HISTORY OF SETI AND THE SEARCH FOR HABITABLE WORLDS

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class 2

SETI

Search for Technosignatures

Exoplanet searches

Radio SETI

Optical SETI

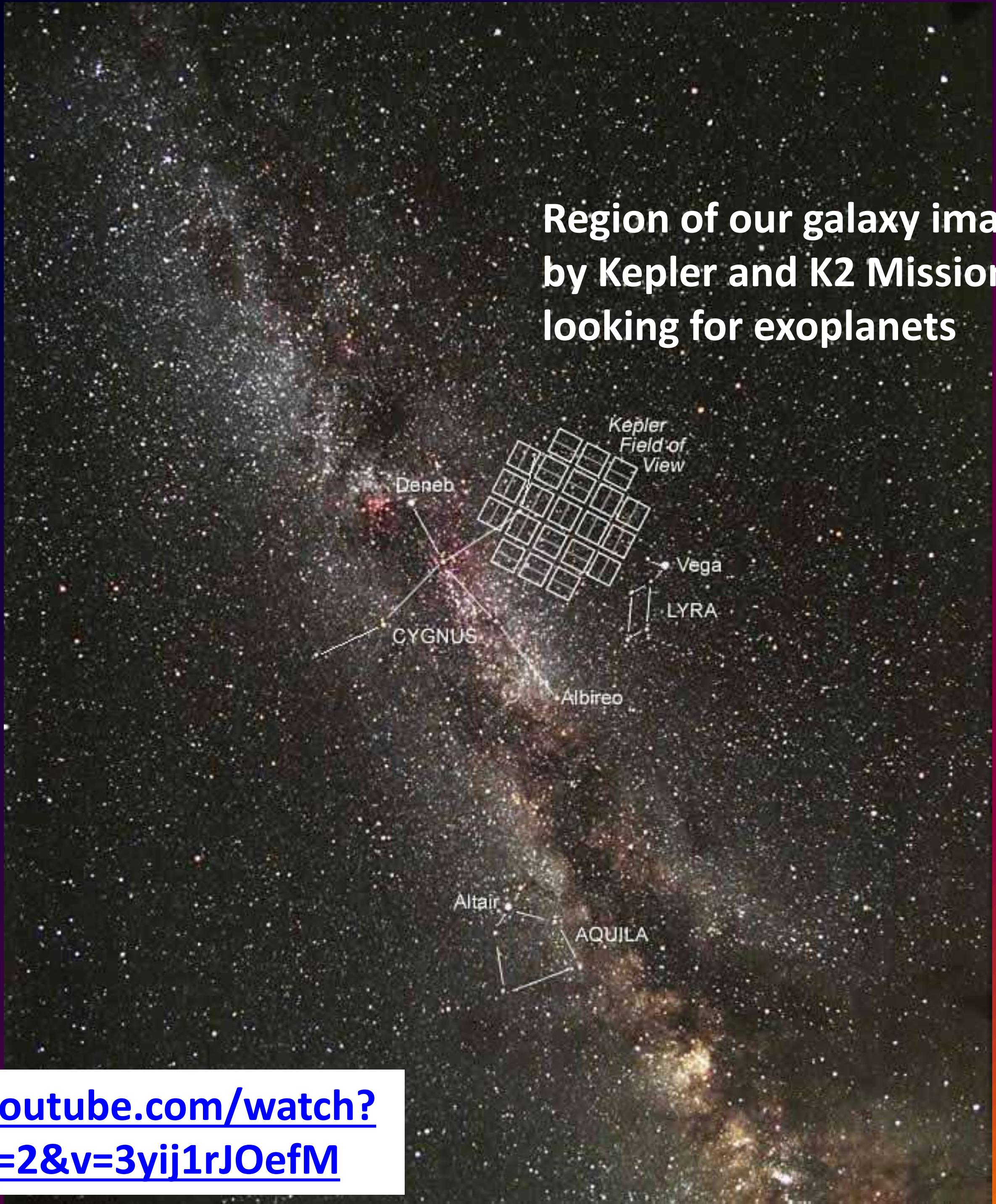
Search for biosignatures

Astrobiology

Picking up where we left off last week…
One aspect of the search for Ets is searching for habitable worlds around other stars, habitable being defined as able to support liquid water on their surface.

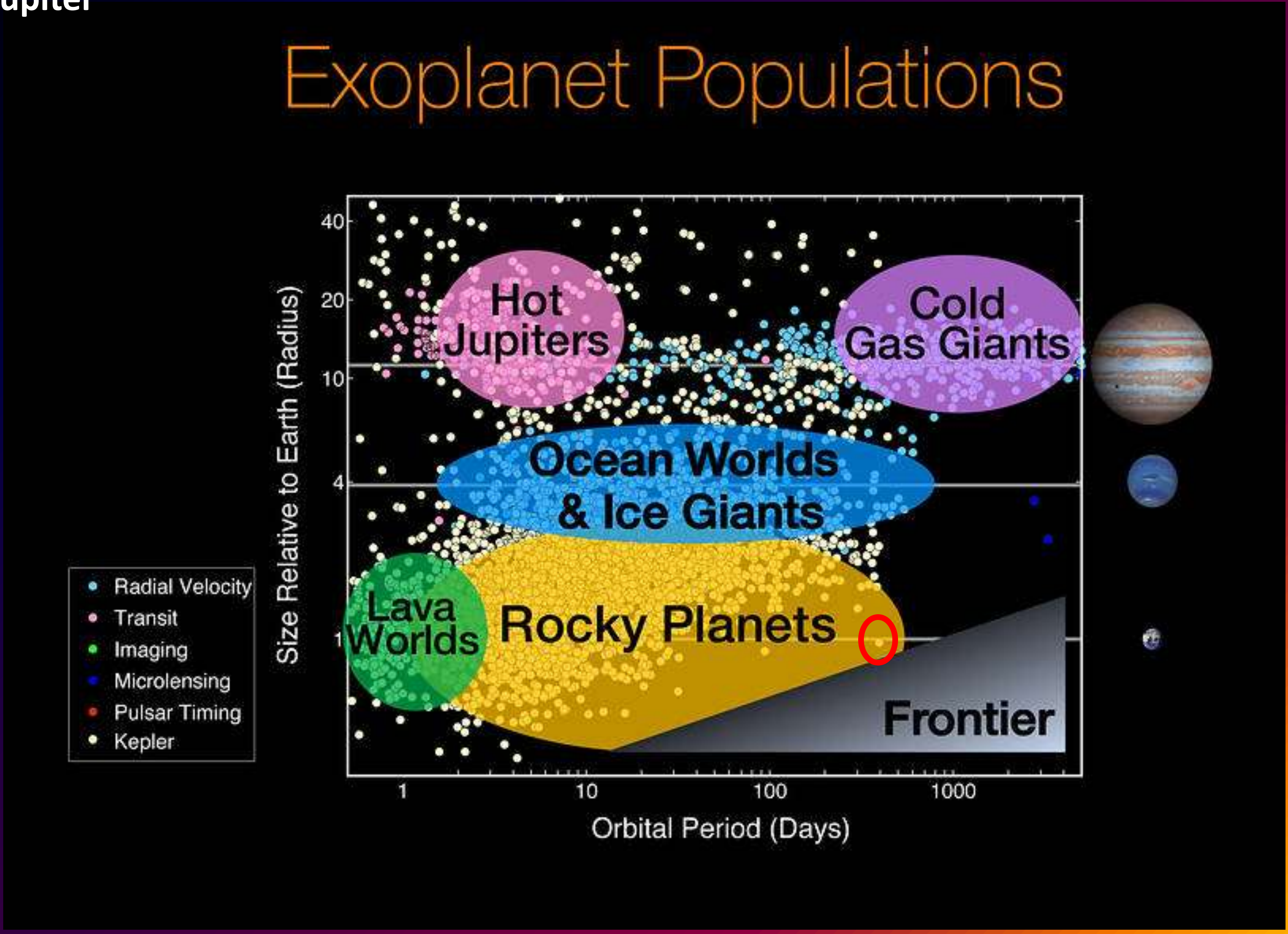
Kepler and K2 Missions found thousands of planets orbiting other stars in our galactic neighborhood.

