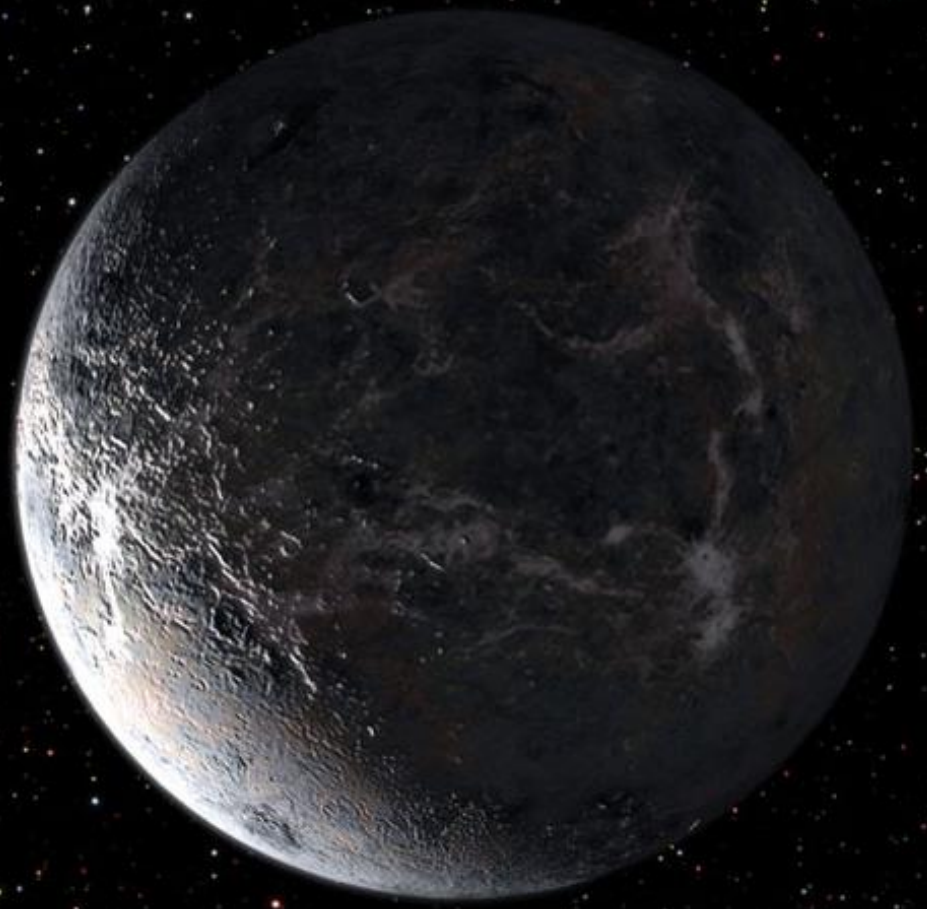
Jet Propulsion Laboratory
California Institute of Technology

The Steward Observatory Public Evening Series
October 2016

The Search for Planets, Habitability, and Life in our Galaxy

Dr. Nick Siegler
Program Chief Technologist
NASA Exoplanet Exploration Program



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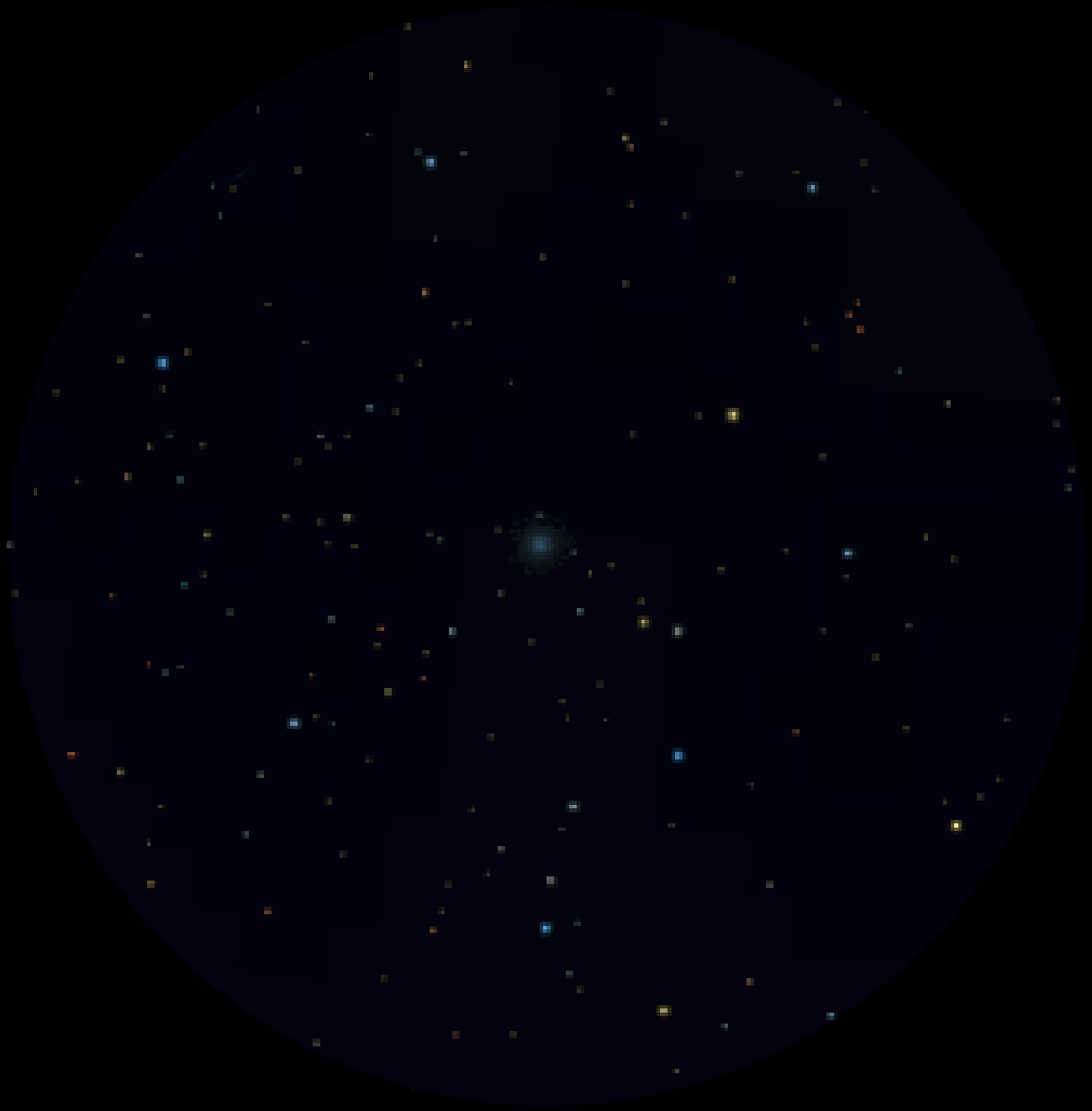
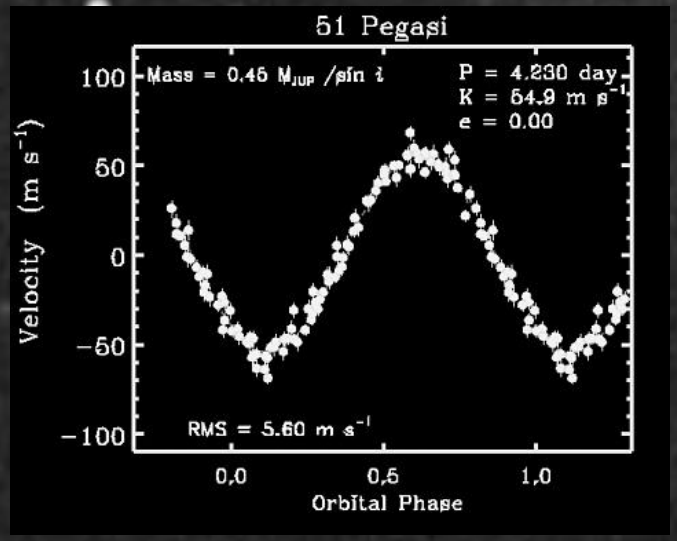
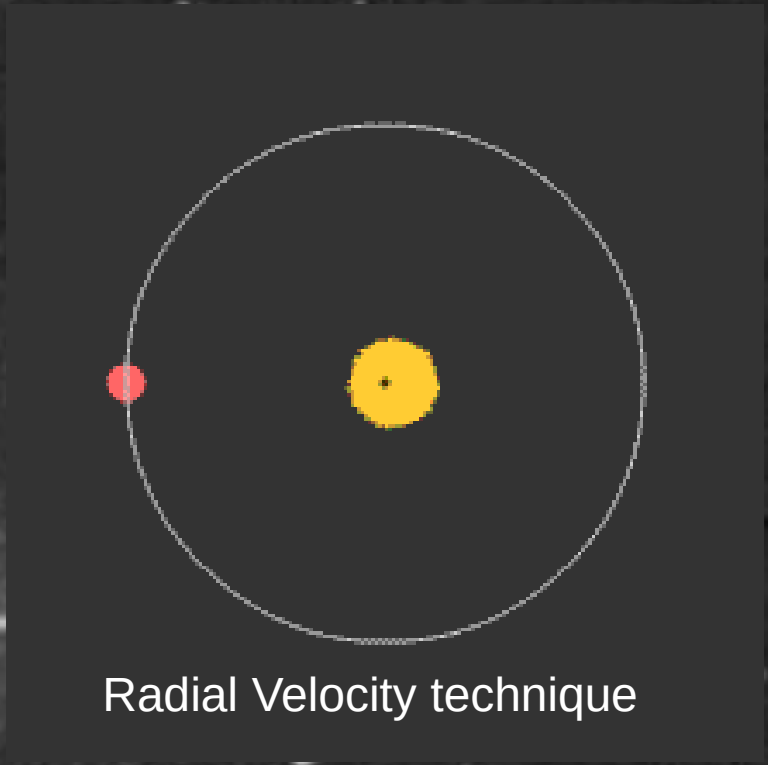


Photo: Roberto Mura

photo: Brocken Inaglory

51 Pegasi

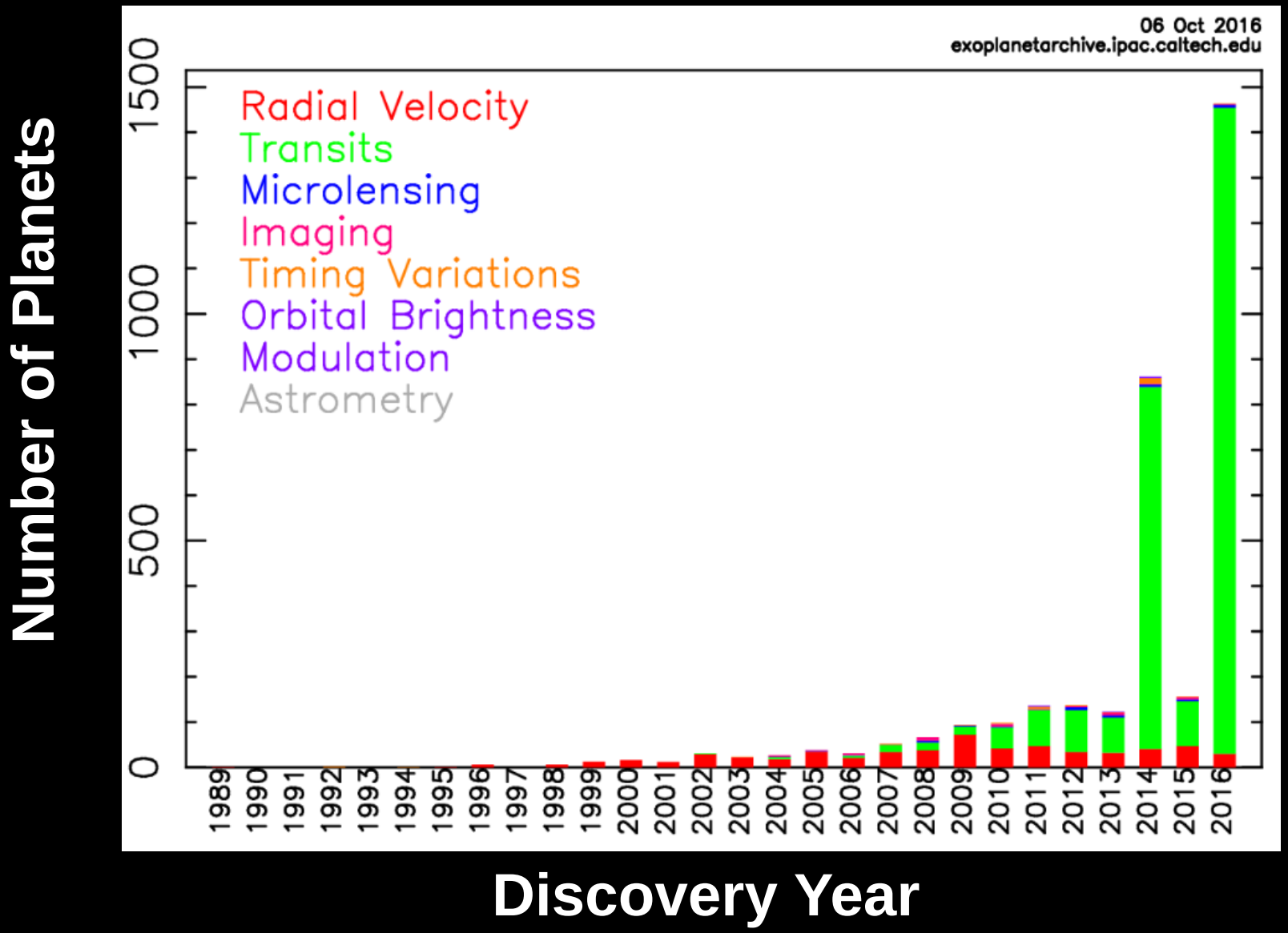




Mayor & Queloz 1995; http://www.schoolsobservatory.org.uk/astro/stars/exodetect

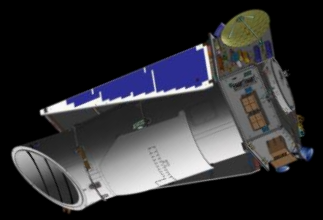
3,396 Confirmed Exoplanets

(as of 10/8/16)

