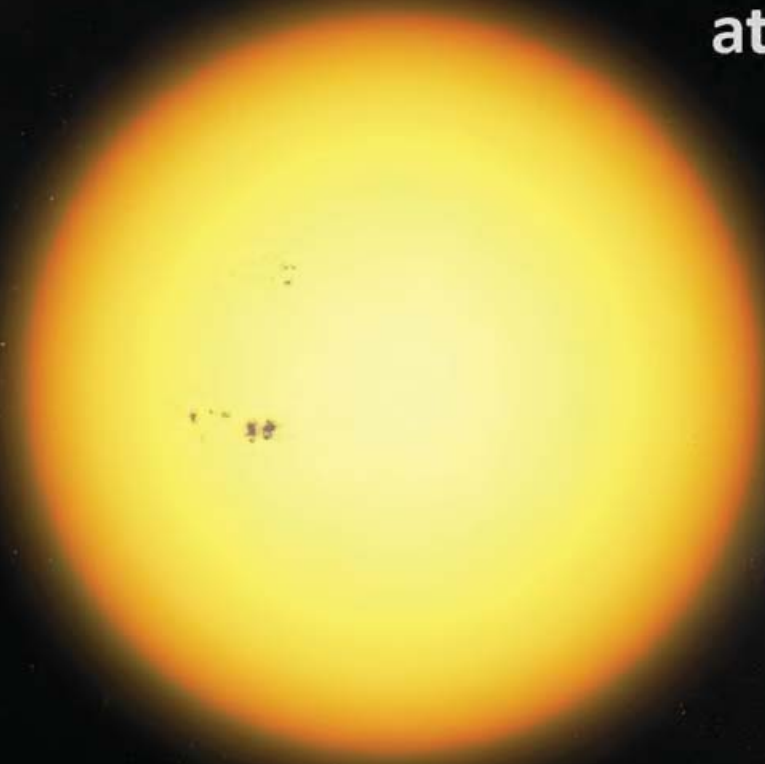
Three terrestrial planets with orbits of
1.5, 2.4 and ~18 days

Gillon et al. Nature May 2016



Ultracool dwarf stars host planets !

**TRAPPIST-1, a tiny star
at only 40,5 ly**



Sun



TRAPPIST-1

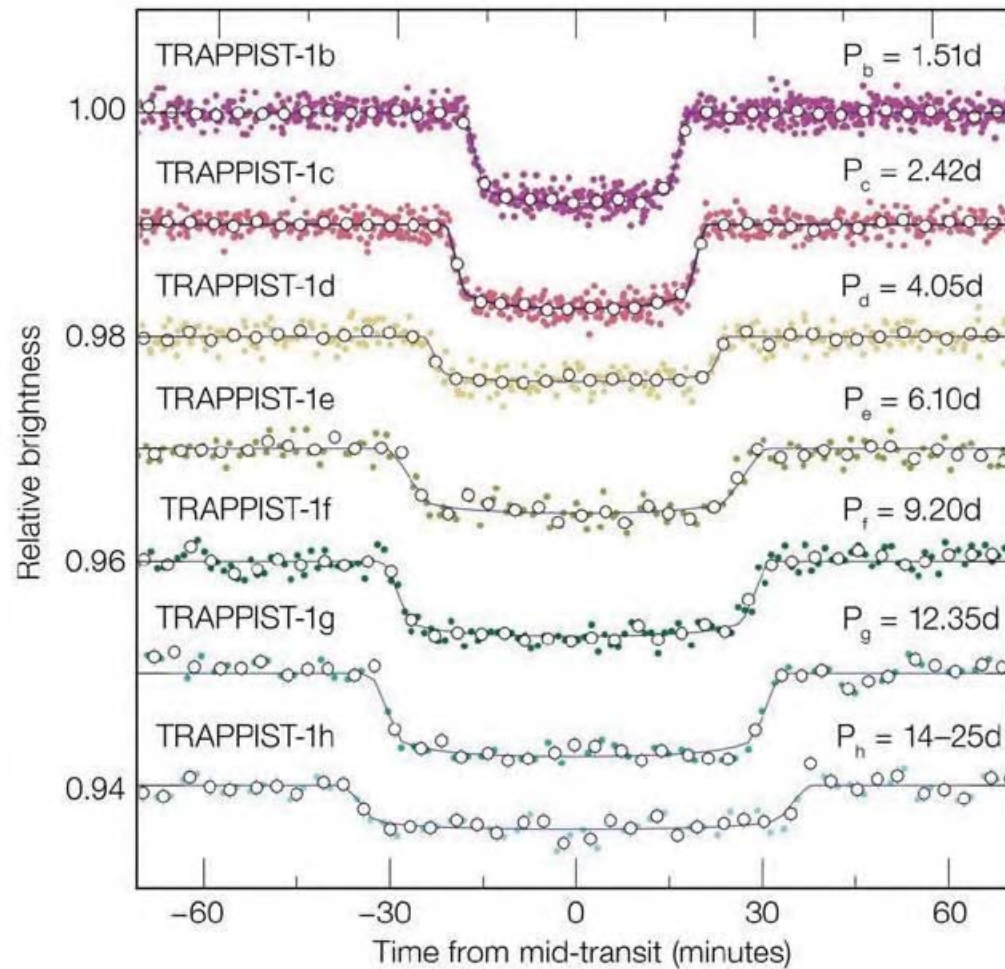
8% solar mass
12% solar radius
~ 7.6 Gyr