Region of our galaxy imaged by Kepler and K2 Missions, looking for exoplanets

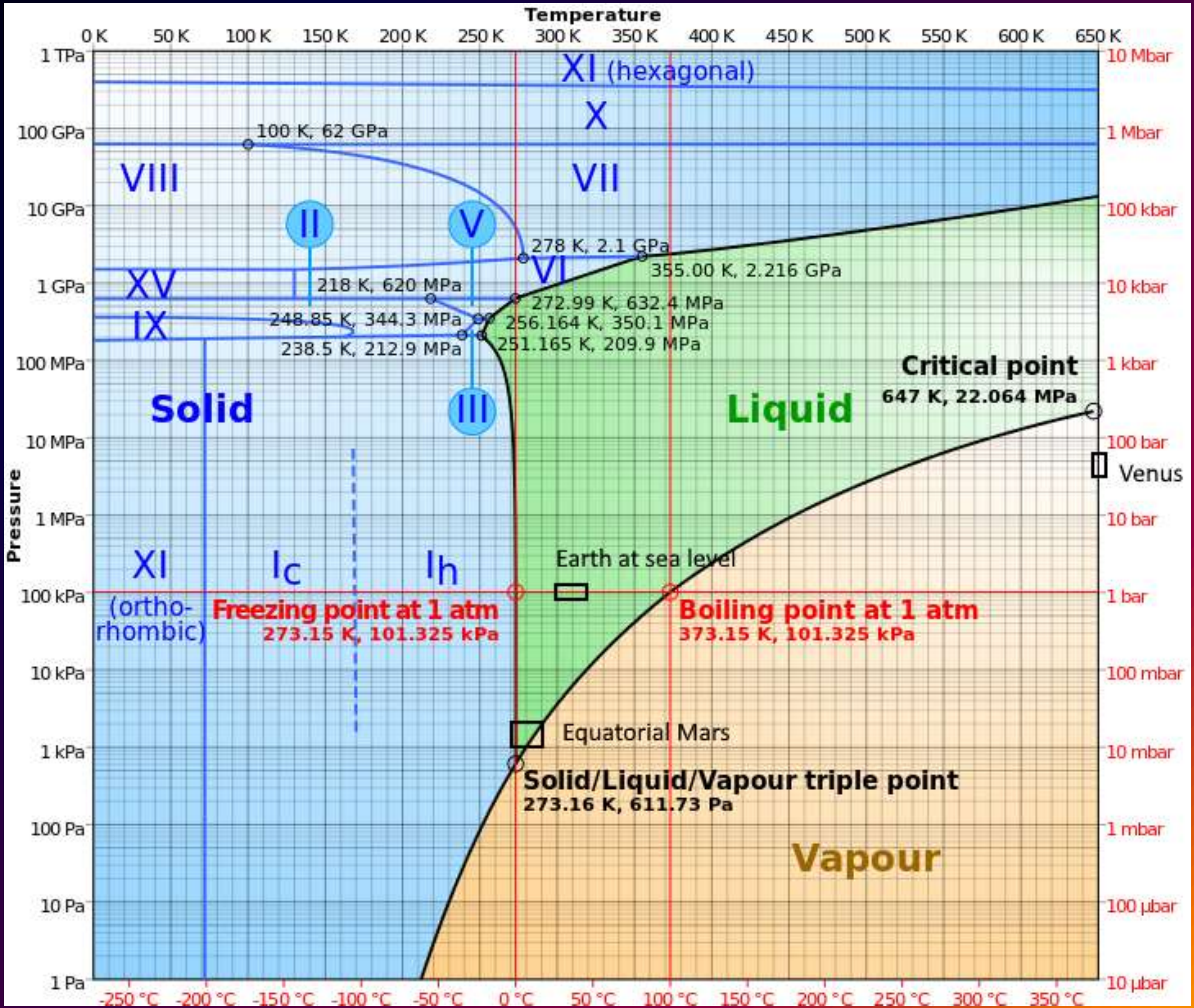


https://www.youtube.com/watch?time_continue=2&v=3yij1rJOefM

Types of planets discovered by Kepler and K2 compared to Earth, Neptune, and Jupiter



PHASE DIAGRAM FOR WATER



MICHAEL H. HART

ICARUS 37, 351–357 (1979)

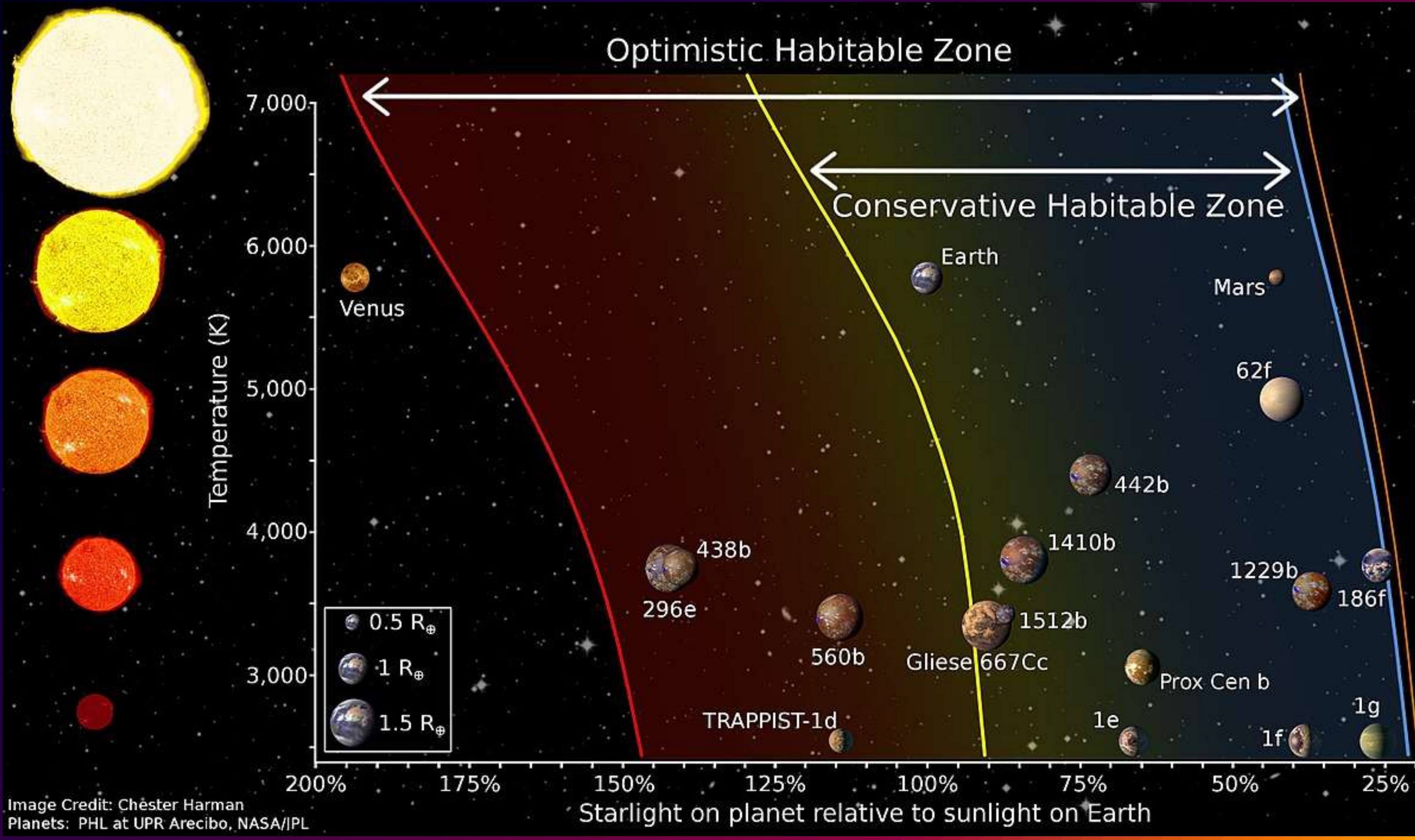
Our Sun

TABLE IV

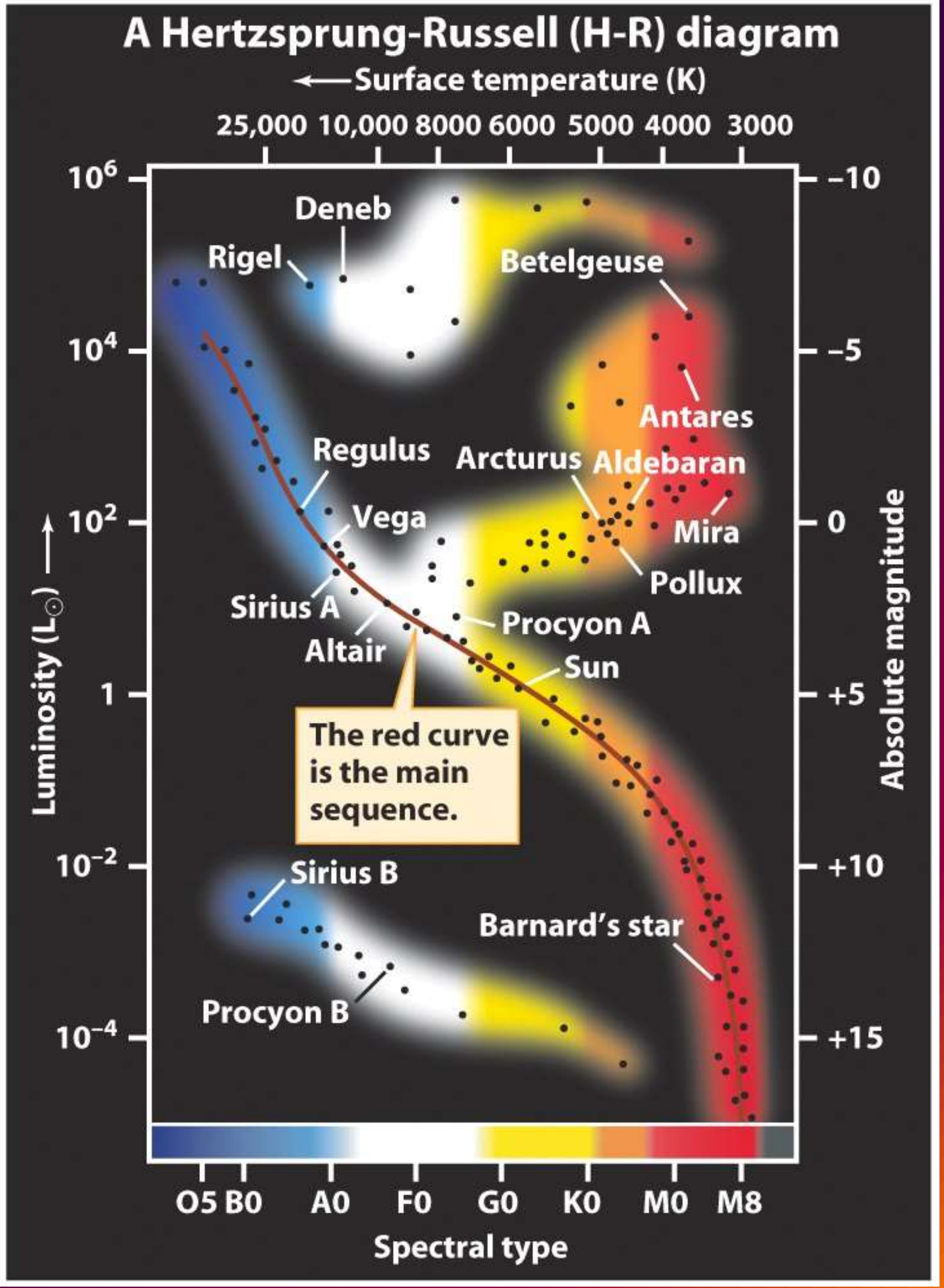
HABITABLE ZONES ABOUT MAIN-SEQUENCE STARS[a]