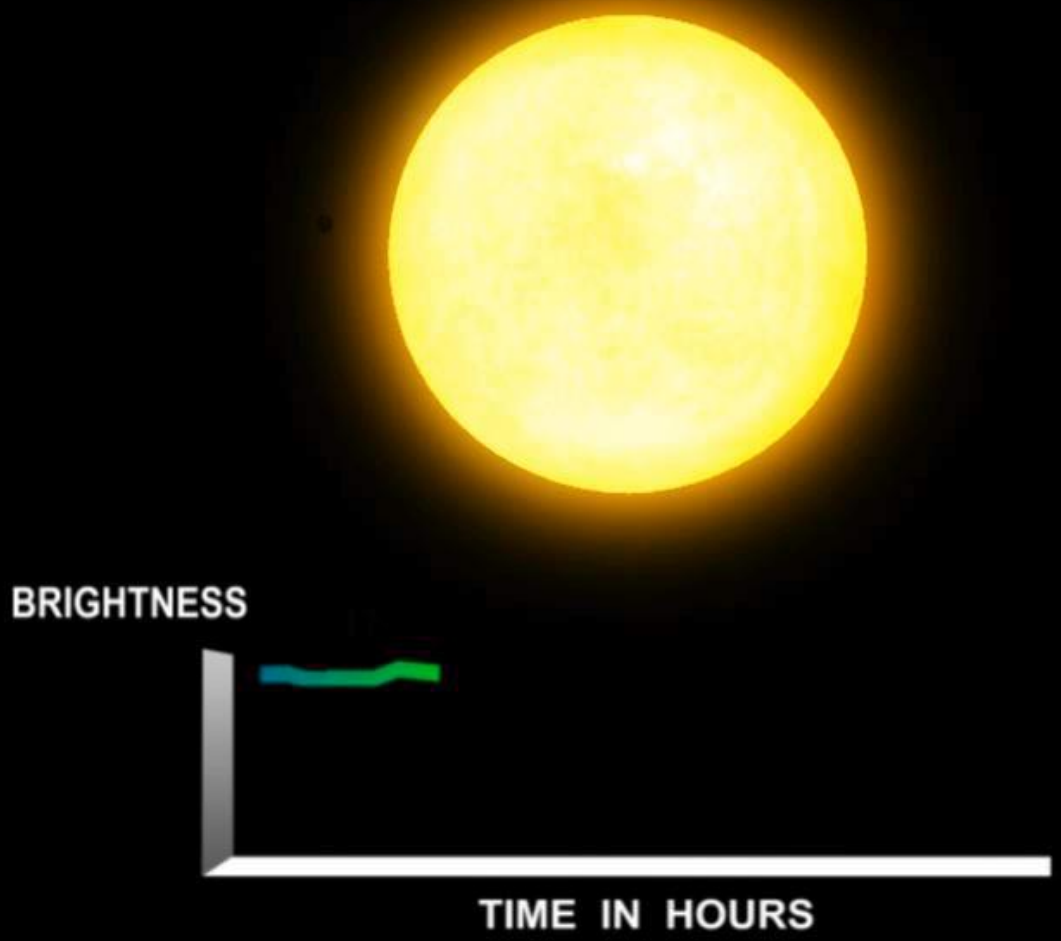


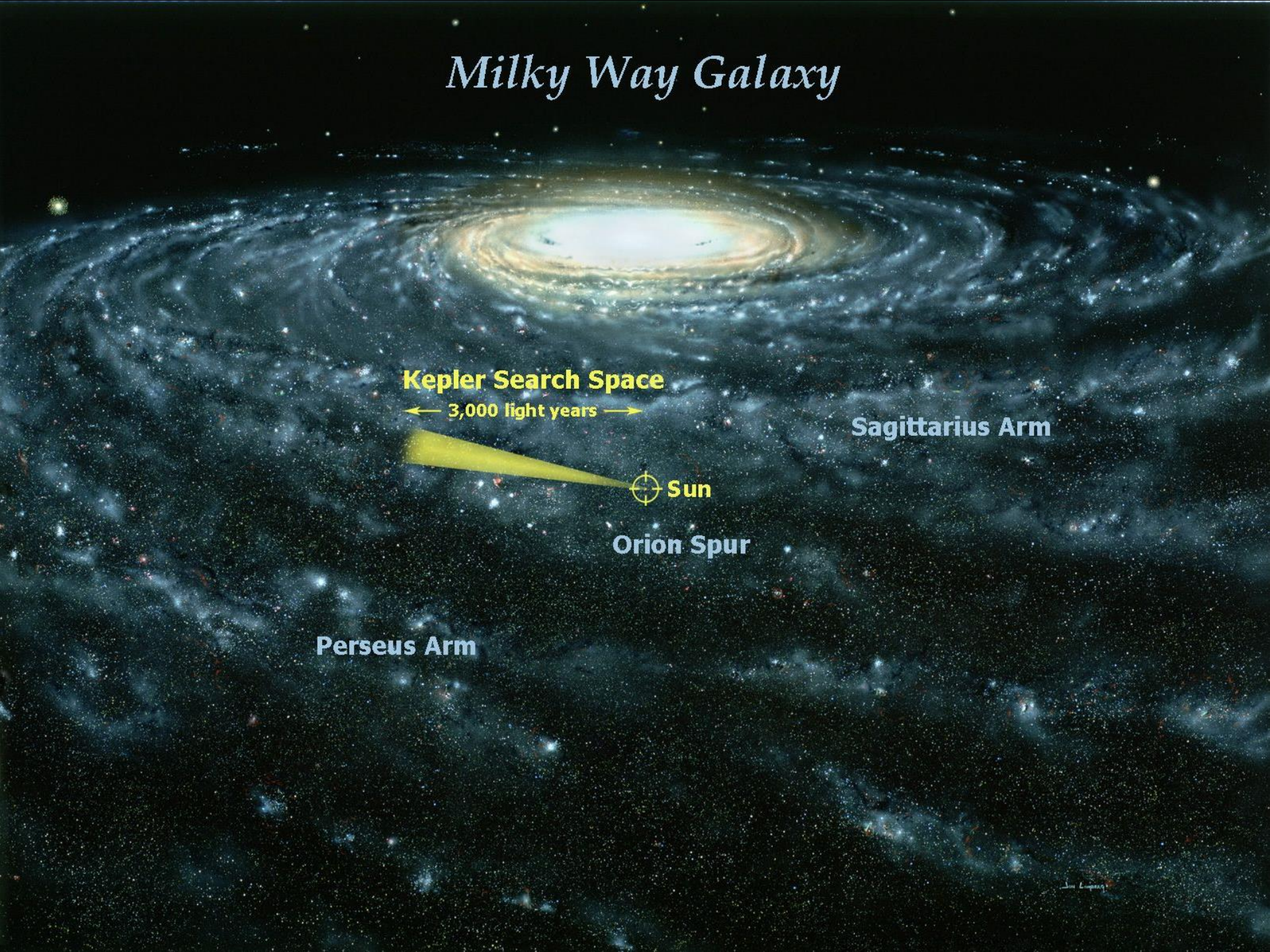
:http://exoplanetarchive.ipac.caltech.edu/exoplanetplots/

Transit Technique



Kepler




Milky Way Galaxy
Kepler Search Space
3,000 light years
Sun
Sagittarius Arm
Orion Spur
Perseus Arm

Lava Planets

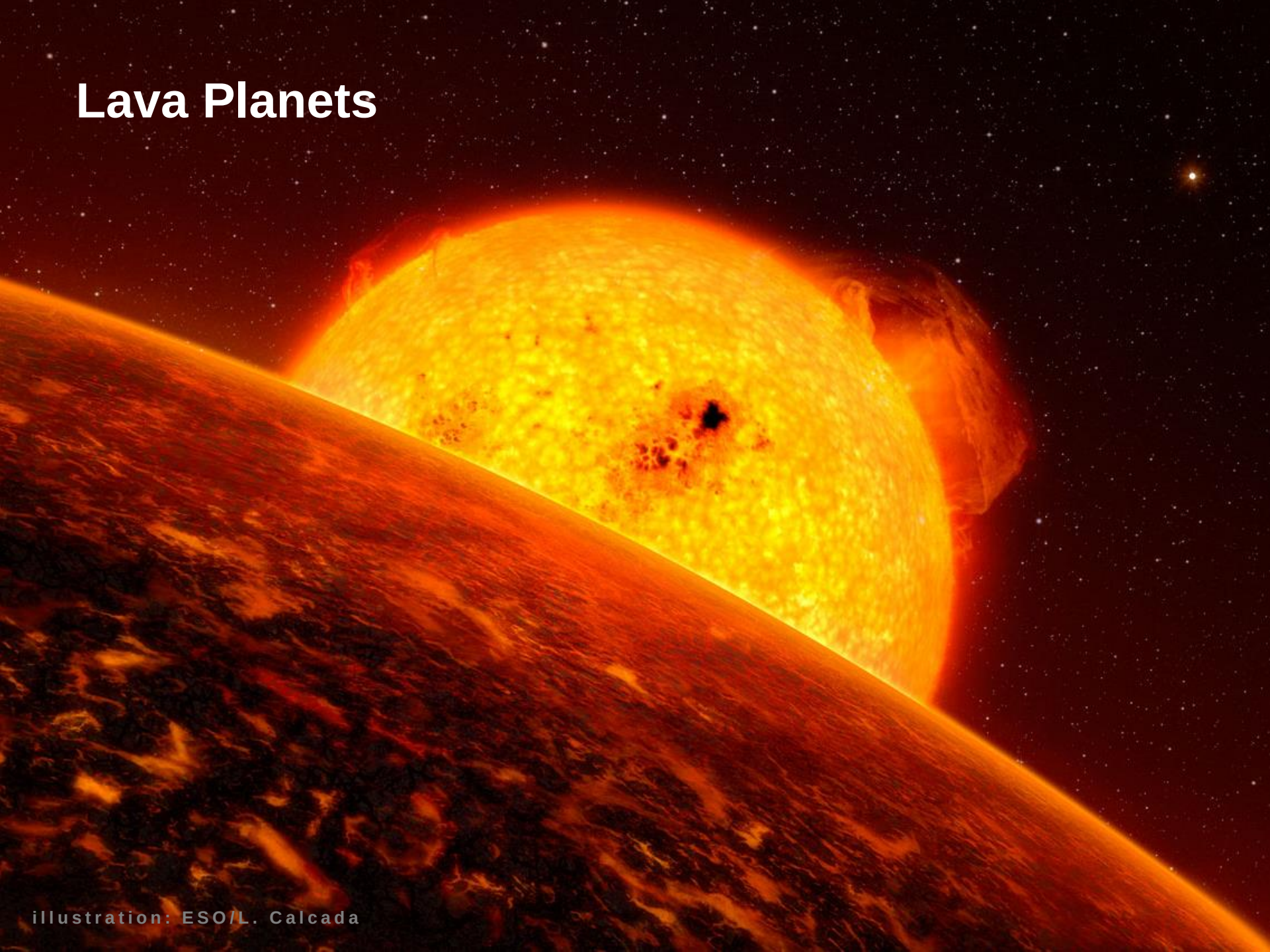
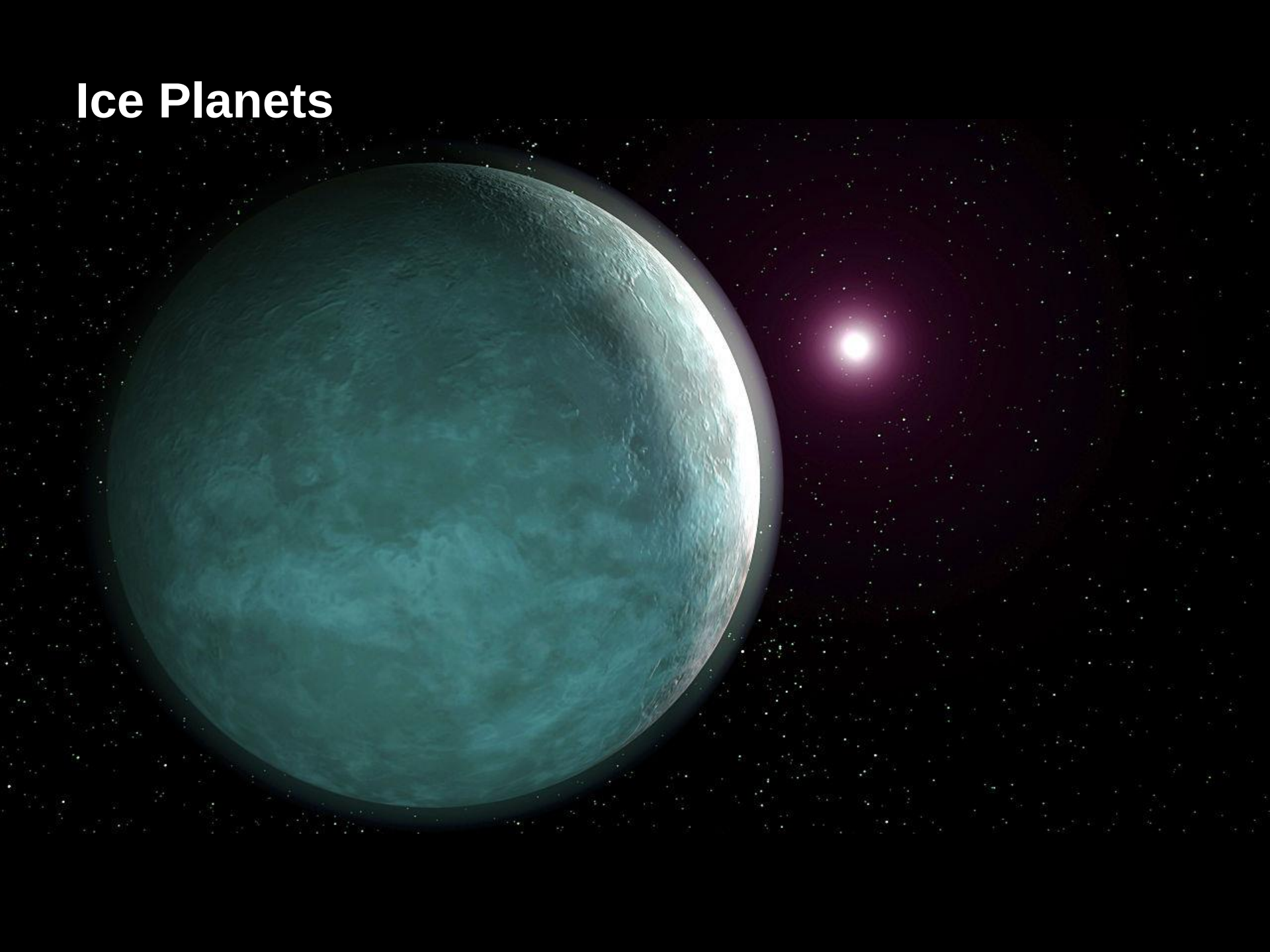