2016 :intensive observing campaign

Détection of many new transits !

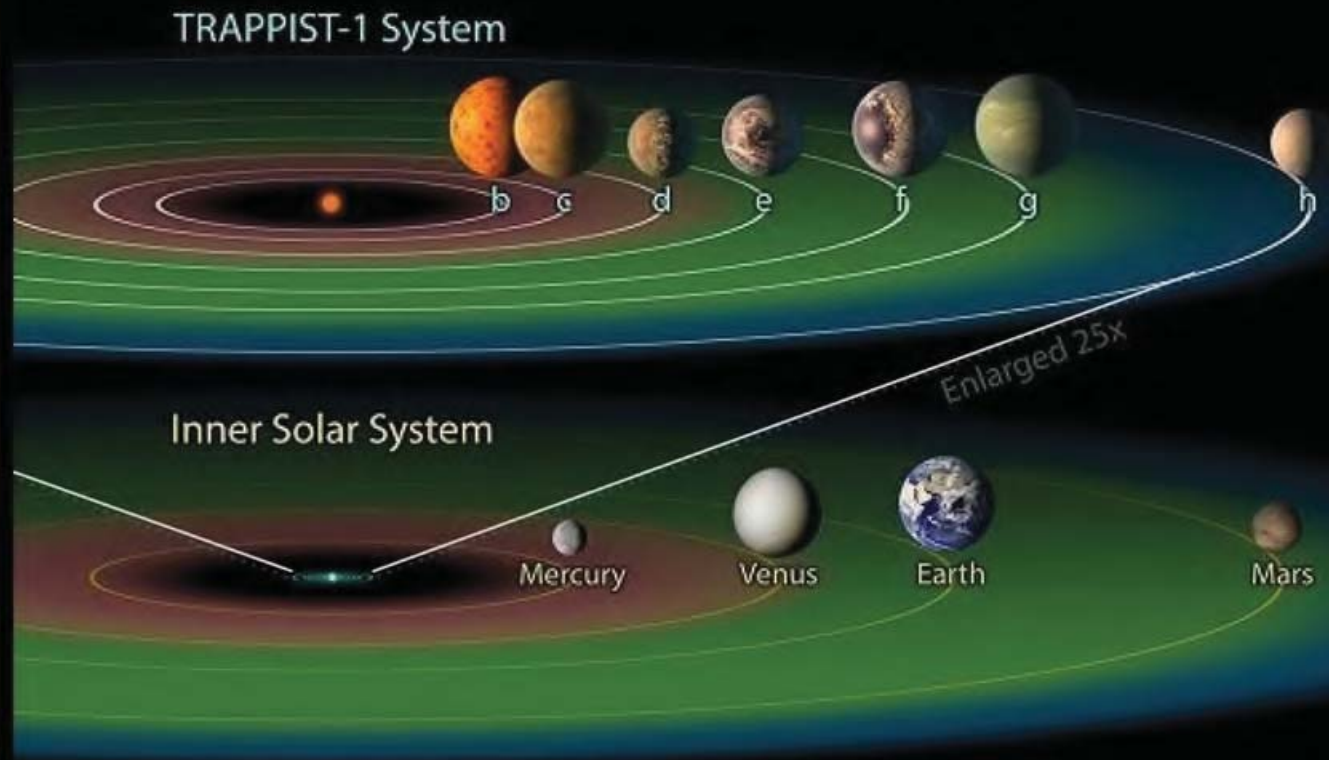


Seven Earth size rocky planets !



Gillon et al. Nature 2017
Gillon et al. Nature 2016

The seven wonders of TRAPPIST-1



7 earth size planets, and 3 in the habitable zone !