Stellar mass ($M/M_\odot$)	Approximate spectral type	Continuously habitable zone		
		r_{inner} (AU)	r_{outer} (AU)	width (AU)
1.20	F7	1.543	1.630	0.087
1.15	F8	1.370	1.454	0.084
1.10	F9	1.221	1.292	0.071
1.05	G0	1.083	1.143	0.060
1.00	G2	0.958	1.004	0.046
0.95	G5	0.840	0.874	0.034
0.90	G8	0.732	0.755	0.023
0.85	K0	0.634	0.649	0.015
0.80	K2	0.542	0.551	0.009
0.75	K4	0.460	0.463	0.003
0.715	K5	0.407	0.407	—

HABITABLE ZONEs defined for main sequence stars:

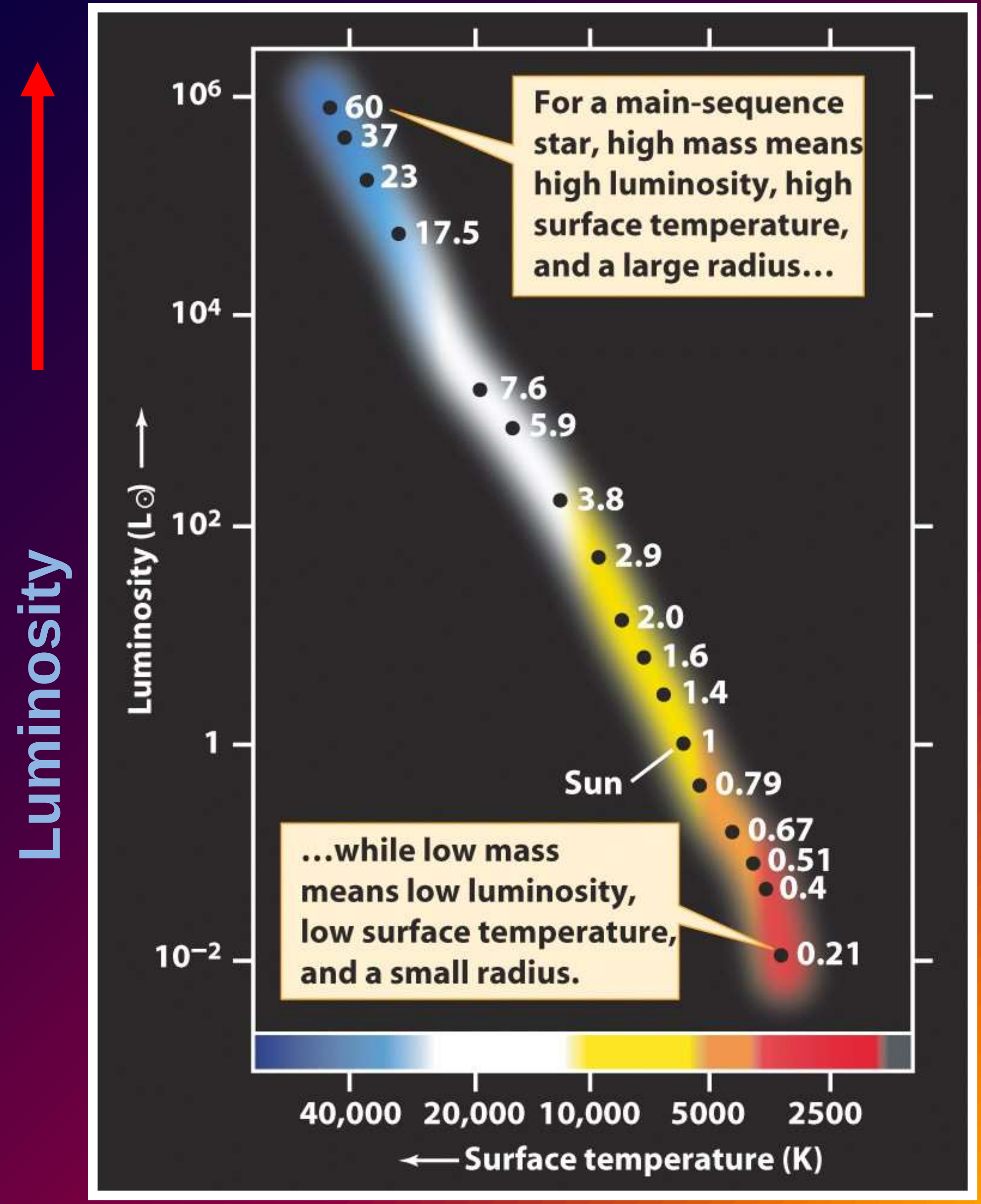


Main Sequence: Stars that are fusing hydrogen into helium in their cores



Greater mass means greater central pressure & temperature and greater luminosity...

Greater core pressure increases the RATE of nuclear reactions, resulting in greater luminosity.

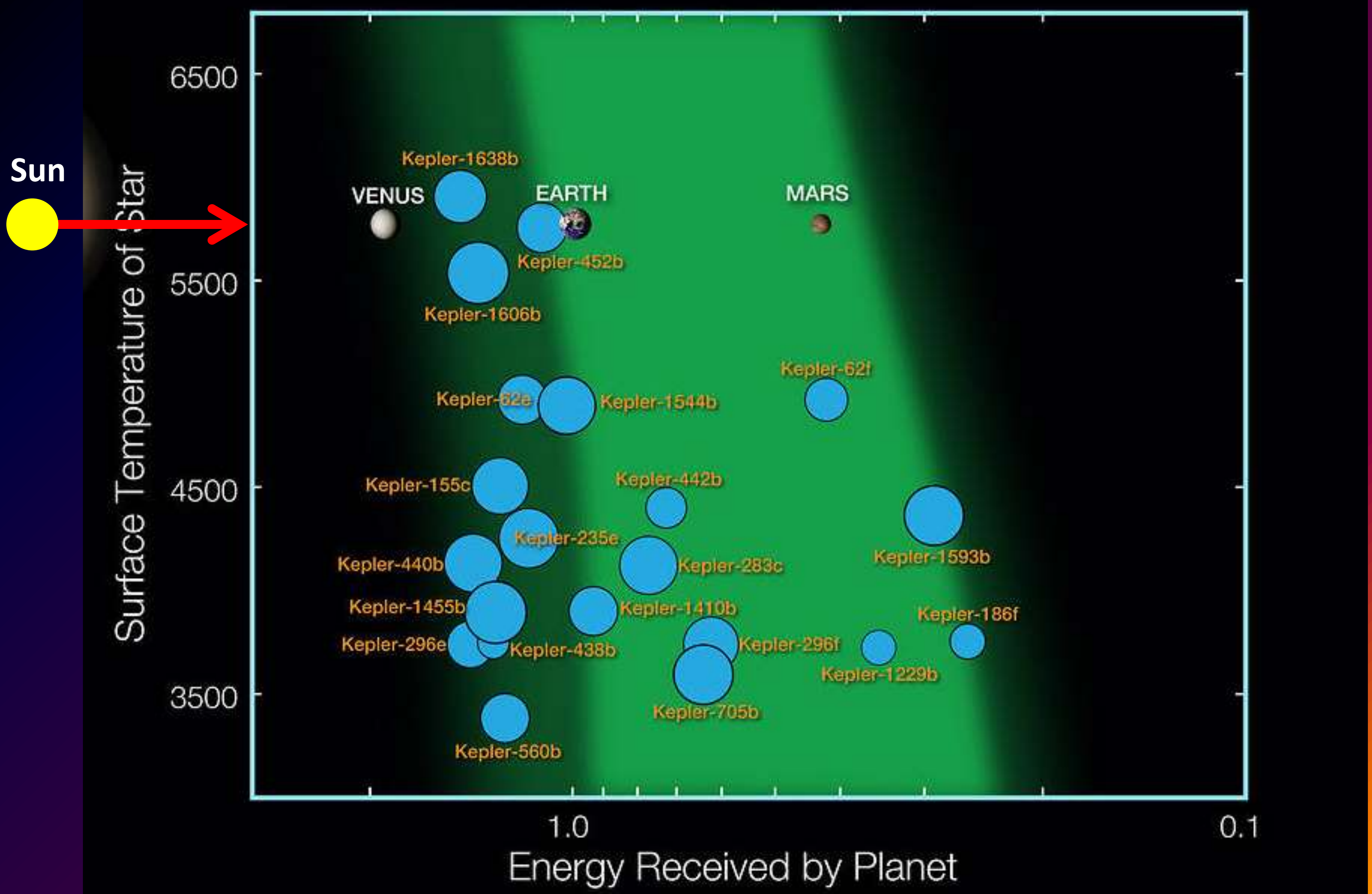


Approximate relationship between Mass and Luminosity:

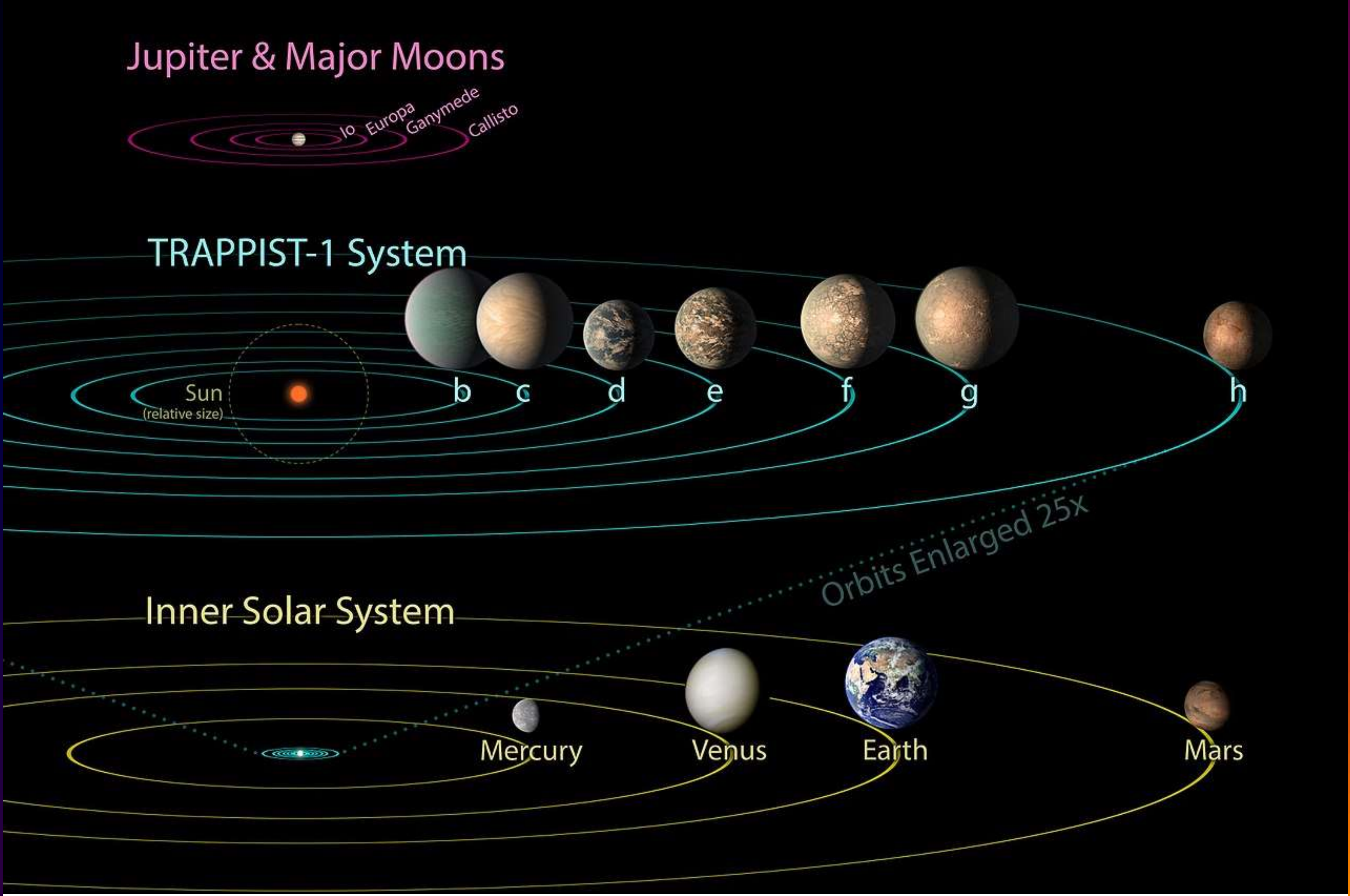
$$L \cong M^{3.5}$$

for main sequence stars

Some of the Kepler planets in the habitable zones of their stars



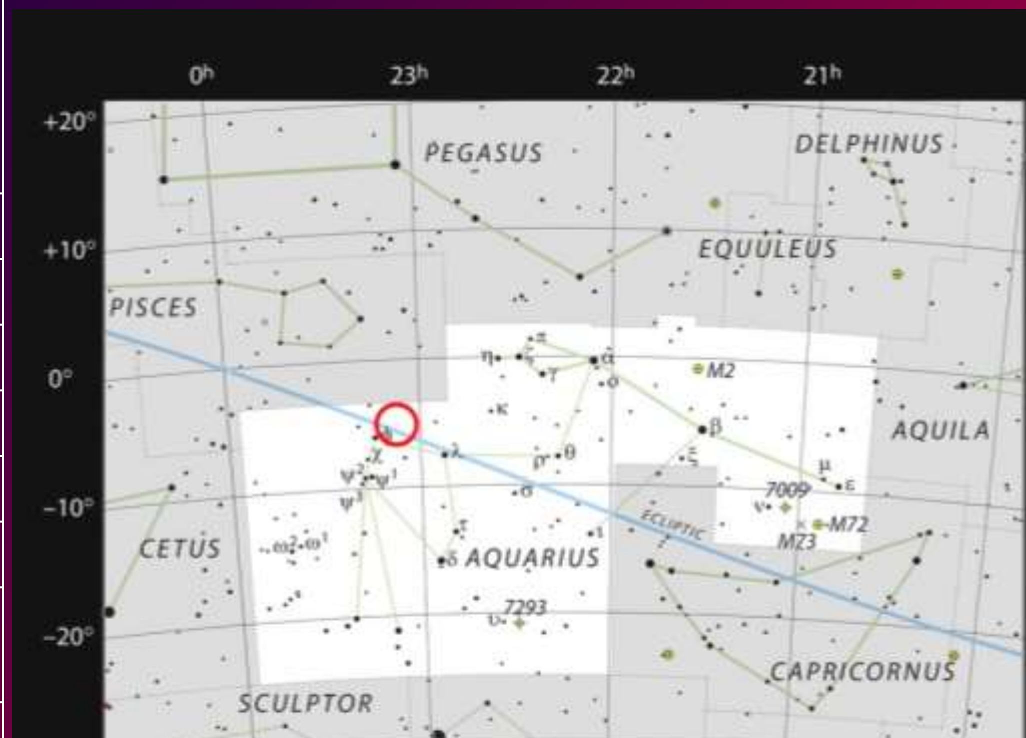
In 2015 the Transiting Planets and Planetesimals Small Telescope (TRAPPIST) discovered a **7-planet system of rocky exoplanets around a small red dwarf, ~ 40 ly away.**

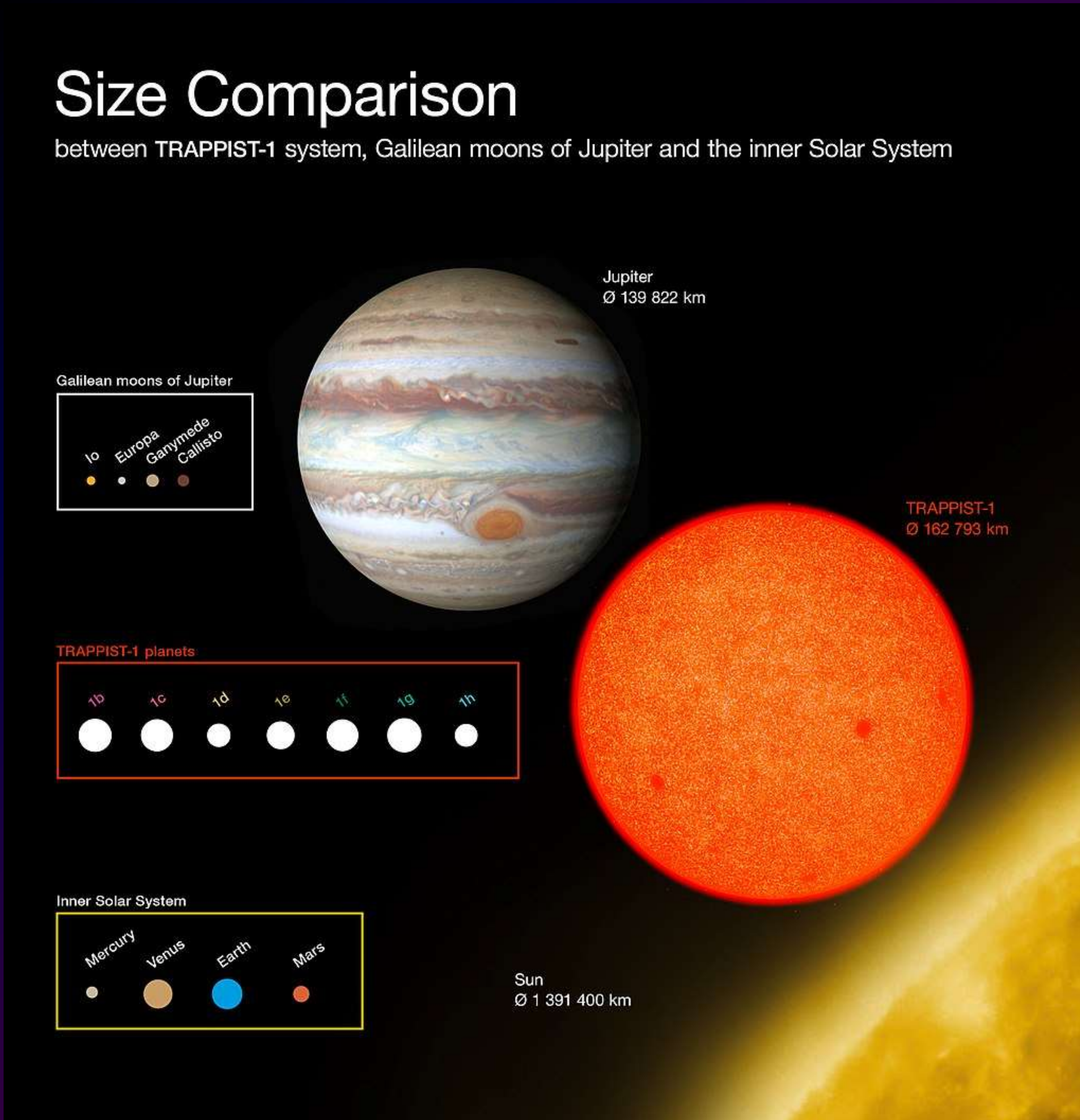


https://www.nasa.gov/feature/jpl/new-clues-to-trappist-1-planet-compositions-atmospheres