illustration: ESO/L. Calcada

Ice Planets



Planets with two stars

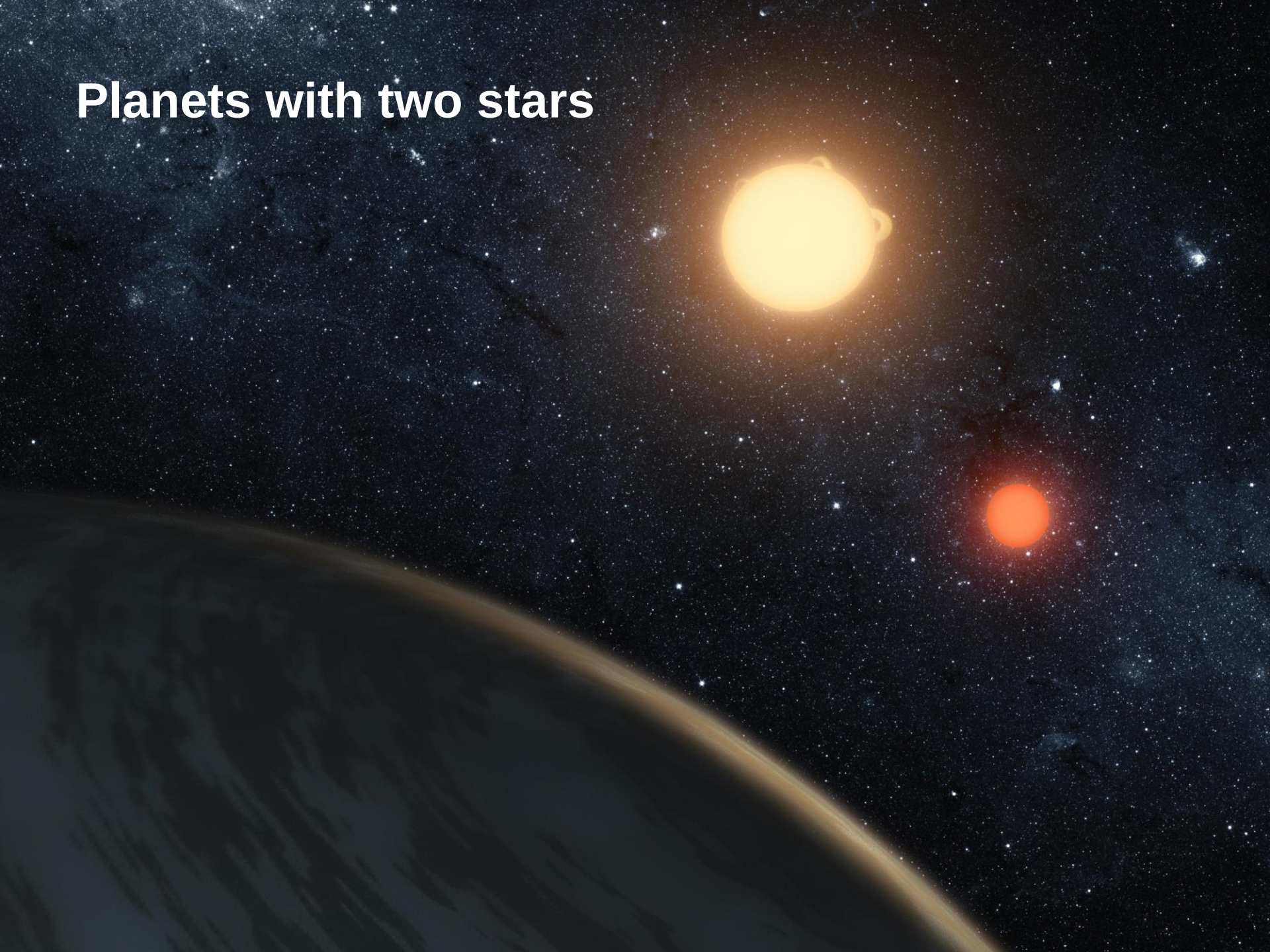
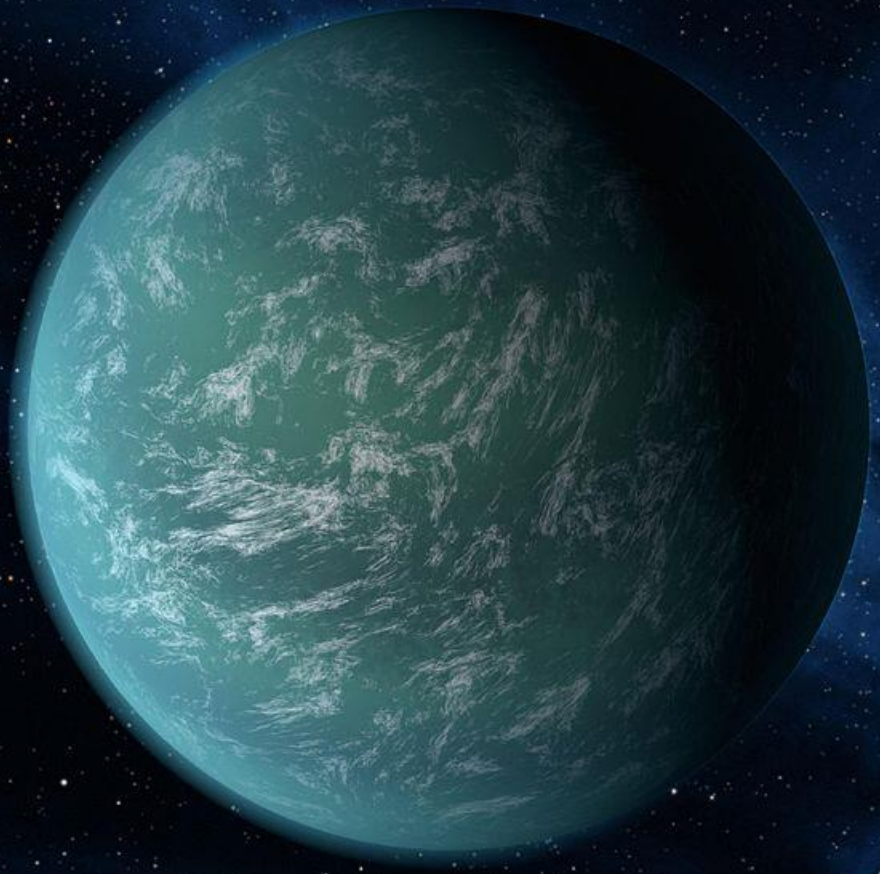
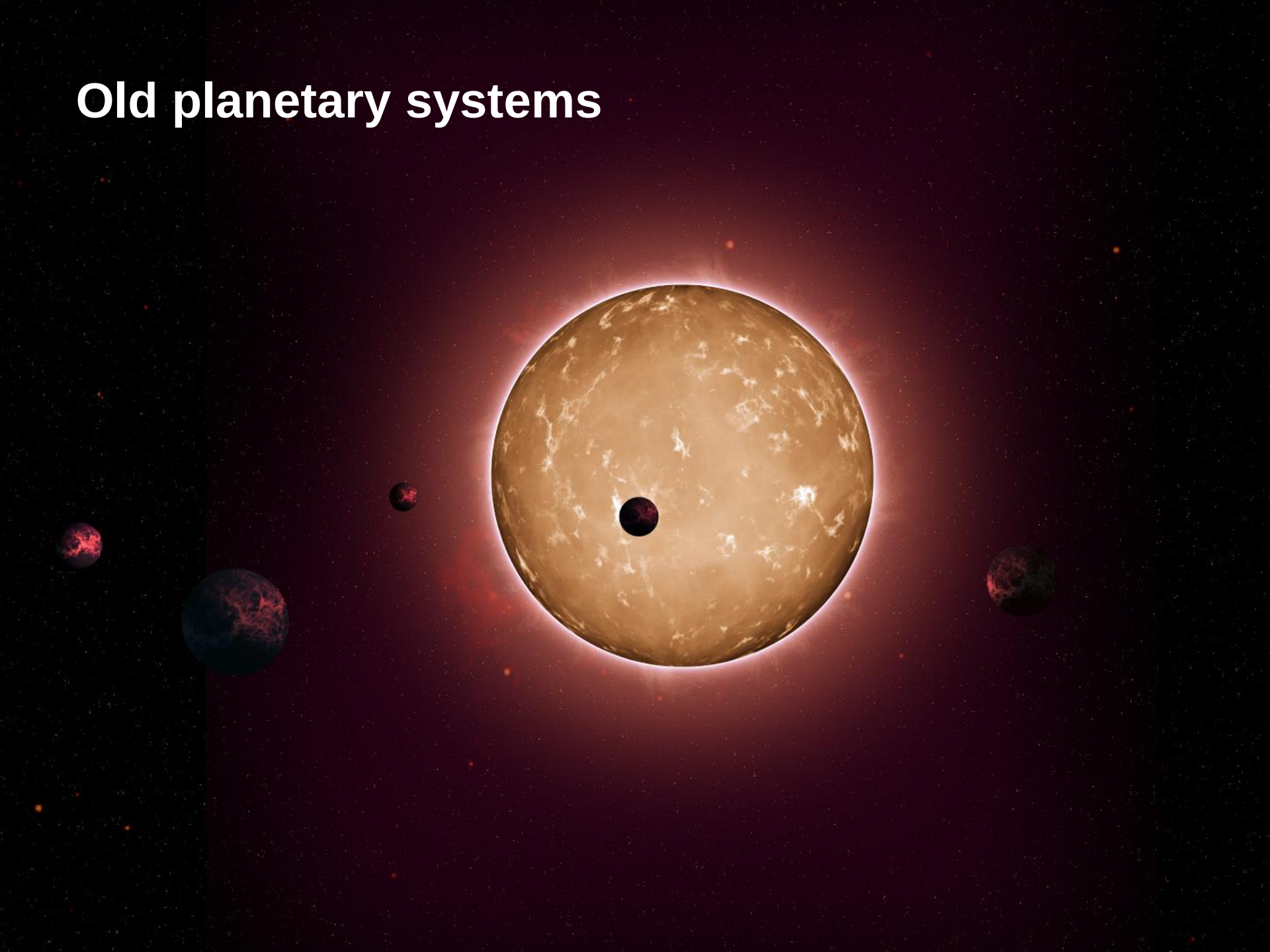