Credits: NASA

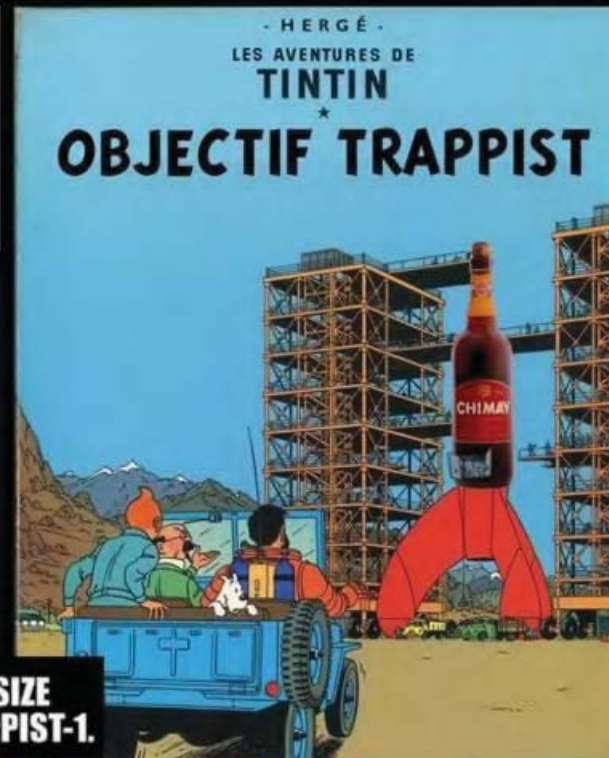
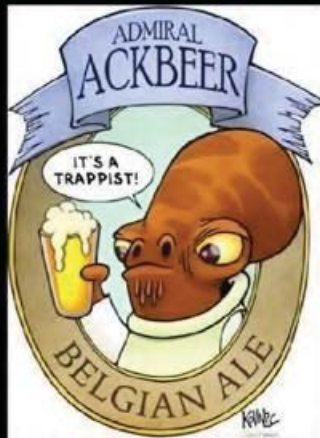
NASA press conference Washington DC



TRAPPIST-1 makes the headlines!



TRAPPIST-1 and its planets are a buzz!



NASA HAS REVEALED SEVEN EARTH-SIZE PLANETS AROUND A STAR CALLED TRAPPIST-1.