Name	2MASS J23062928-0502285
Alternate name	TRAPPIST-1
Right ascension	$\alpha = 23^h\ 06^m\ 29.28^s$
Declination	δ = -05º 02' 28.5''
Constellation	Aquarius
Apparent magnitudes	$V = 18.80 \pm 0.08$, $R = 16.47 \pm 0.07$, $I = 14.0 \pm 0.1$, $J = 11.35 \pm 0.02$, $K = 10.30 \pm 0.02$
Parallax	82.4 ± 0.8 mas
Distance	12.14 ± 0.12 pc
Mass	$0.089 \pm 0.006\ M_{\odot}$
Radius	$0.121 \pm 0.003\ R_{\odot}$
Density	$51.1_{-2.4}^{+1.2}\ \rho_{\odot}$
Effective temperature	2511 ± 37 K
Luminosity	$0.000522 \pm 0.000019\ L_{\odot}$
Metallicity [Fe/H]	+0.04 ± 0.08
Age	7.6 ± 2.2 Gyr

comparison with our Sun

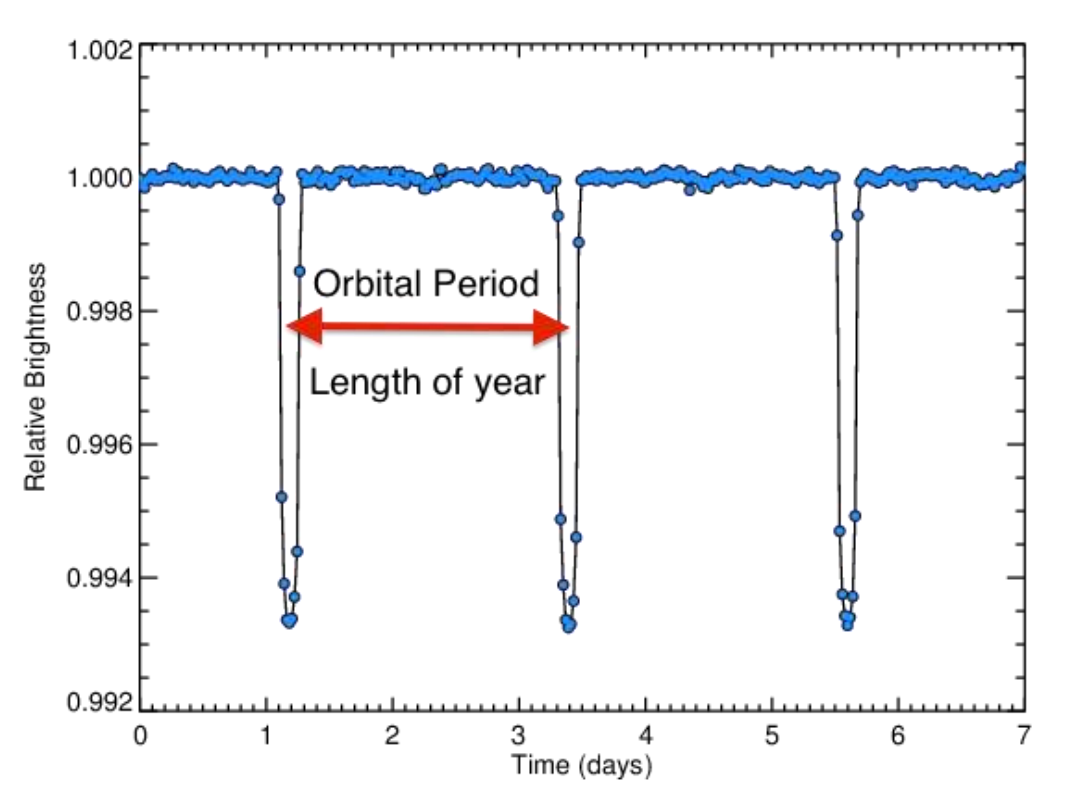


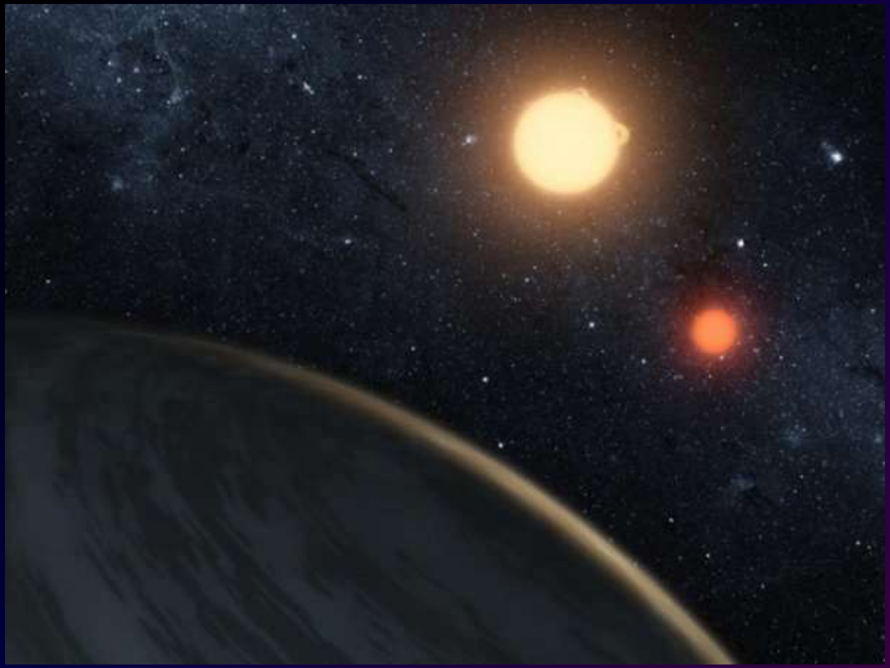

Size Comparison
between TRAPPIST-1 system, Galilean moons of Jupiter and the inner Solar System
Jupiter
Ø 139 822 km
Galilean moons of Jupiter
Io
Europa
Ganymede
Callisto
TRAPPIST-1
Ø 162 793 km
TRAPPIST-1 planets
1b
1c
1d
1e
1f
1g
1h
Inner Solar System
Mercury
Venus
Earth
Mars
Sun
Ø 1 391 400 km

SPECULOOS Southern Observatory
The Search for habitable Planets EClipsing ULtra-cOOl Stars — Finding Earth-like planets around tiny, dim stars using the transit method

How to find exoplanets:

One method is by observing the light curve of a star. There is a decrease in the brightness observed when a planet transits in front of the star, from our viewpoint.