photo: 20th Century Fox/George Lucas

Water Worlds

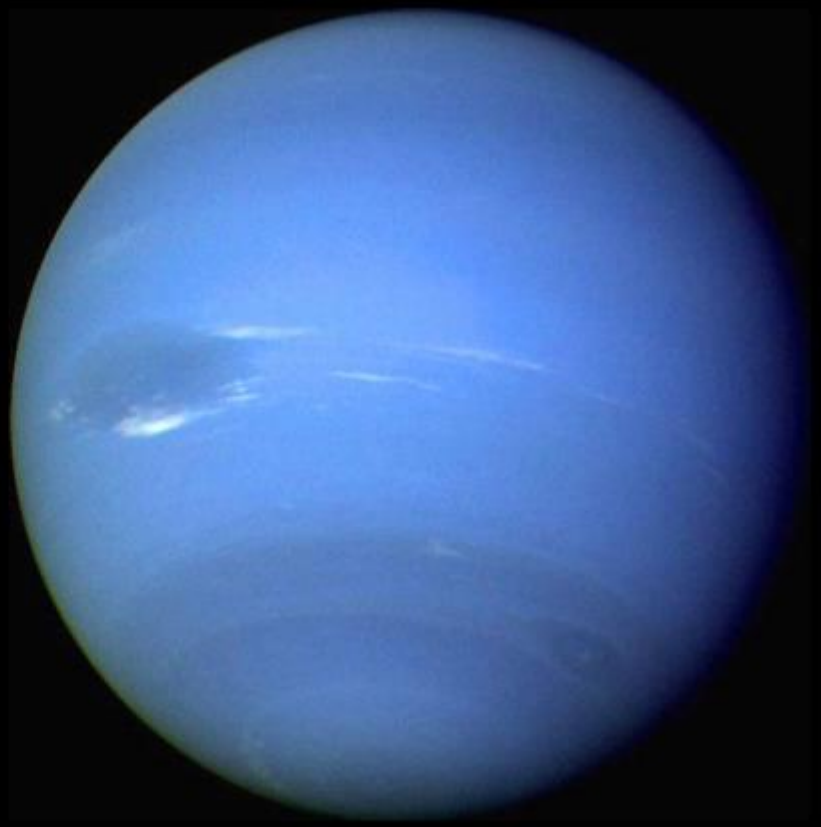


Old planetary systems



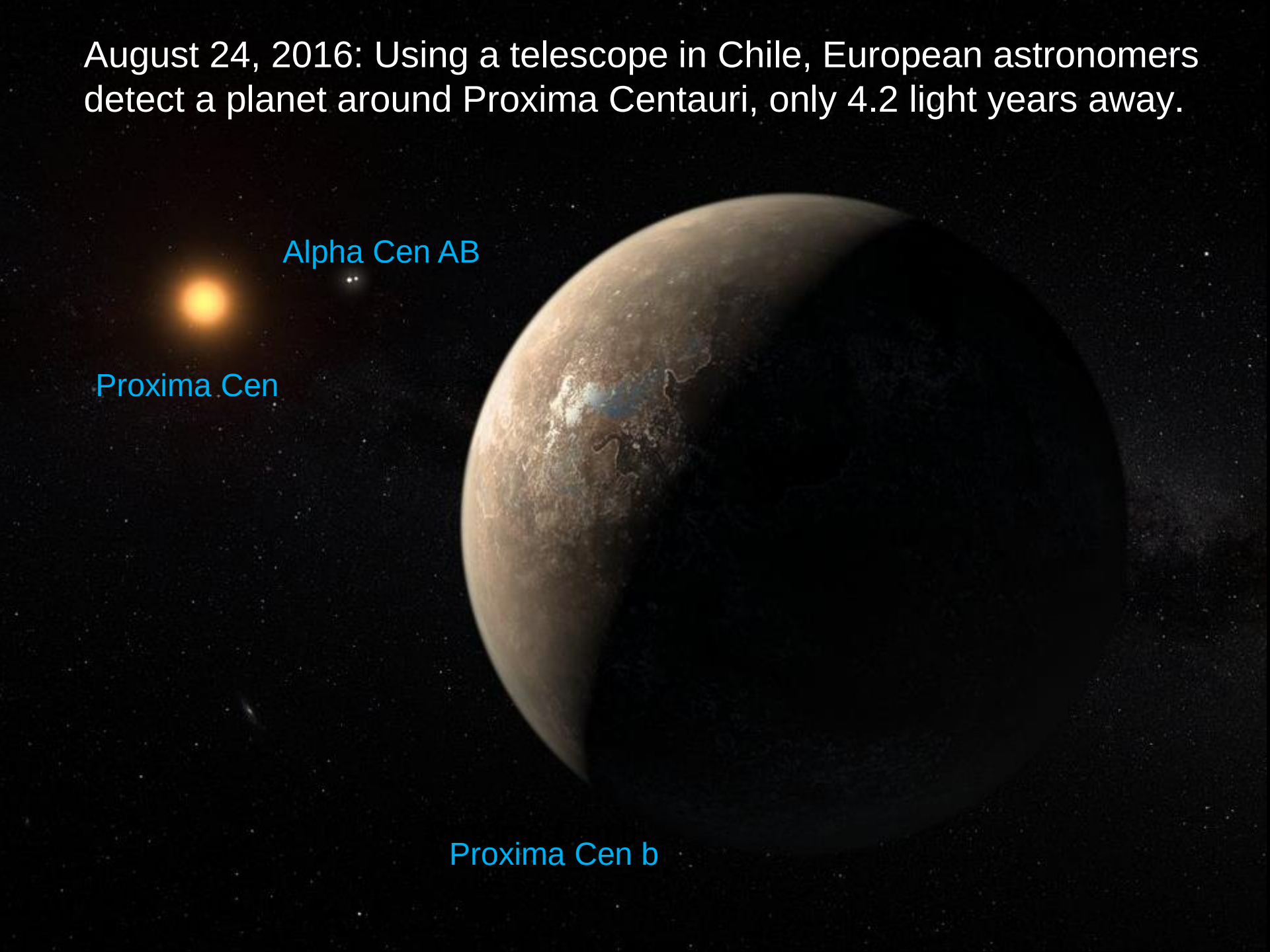
Nomad planets not bound to any star at all!

Earth



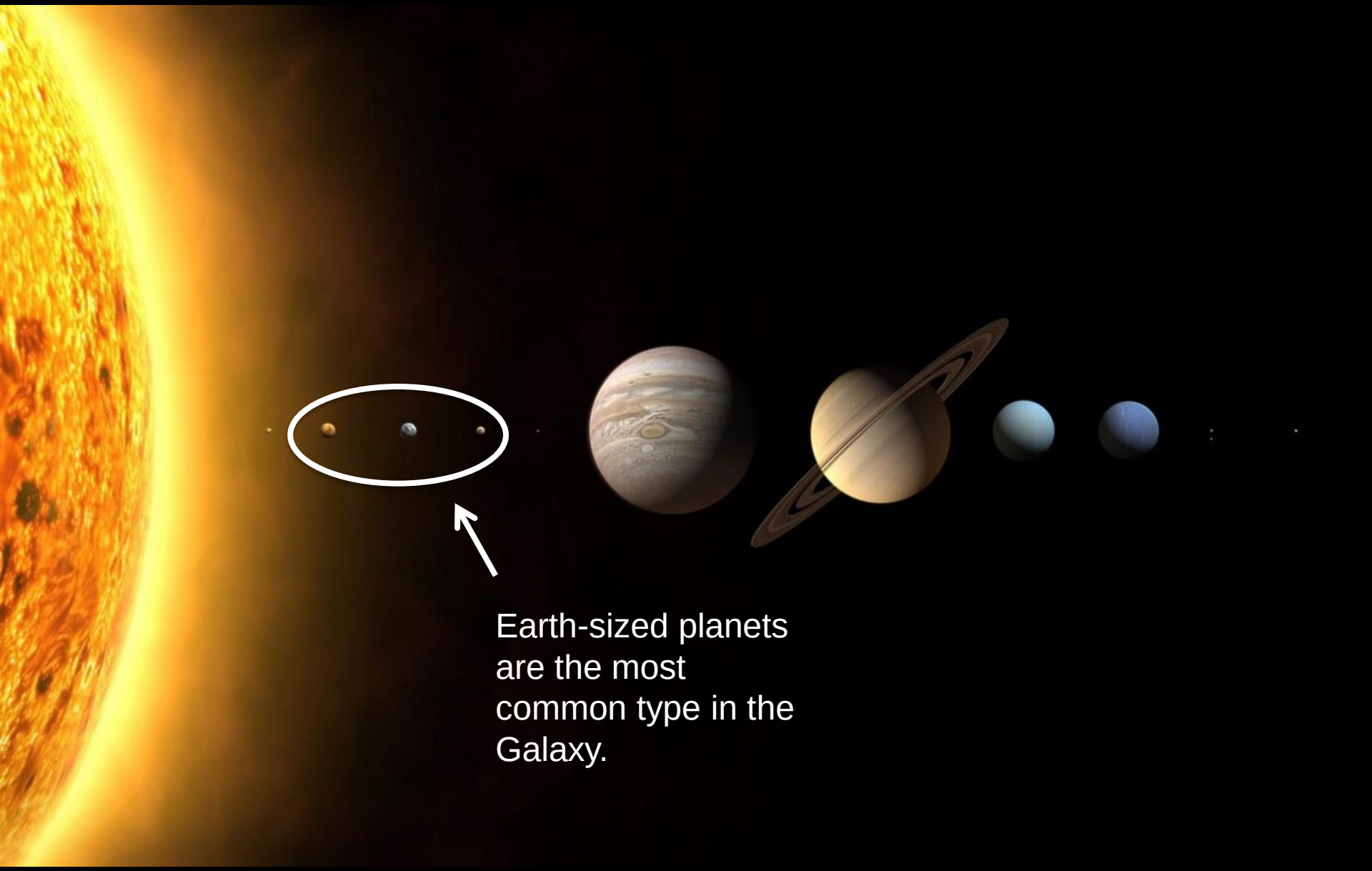
Neptune
3.9 Earth radii

August 24, 2016: Using a telescope in Chile, European astronomers detect a planet around Proxima Centauri, only 4.2 light years away.

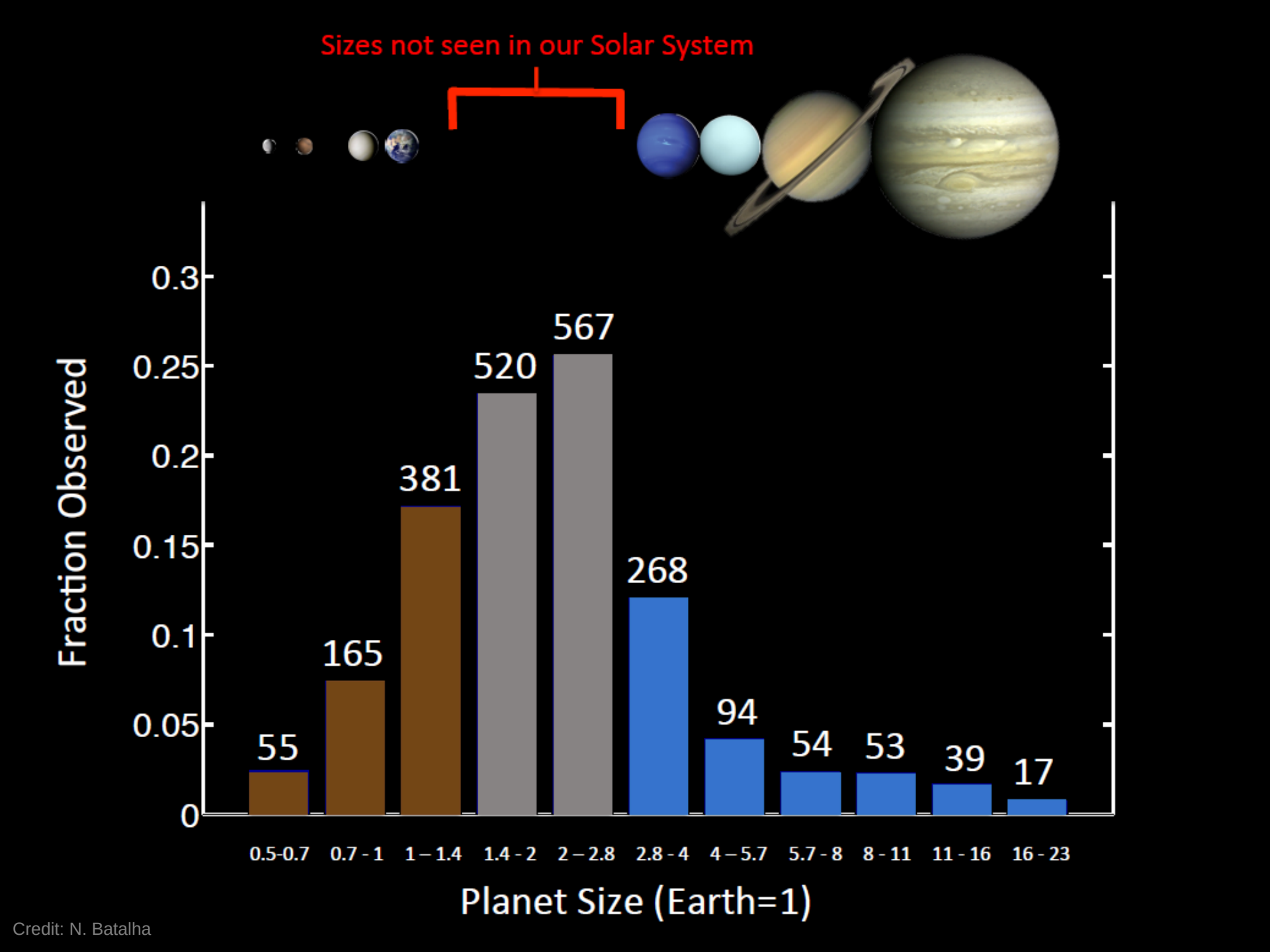


On average there is at least one planet for each of the stars in the night sky

(…and likely many more)