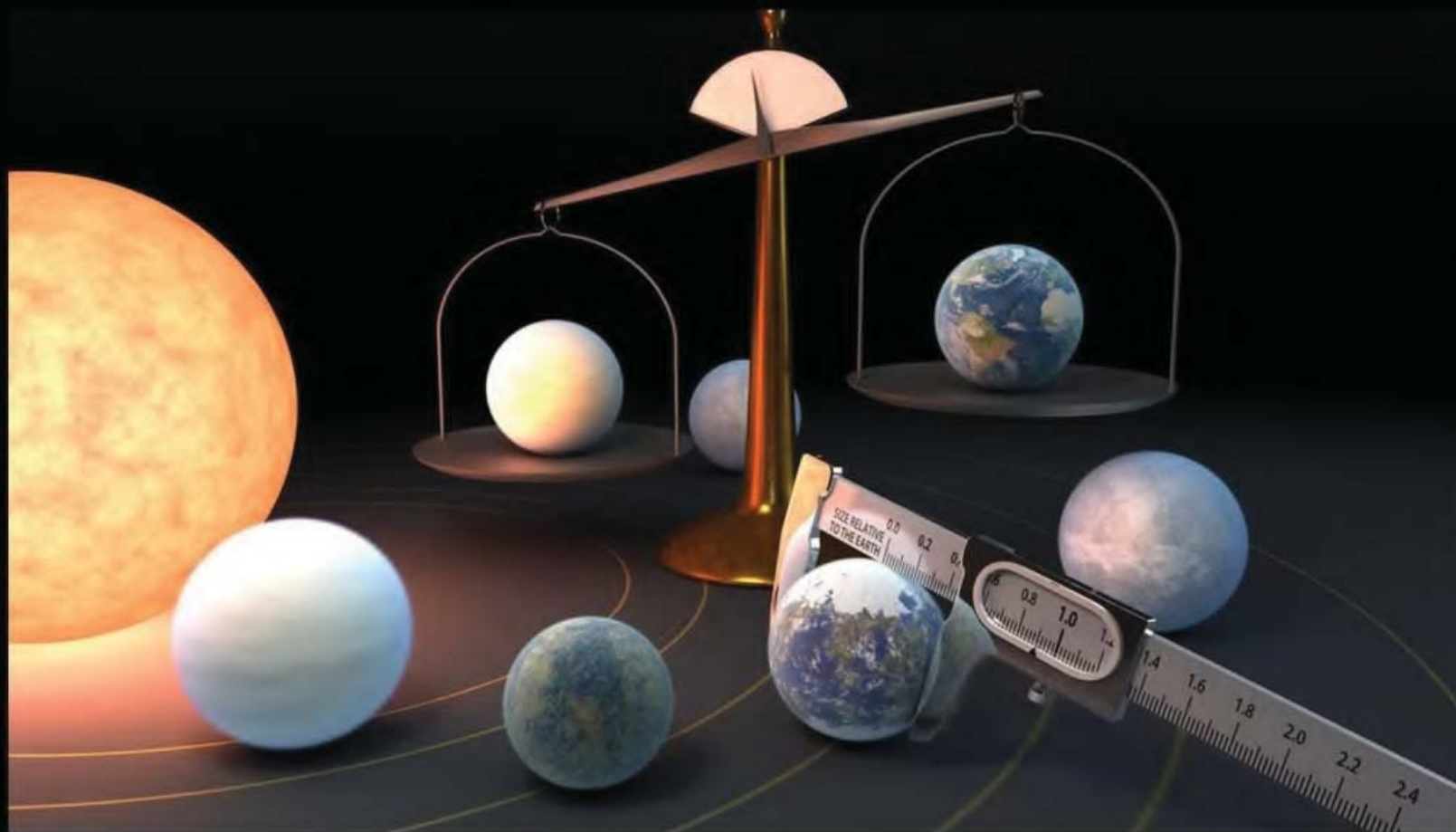
TRAPPIST-1 and arts



IN ISOLATION

https://www.youtube.com/watch?v=9_5Yt1dp9yI
<https://www.youtube.com/watch?v=GhqZhVeTud0>

New measurements



275 papers published and 1214 citations!