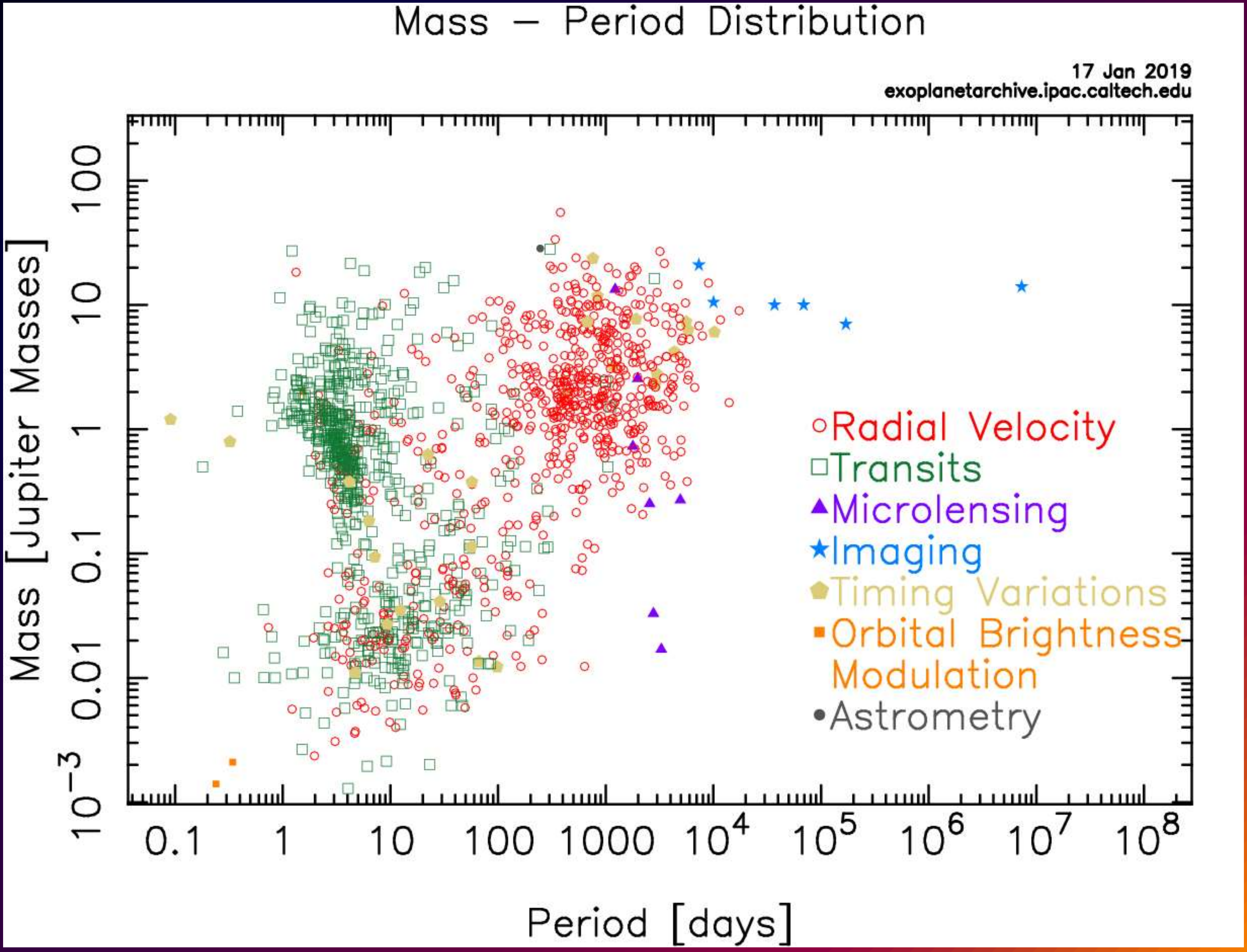
Kepler 1647b – a real circumbinary planet (artist's rendition)

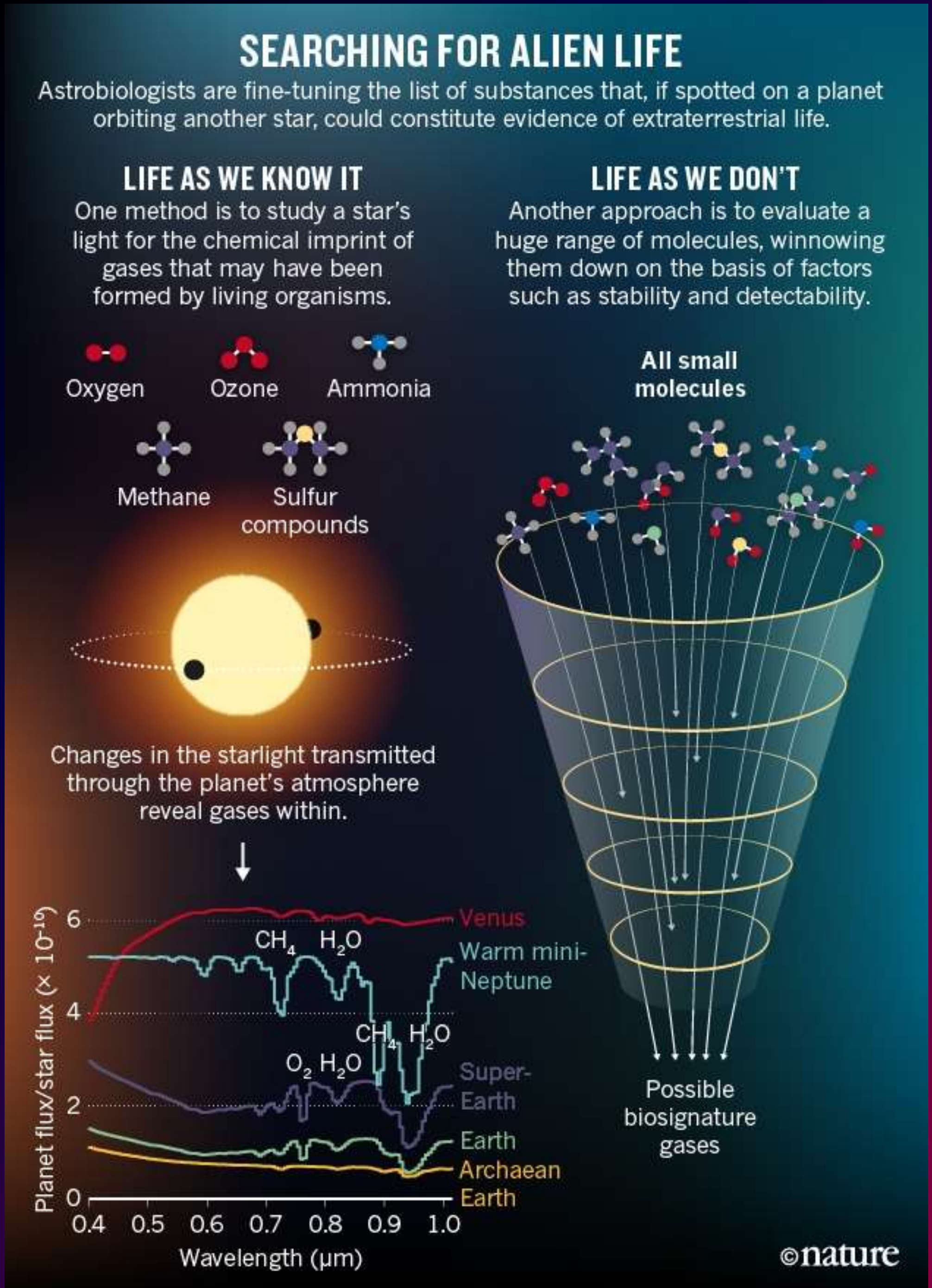
Detected by the transit method

fictional Tatooine

3,885 confirmed exoplanets as of Jan. 17, 2019

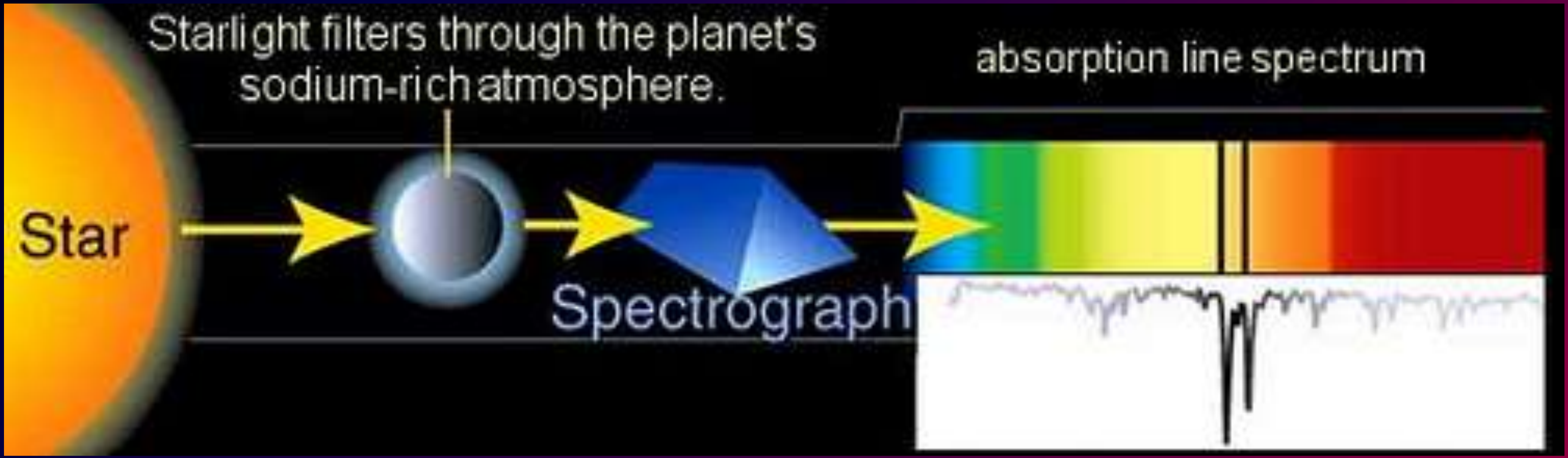
NASA Exoplanet Archive
https://exoplanetarchive.ipac.caltech.edu/