Credit: www.zastavki.com



Credit: N. Batalha

Earth-sized planets in the Habitable Zone are common

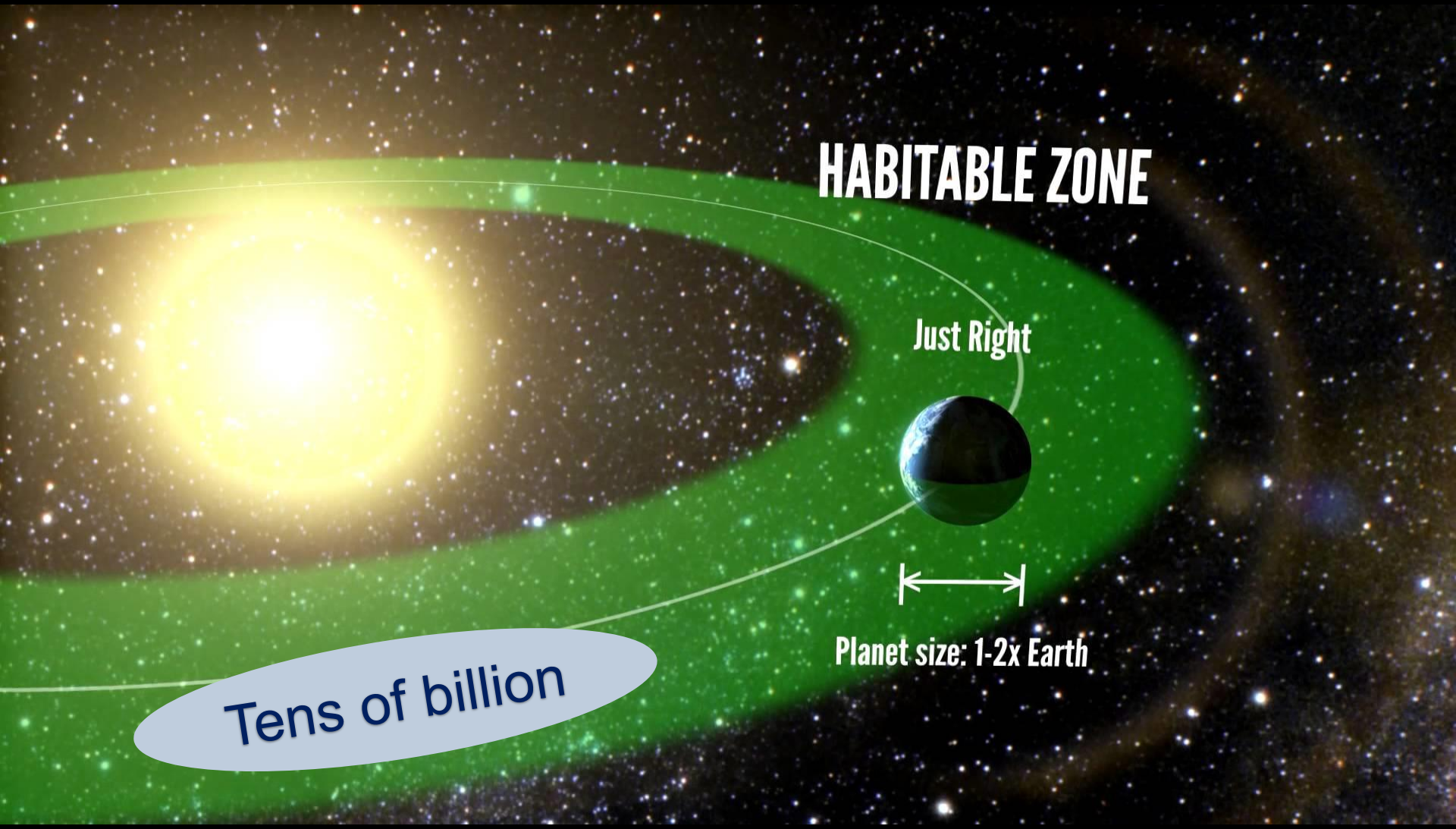


illustration: Petigura/UC Berkeley, Howard/UH-Manoa, Marcy/UC Berkeley

The Search for Life

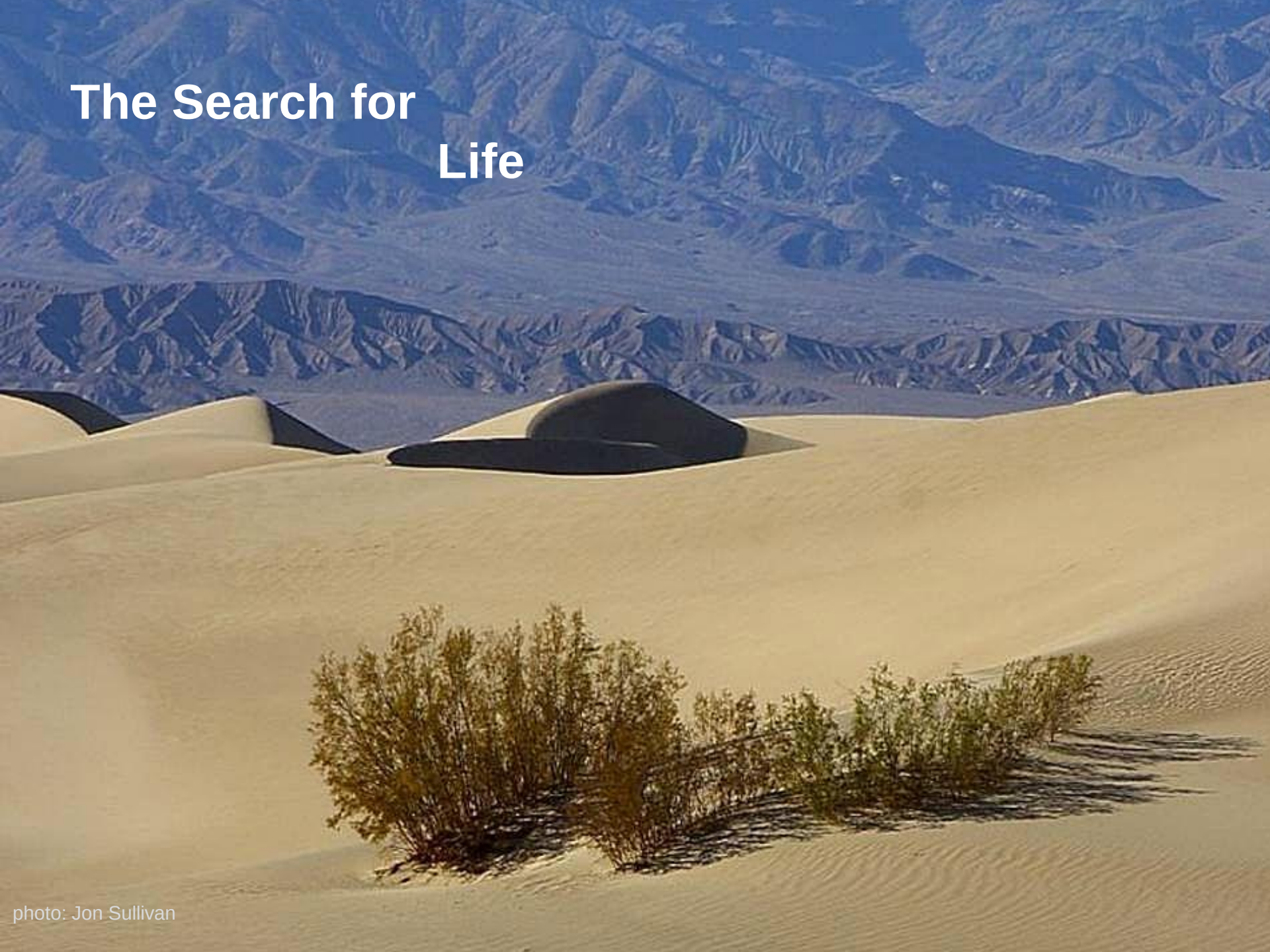
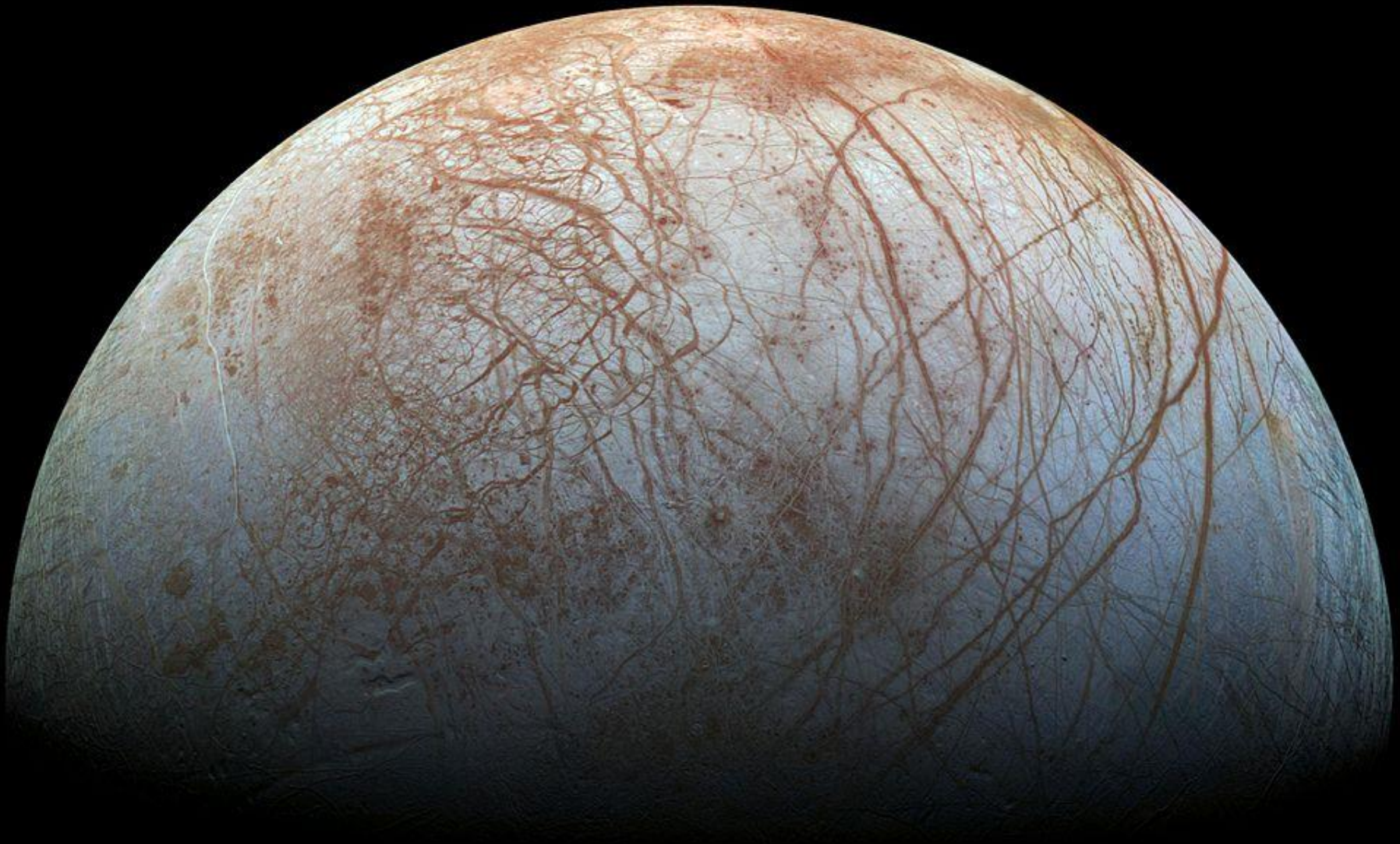


photo: Jon Sullivan

Approach #1
The Search for Life in our Solar System



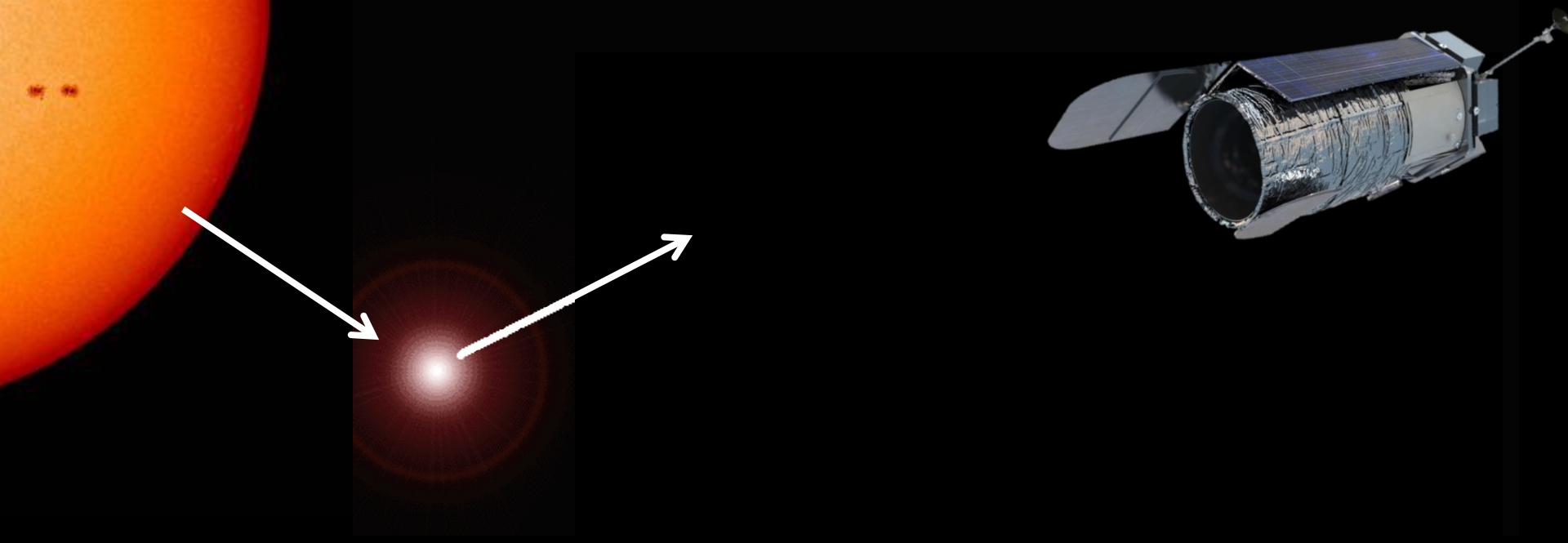
Approach #2
Listening and watching for signs of intelligent life

photo: SETI Institute

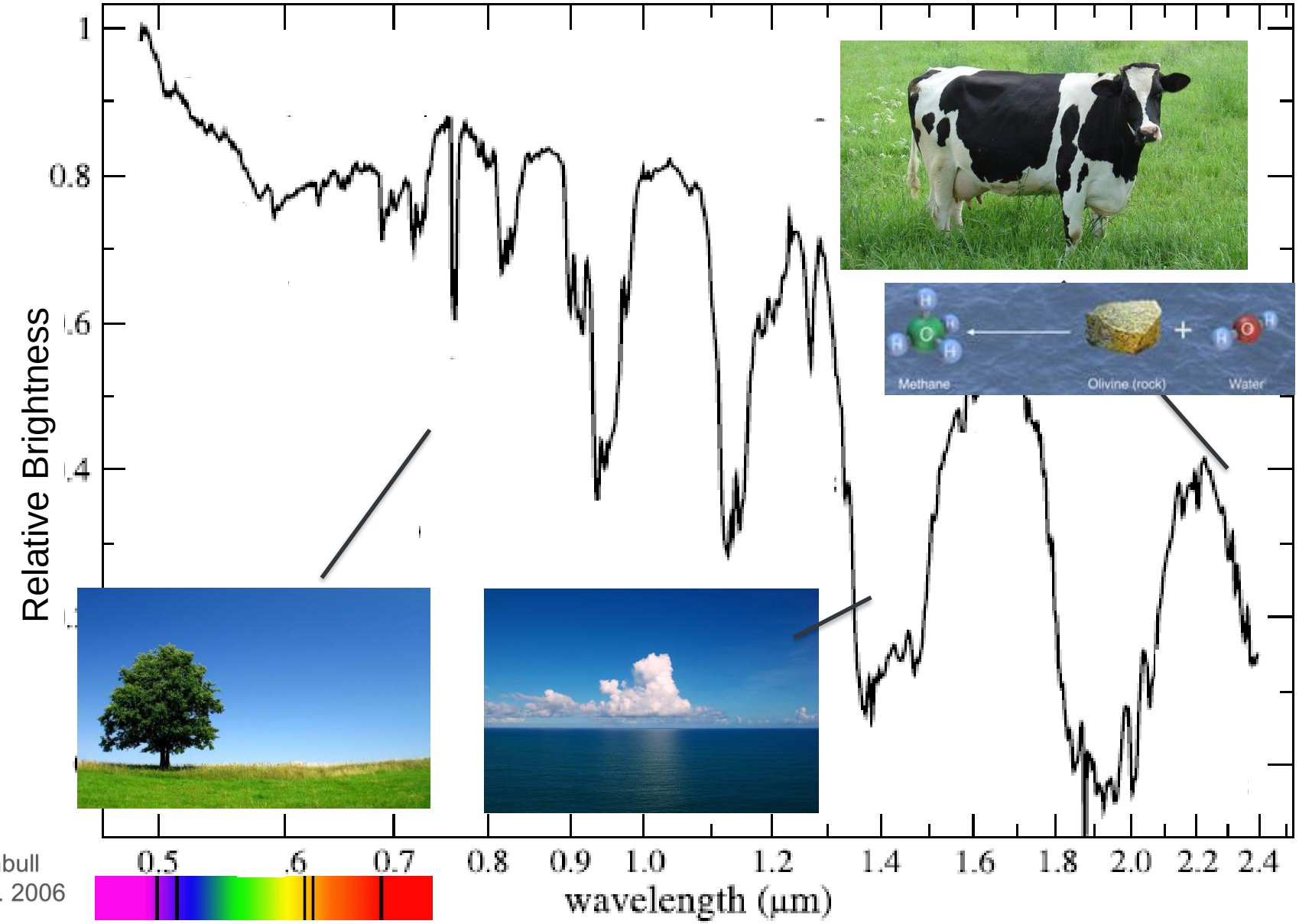
Approach #3:
Probing the atmospheres of exoplanets for biological signatures

photo: dbking

photo: ESO/Y. Beletsky (ESO)