The TRAPPIST-1 planets portrait

TRAPPIST-1 System
Feb. 2018

Illustrations

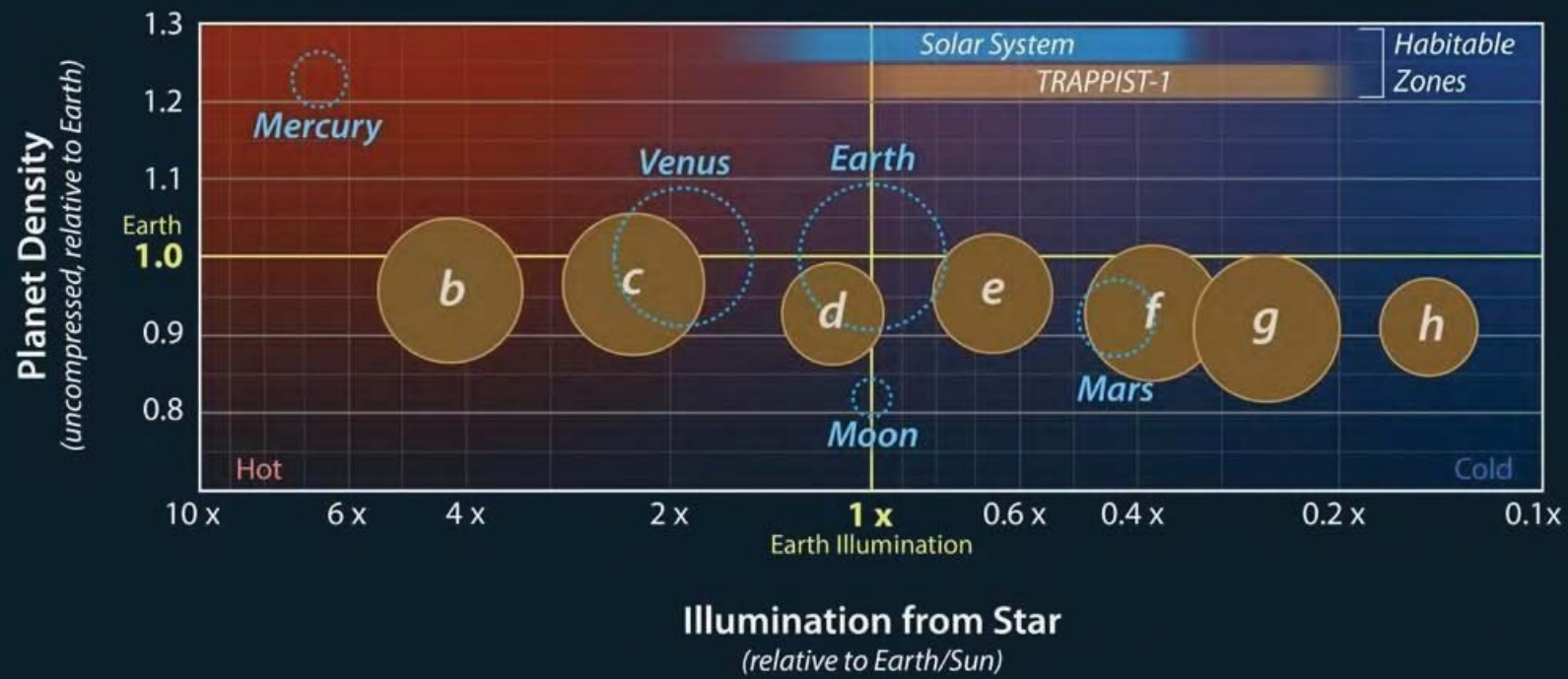
	b	c	d	e	f	g	h
Orbital Period	1.51 days	2.42 days	4.05 days	6.10 days	9.21 days	12.35 days	18.77 days
Distance to Star	0.0115 AU	0.0158 AU	0.0223 AU	0.0293 AU	0.0385 AU	0.0469 AU	0.0619 AU
Planet Radius	1.12 R_{earth}	1.10 R_{earth}	0.79 R_{earth}	0.92 R_{earth}	1.05 R_{earth}	1.13 R_{earth}	0.76 R_{earth}
Planet Mass	1.37 M_{earth}	1.31 M_{earth}	0.39 M_{earth}	0.69 M_{earth}	1.04 M_{earth}	1.32 M_{earth}	0.33 M_{earth}
Planet Density	0.99 ρ_{earth}	0.99 ρ_{earth}	0.79 ρ_{earth}	0.89 ρ_{earth}	0.91 ρ_{earth}	0.92 ρ_{earth}	0.75 ρ_{earth}
Surface Gravity	1.10 g	1.09 g	0.62 g	0.82 g	0.95 g	1.04 g	0.57 g