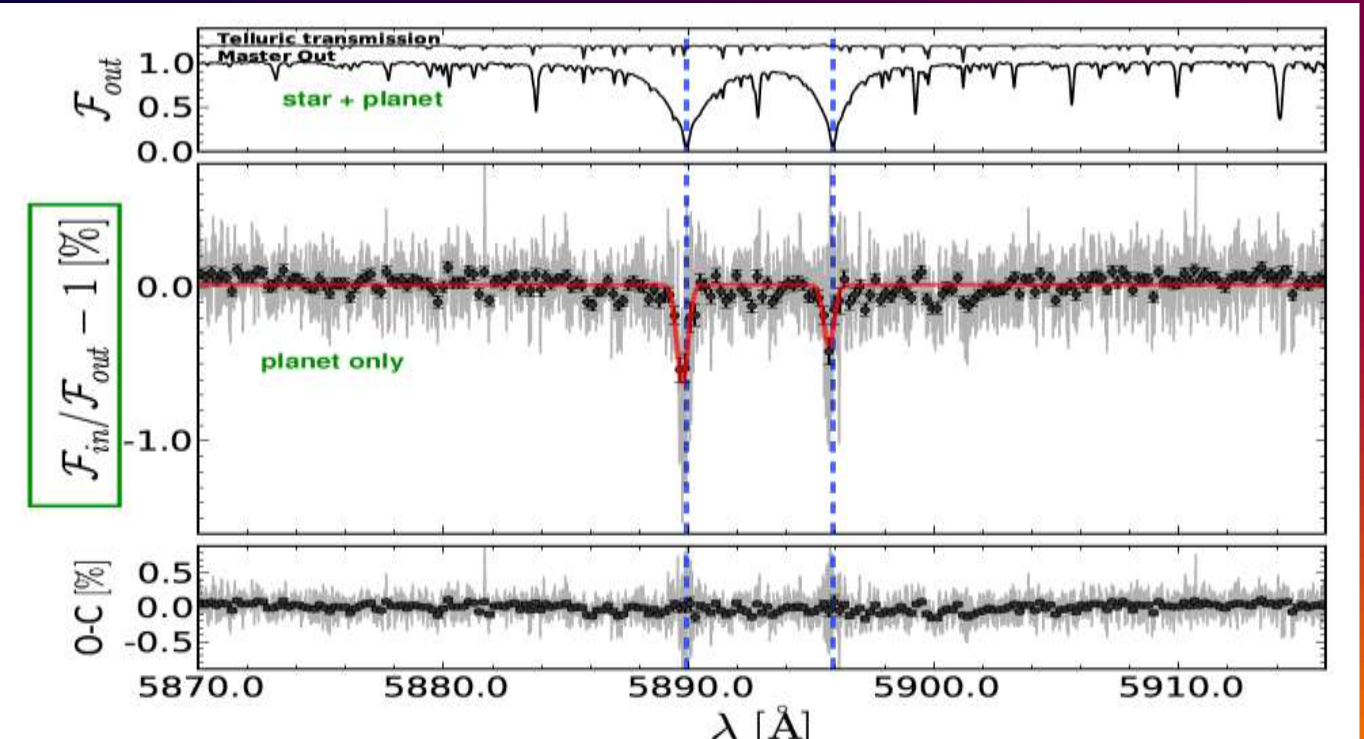




Continuing search for exoplanets extends to the search for biosignatures in the atmospheres of exoplanets

Detecting elements and compounds in the atmospheres of exoplanets by using absorption spectra. Example:





A BRIEF HISTORY OF SETI

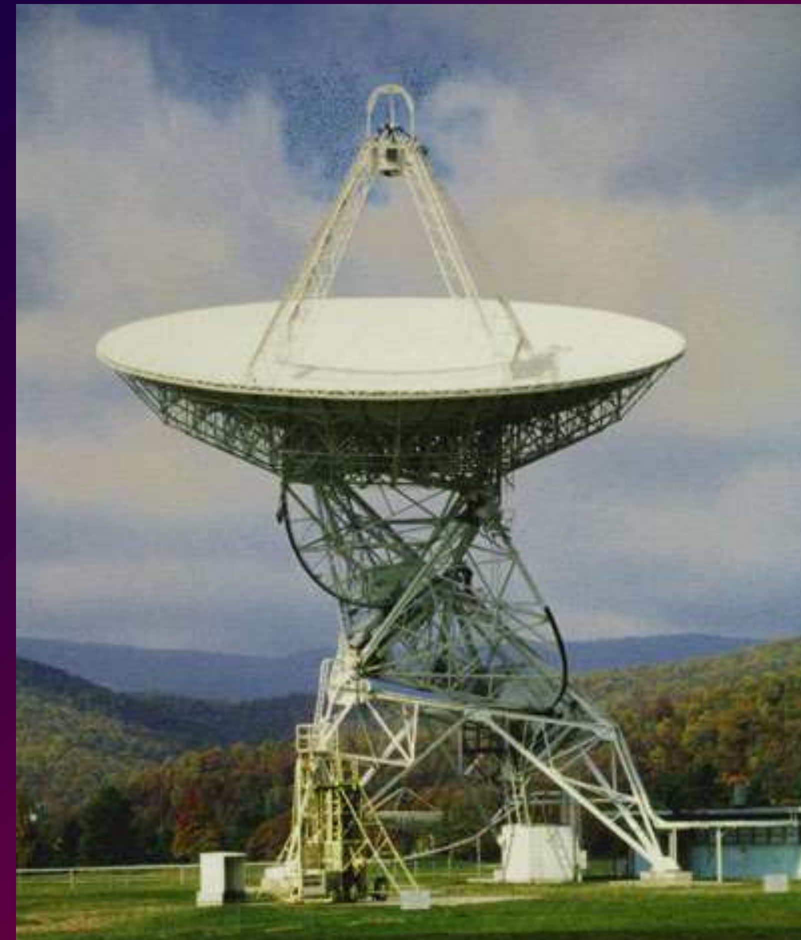
Aliens made in our image…

At this very minute, with almost absolute certainty, radio waves sent forth by other intelligent civilizations are falling on the earth. A telescope can be built that, pointed in the right place, and tuned to the right frequency, could discover these waves. Someday, from somewhere out among the stars, will come the answers to many of the oldest, most important, and most exciting questions mankind has asked.

—Frank D. Drake,
(Intelligent Life in Space
The MacMillan Co.)

First organized SETI: Project Ozma

1960
Cornell University, NY
Astronomer Frank Drake



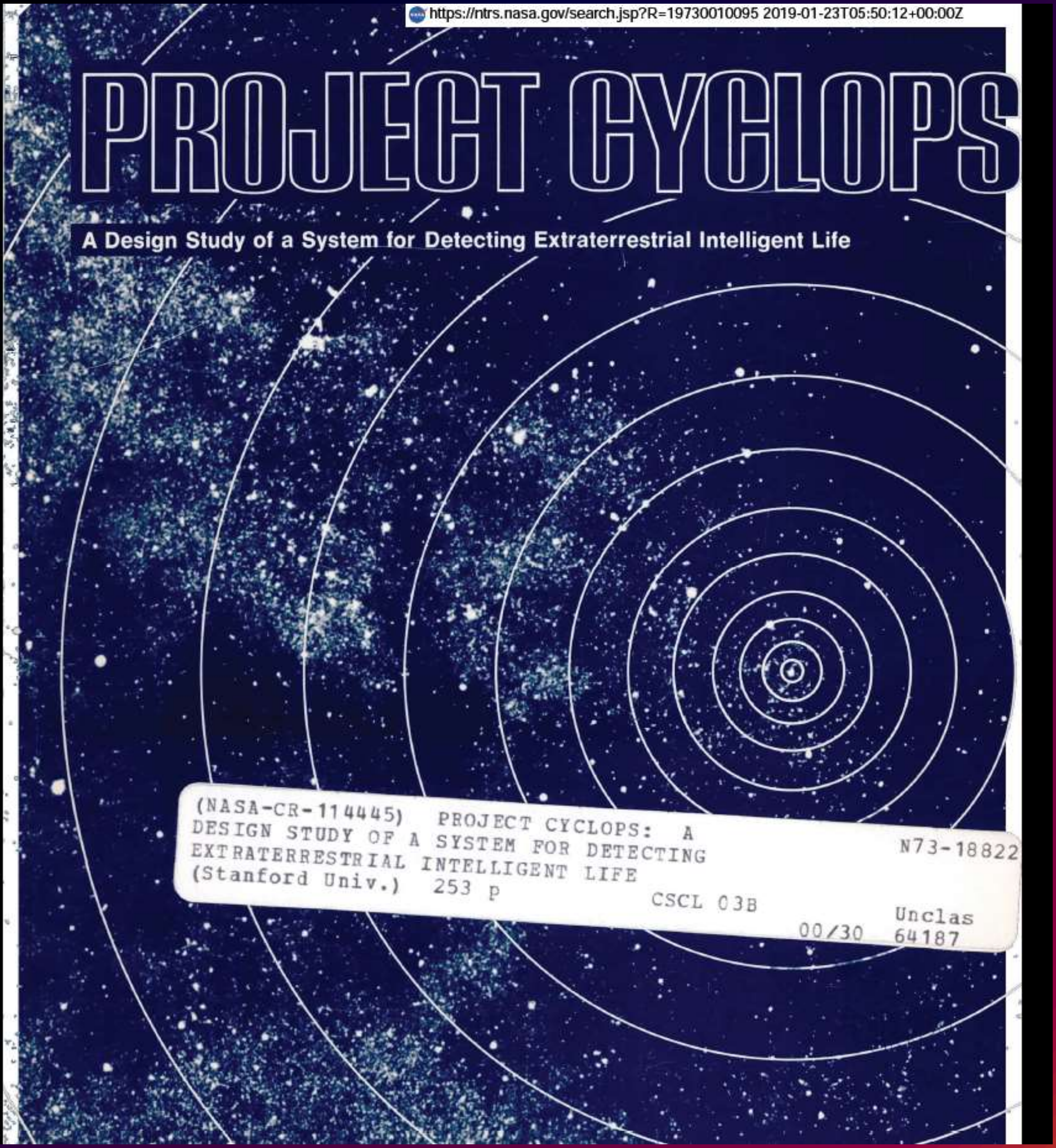
National Radio Astronomy Observatory
in Green Bank, West Virginia