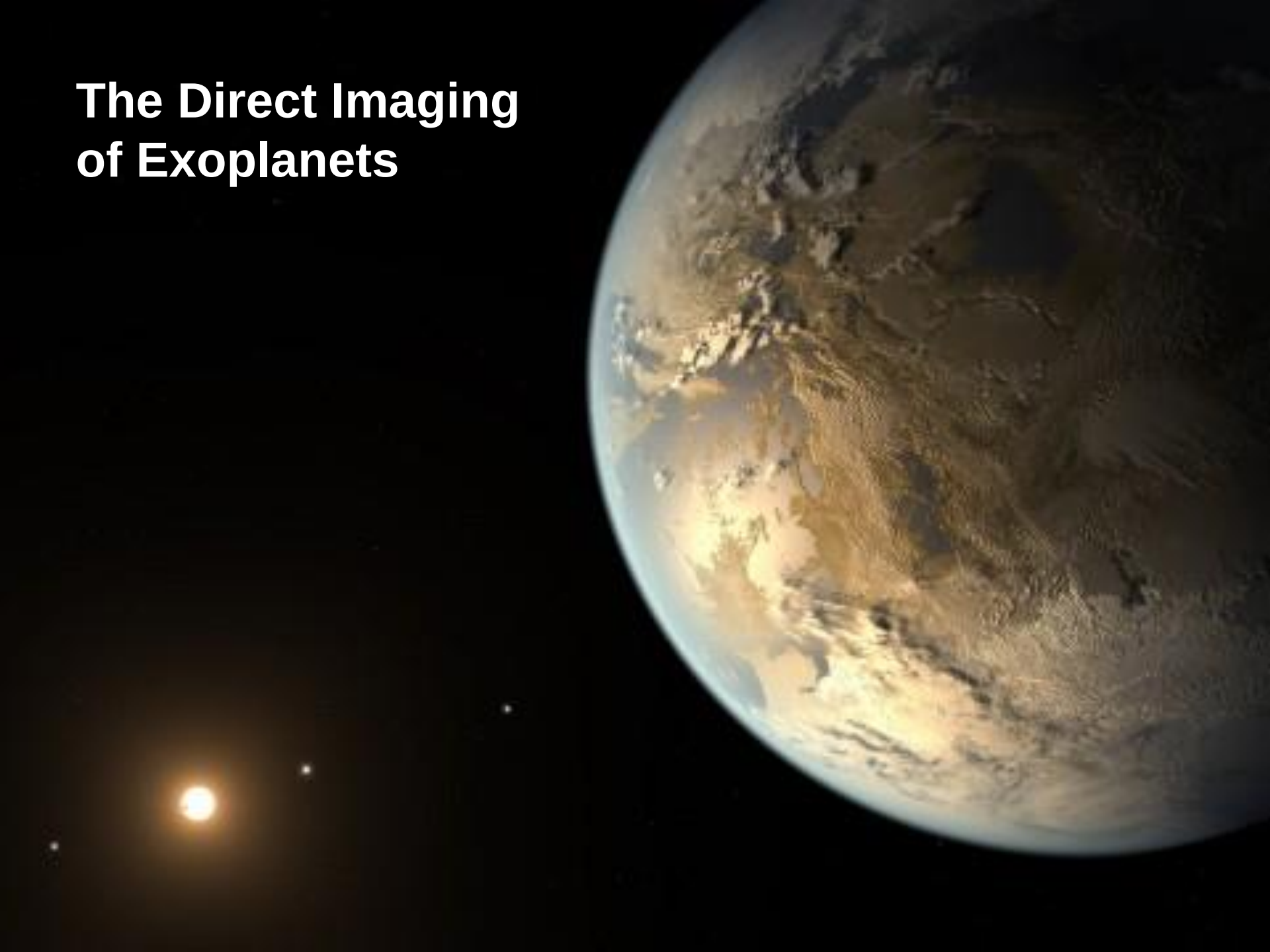


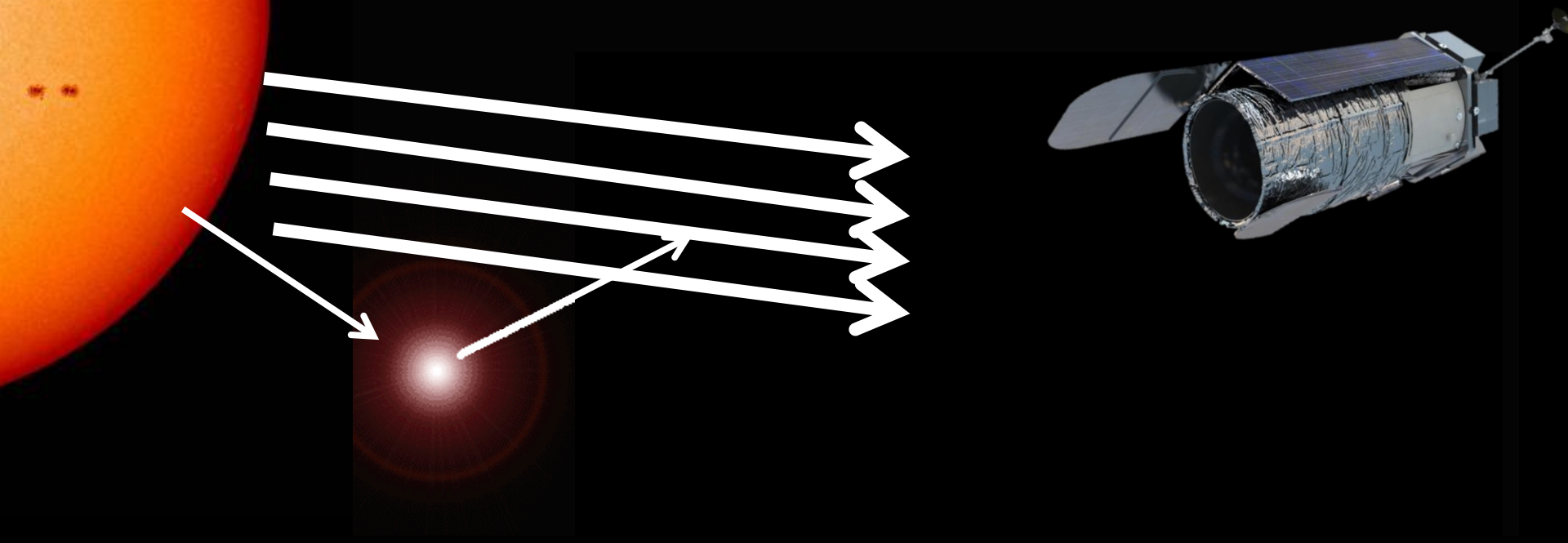
Detecting Life on an Exoplanet

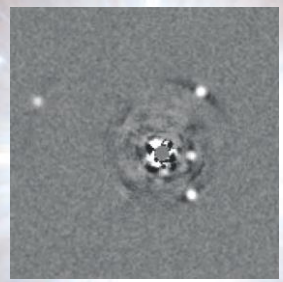


Turnbull
et al. 2006

The Direct Imaging of Exoplanets





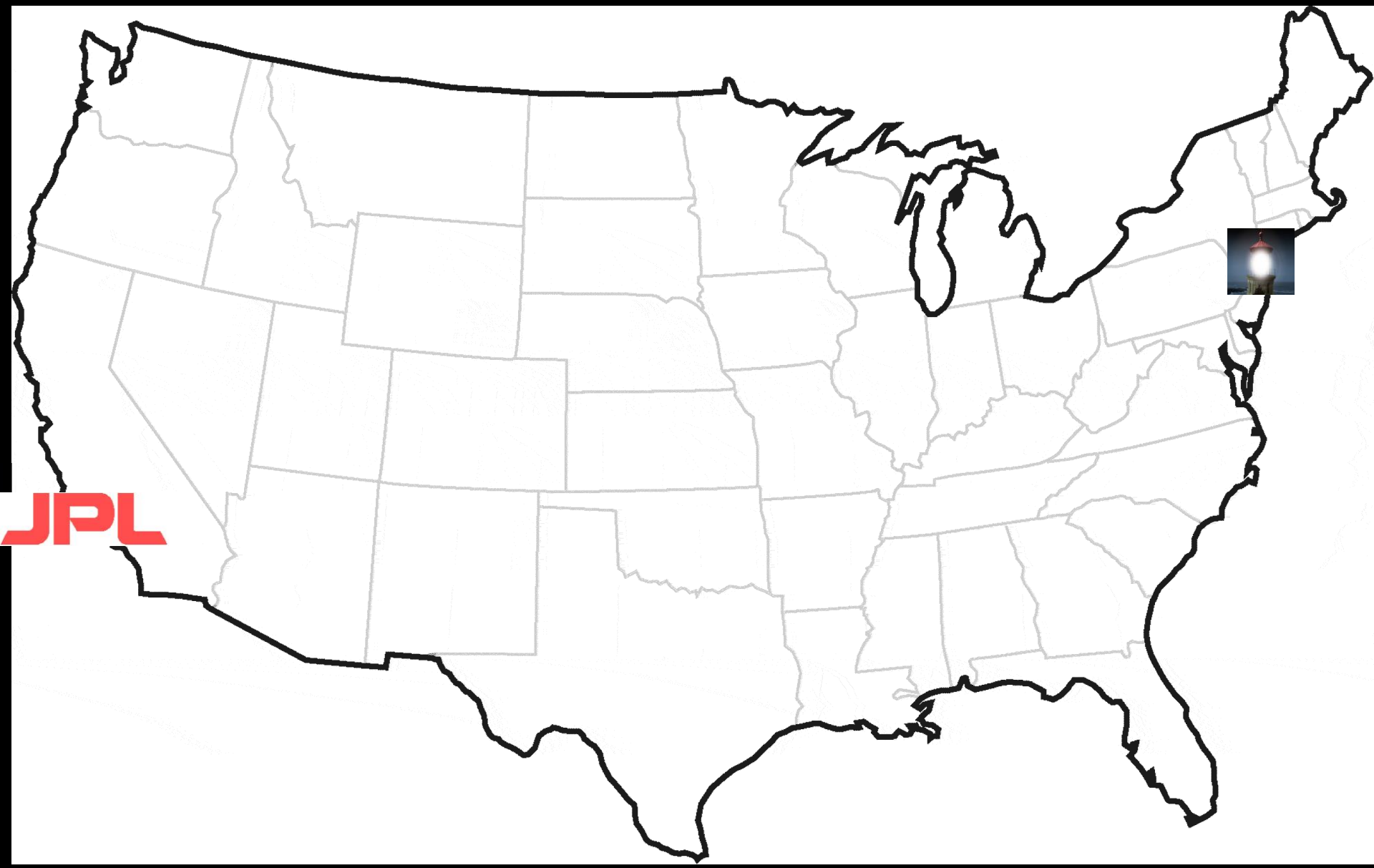


An Earth-size planet in the habitable zone of a Sun-like star is very faint

- 10 billion times fainter!