Solar System Rocky Planets

	Mercury	Venus	Earth	Mars
Orbital Period	87.97 days	224.70 days	365.26 days	686.98 days
Distance to Star	0.387 AU	0.723 AU	1.000 AU	1.524 AU
Planet Radius	0.38 R_{earth}	0.95 R_{earth}	1.00 R_{earth}	0.53 R_{earth}
Planet Mass	0.06 M_{earth}	0.82 M_{earth}	1.00 M_{earth}	0.11 M_{earth}
Planet Density	0.98 ρ_{earth}	0.95 ρ_{earth}	1.00 ρ_{earth}	0.71 ρ_{earth}
Surface Gravity	0.38 g	0.90 g	1.00 g	0.38 g

Agol et al. 2021

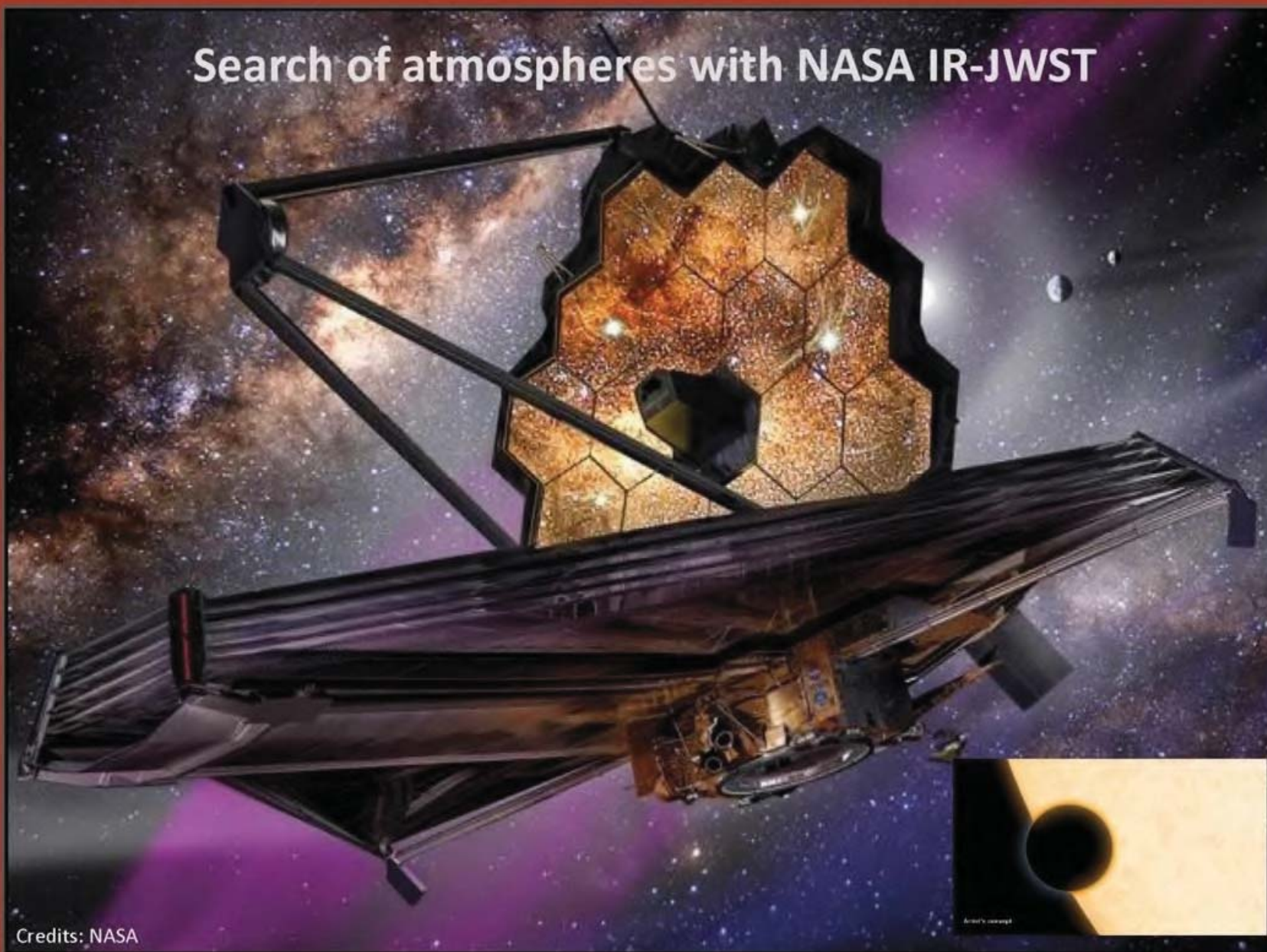
TRAPPIST-1/Solar System Comparison



Red worlds...