Objective: Search for signs of intelligent life in distant planetary systems

Method: Scan a 400 kHz bandwidth for
21 cm (1420 MHzradio frequency emission

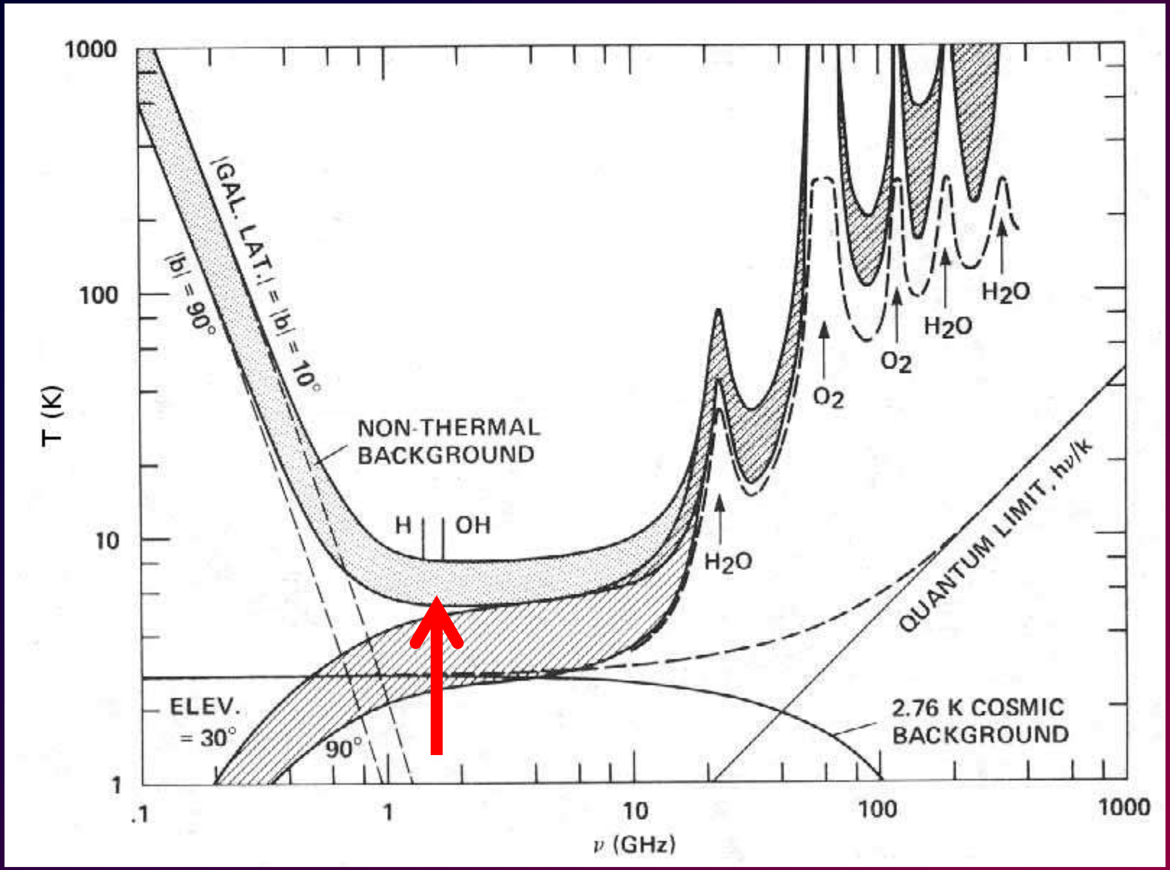
21 cm is the frequency of spontaneous spin
flip of a hydrogen atom.
It was thought that this would be familiar to any civilization trying to transmit.

4 months of taking data – no signal found



1971 NASA project to design an optimal SETI

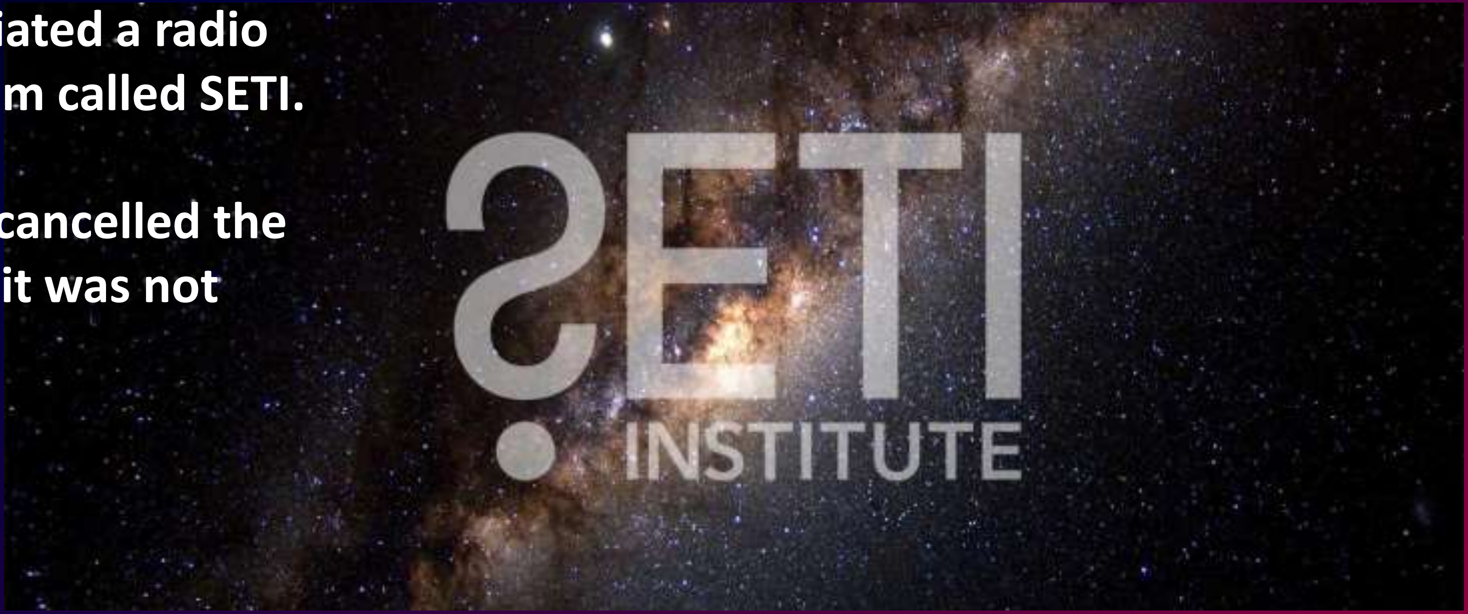
using optimal frequency window in the microwave region of the EM spectrum



"Nature has provided us with a rather narrow quiet band in this best part of the spectrum that seems especially marked for interstellar contact. It lies between the spectral lines of hydrogen (1420 MHz) and the hydroxyl radical (1662 MHz). …these two emissions of the disassociation products of water beckon all water-based life to search for its kind at the age-old meeting place of all species: the water hole."

In 1992 NASA initiated a radio astronomy program called SETI.

In 1993 Congress cancelled the funding, claiming it was not valid science.



Mountainview, CA

The SETI Institute was incorporated as a 501(c)3 California Non-Profit Corporation on November 20, 1984. The inaugural officers of the Institute were CEO Thomas Pierson and SETI scientist Jill Tarter. The Institute began operations on February 1, 1985.

6 research divisions:

Astrobiology
Astronomy & Astrophysics
Climate & Bioscience
Exoplanets
Planetary Exploration
SETI

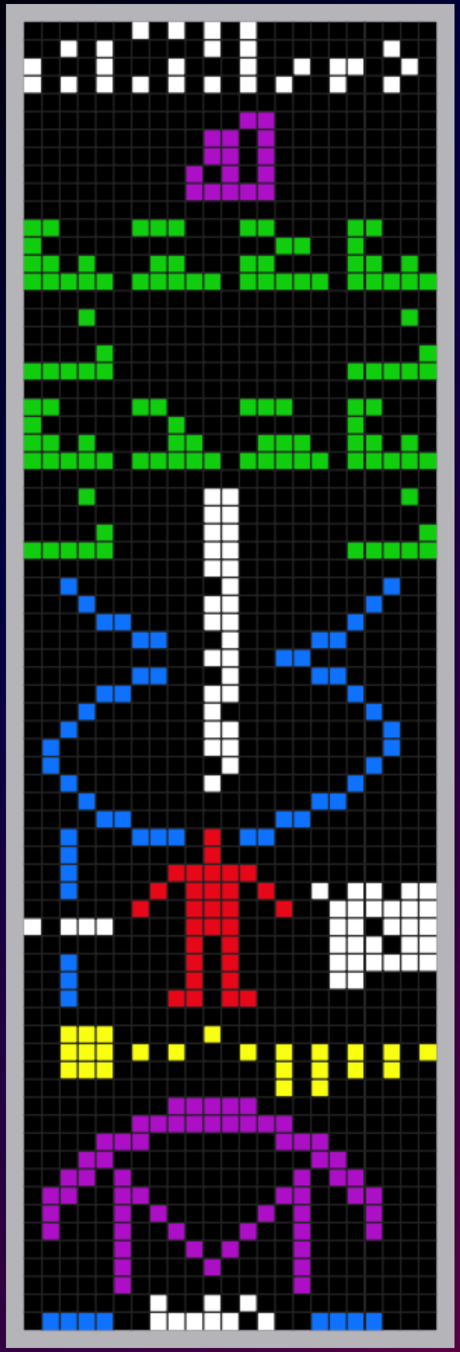
SETI INSTITUTE

https://seti.org/core-research

and Frontier Development Lab

ARTIFICIAL INTELLIGENCE RESEARCH FOR SPACE EXPLORATION AND ALL HUMANKIND

https://frontierdevelopmentlab.org/



What would the social, cultural, and political consequences be if we did make contact with an extra terrestrial intelligent civilization?

https://en.wikipedia.org/wiki/Potential_cultural_impact_of_extraterrestrial_contact