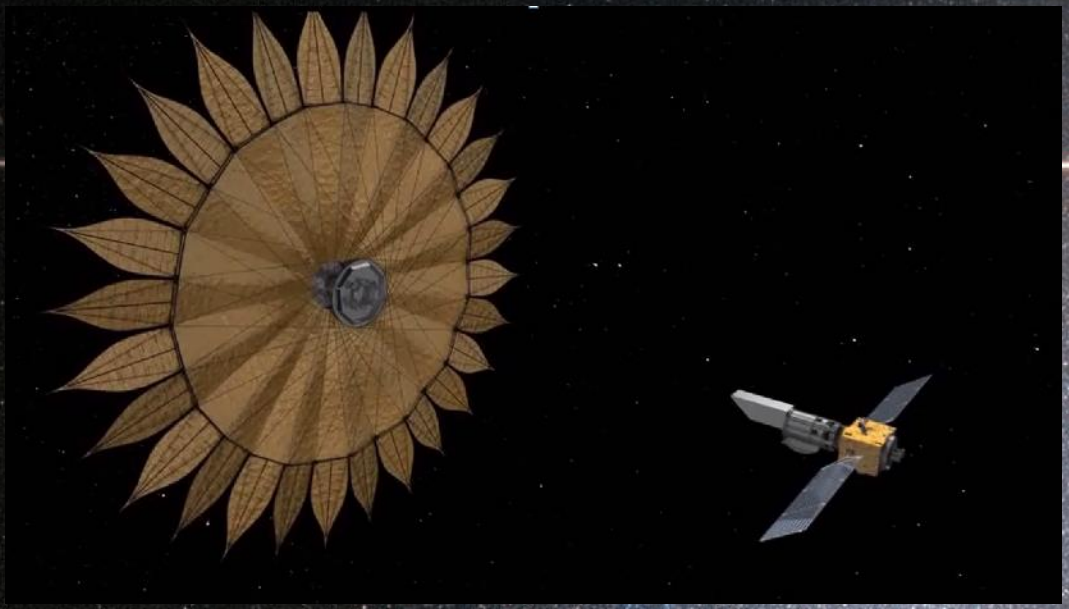
Marois et al. 2010

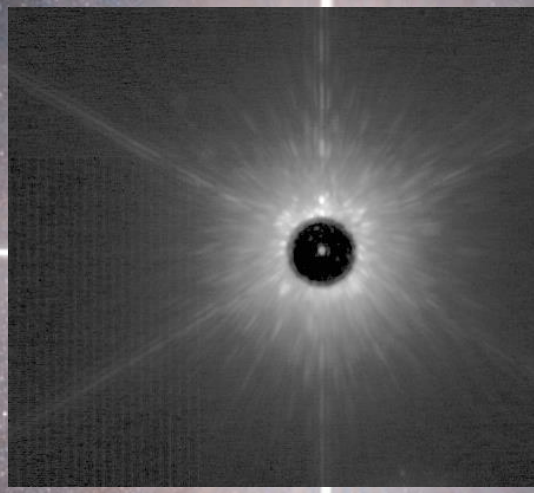
firefly


JPL

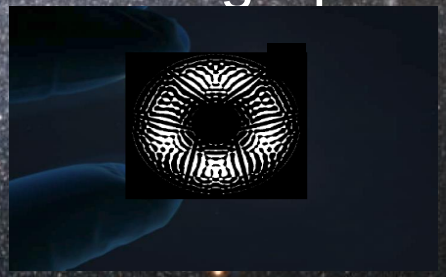
Two Direct Planet Imaging Techniques

Starshade

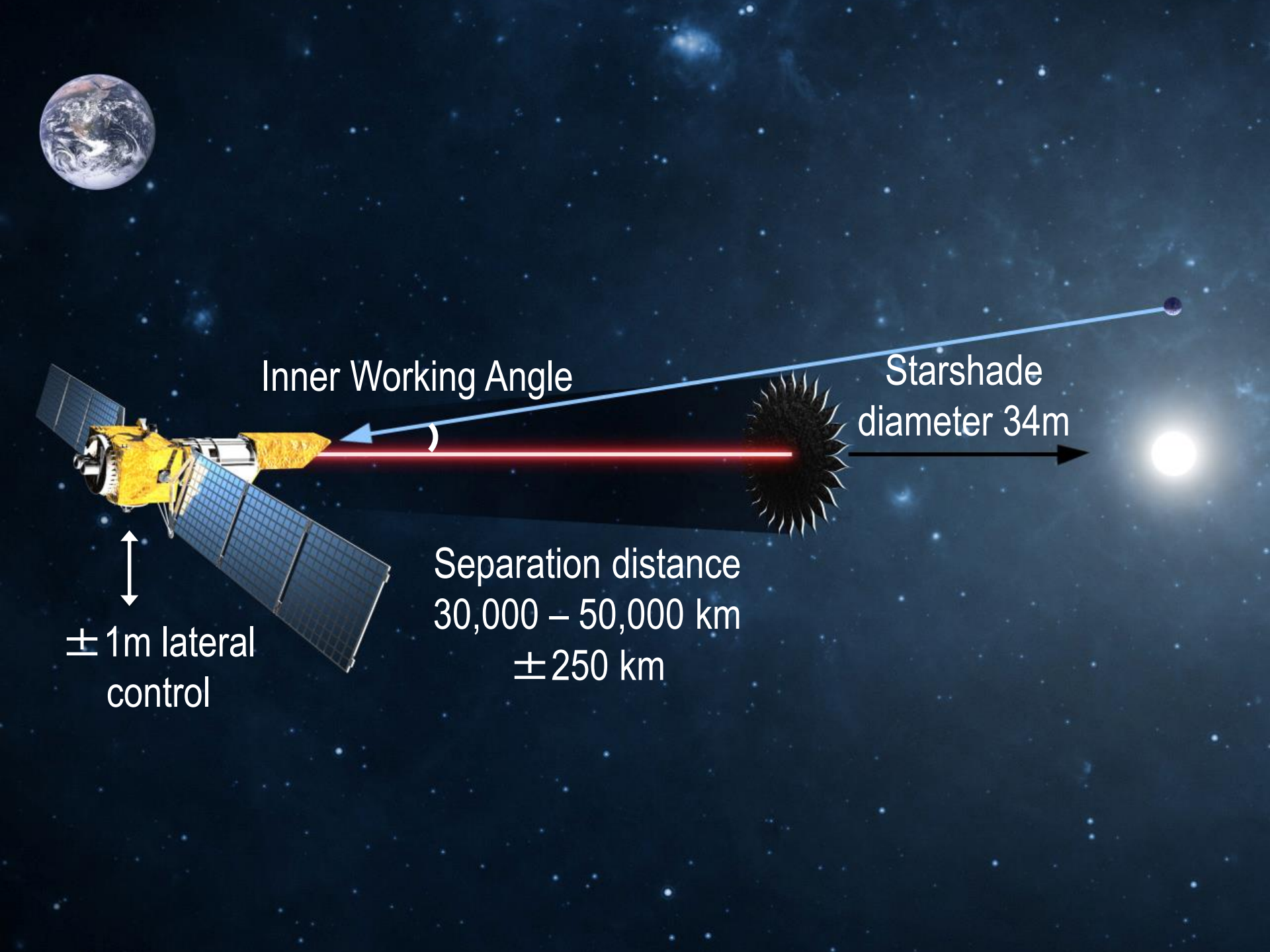




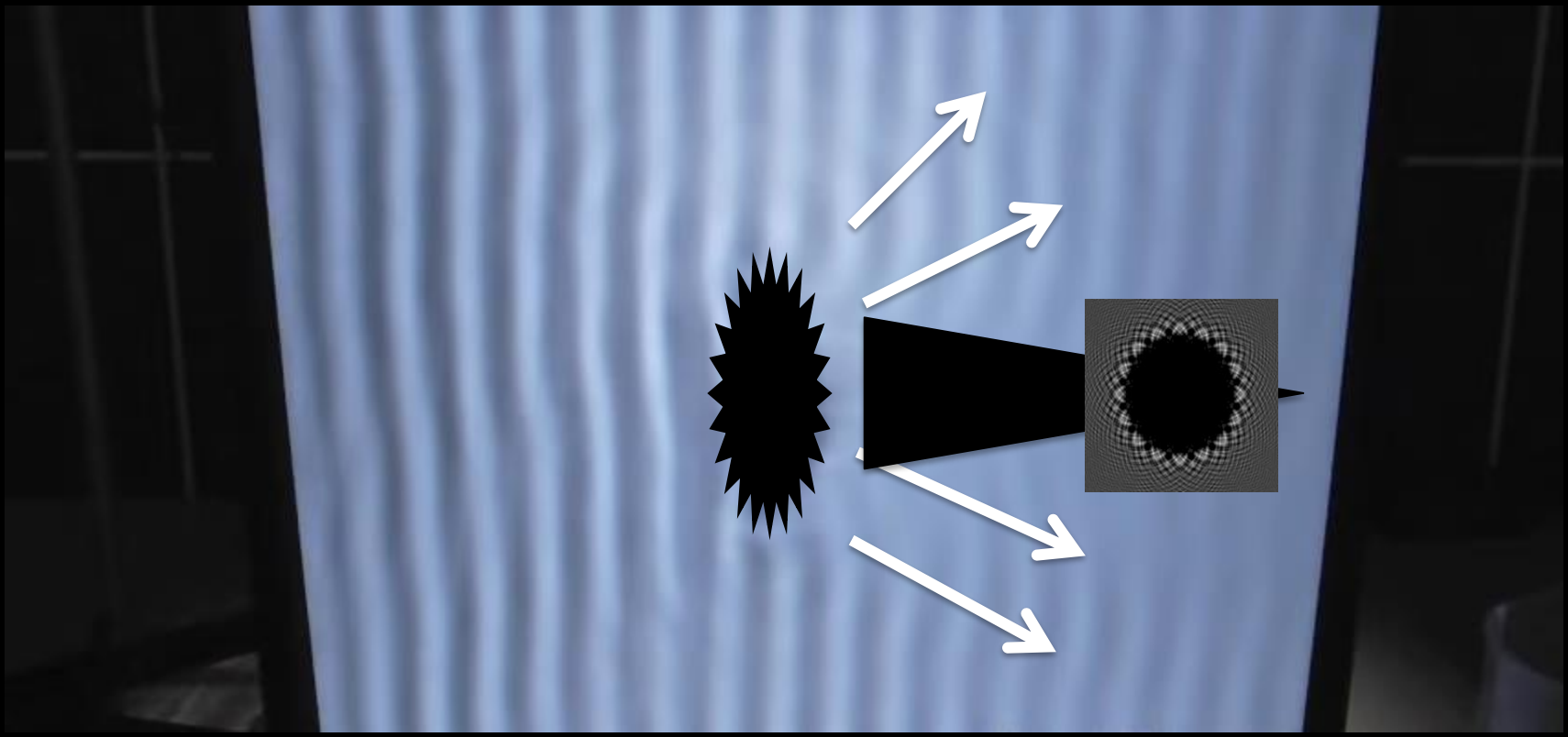
Coronagraph



video: PBS/ Carl Sagan

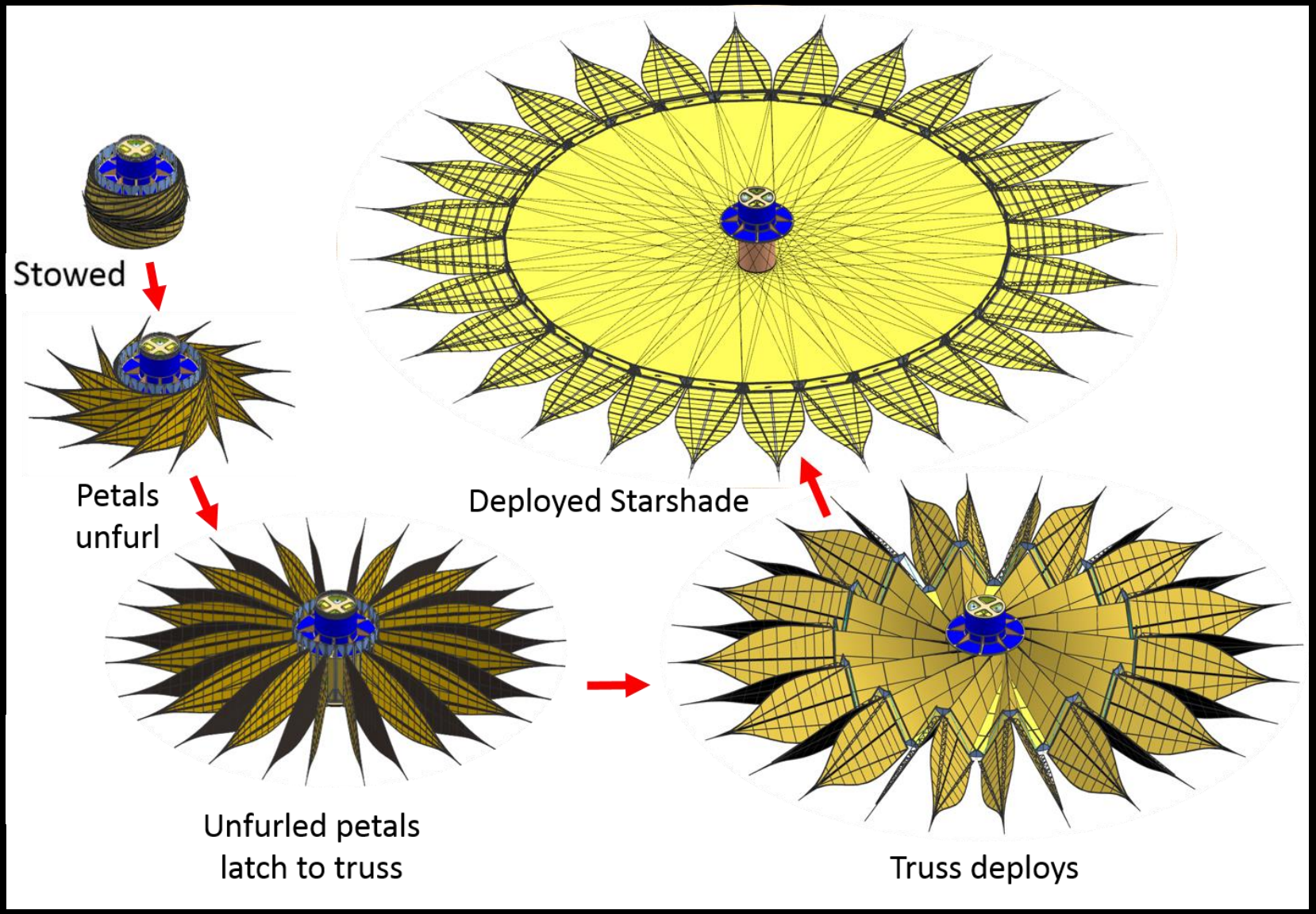

Inner Working Angle
Starshade
diameter 34m
Separation distance
30,000 – 50,000 km
±250 km
±1m lateral
control