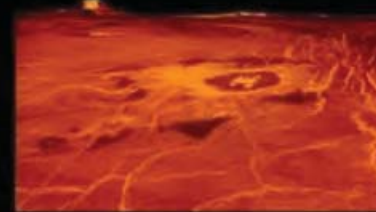
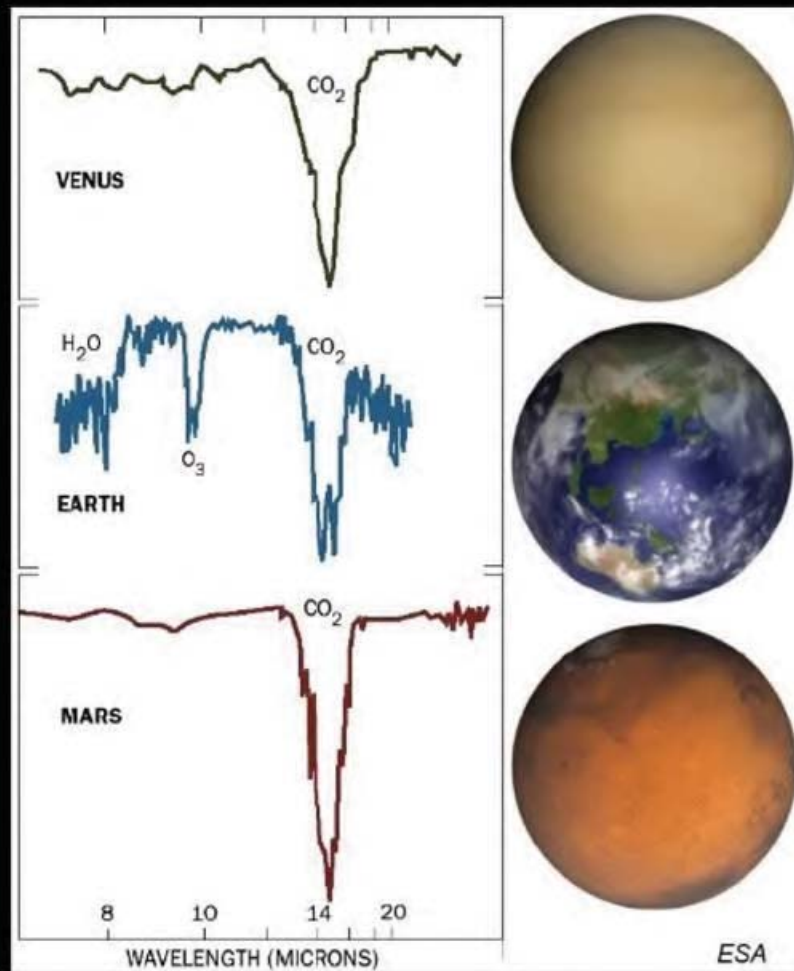


Search of atmospheres with NASA IR-JWST



Credits: NASA

The search for « biosignatures »



SPECULOOS

Search for habitable Planets EClipsing ULtra-
cOOL Stars

<http://www.speculoos.uliege.be>



Observatory



The SPECULOOS-South/North Observatories

1000 red dwarfs
for the next 10 years



San Pedro (Mexico)



Teide (Tenerife)



Paranal (Chile)

SPECULOOS-2c and SPECULOOS-3b



Super Earth

($R=1.4R_{\oplus}$, $P=8.5d$, $d=105$ ly)

Delrez et al. 2022



Hot earth size

($R=0.98R_{\oplus}$, $P=17h$, $d=55$ ly)

Gillon et al. 2024

The European Extremely Large Telescope

2029



Credits: ESO



ESA Plato and Ariel space missions



PLAnetary **T**ransits and
Oscillations of stars
(2026)



Atmospheric **R**emote-sensing
Infrared **E**xoplanet
Large-survey (2029)



stay tuned !

Credits: ESA

Merci pour votre attention