animation: St. Mary’s University, Halifax, Canada



credit: St. Mary's University, Halifax, Canada

Two-Stage Starshade Deployment



Early Inner Disk Deployment Trials at JPL

2 meter Optical Shield Prototype

5 meter Optical Shield Prototype

Optical Demonstration

photo: Northrop Grumman Aerospace Systems

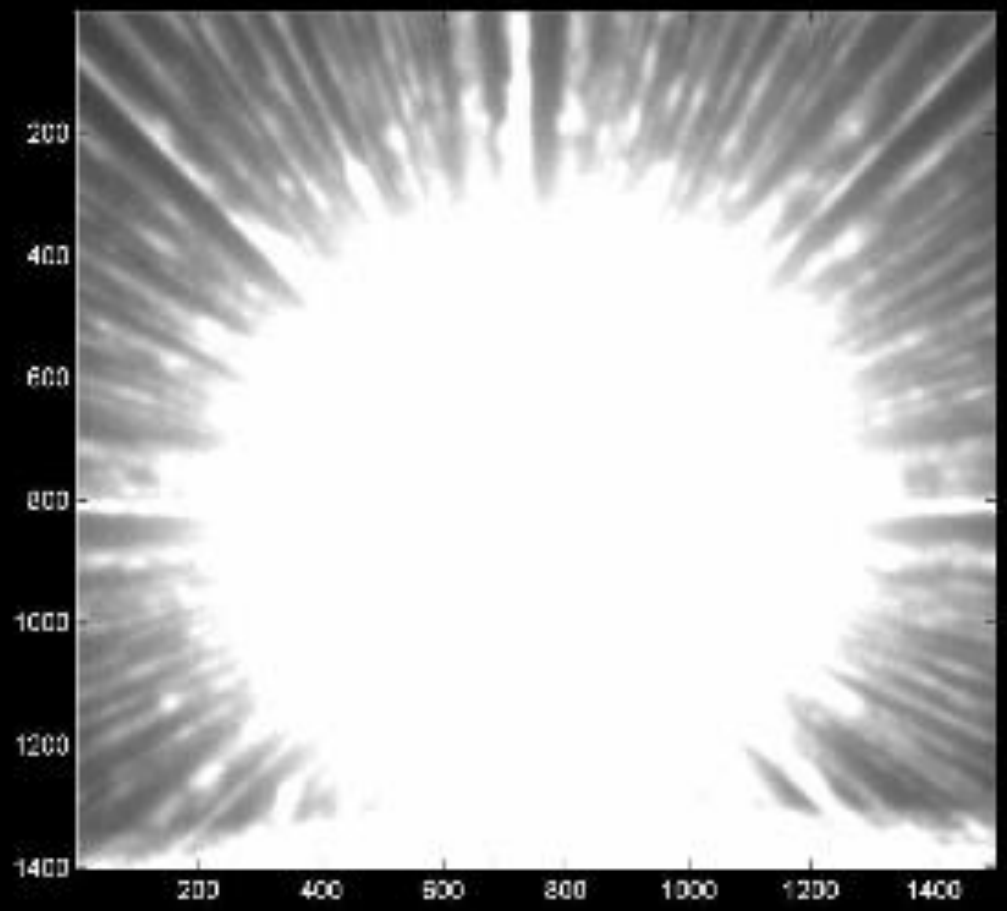


photo: Northrop Grumman Aerospace Systems

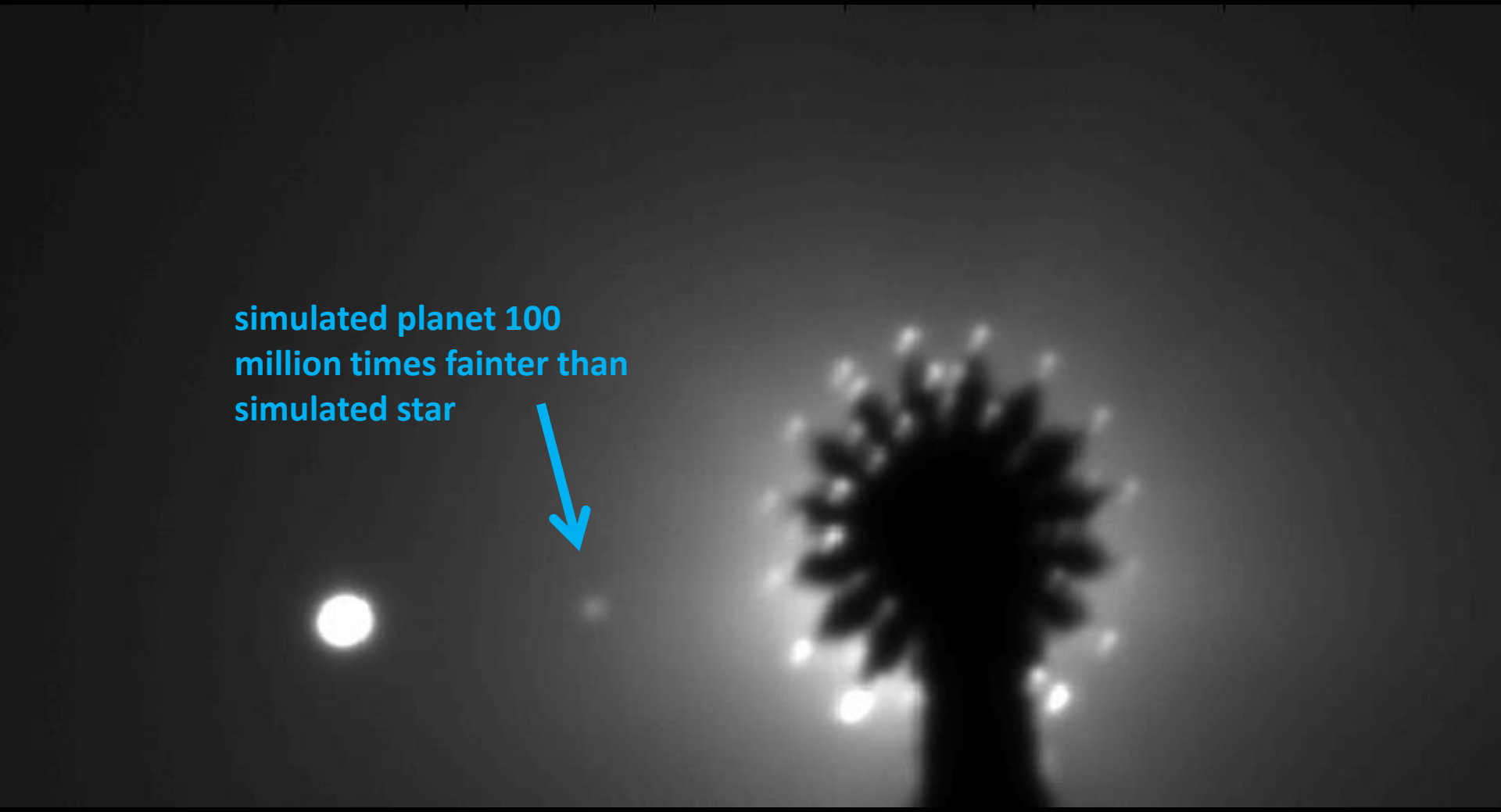


photo: Northrop Grumman Aerospace Systems

From the very large to the very small…

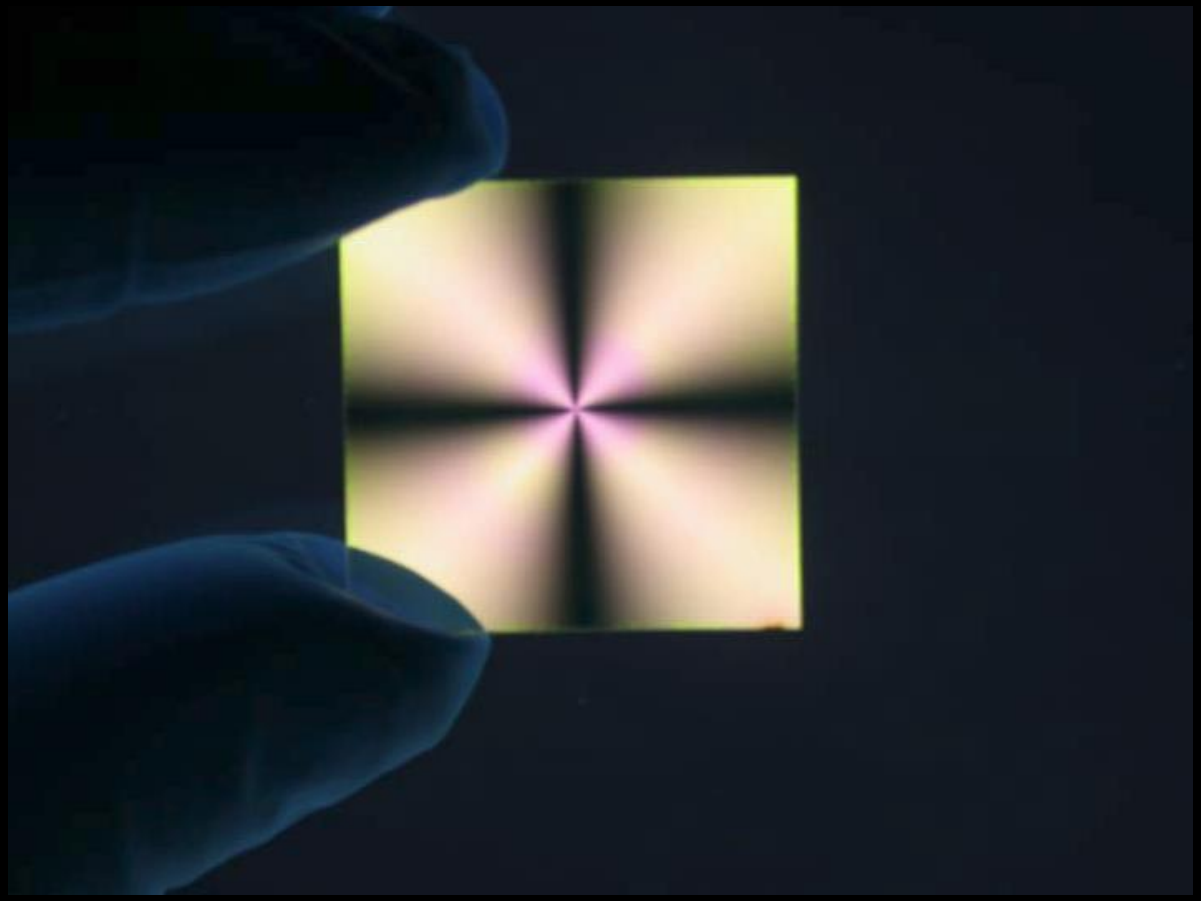


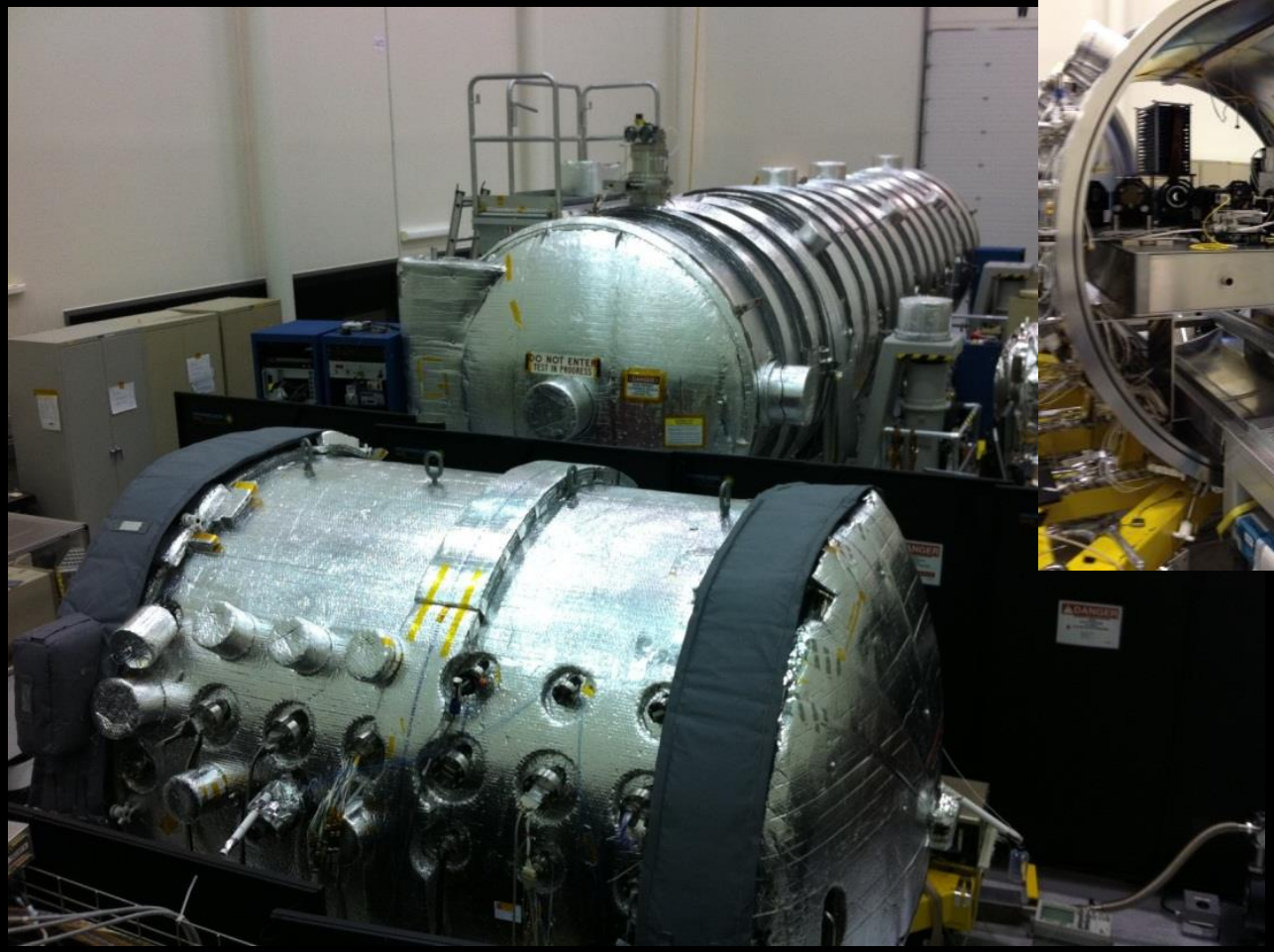
photo: Gene Serabyn/JPL

Bernard Lyot

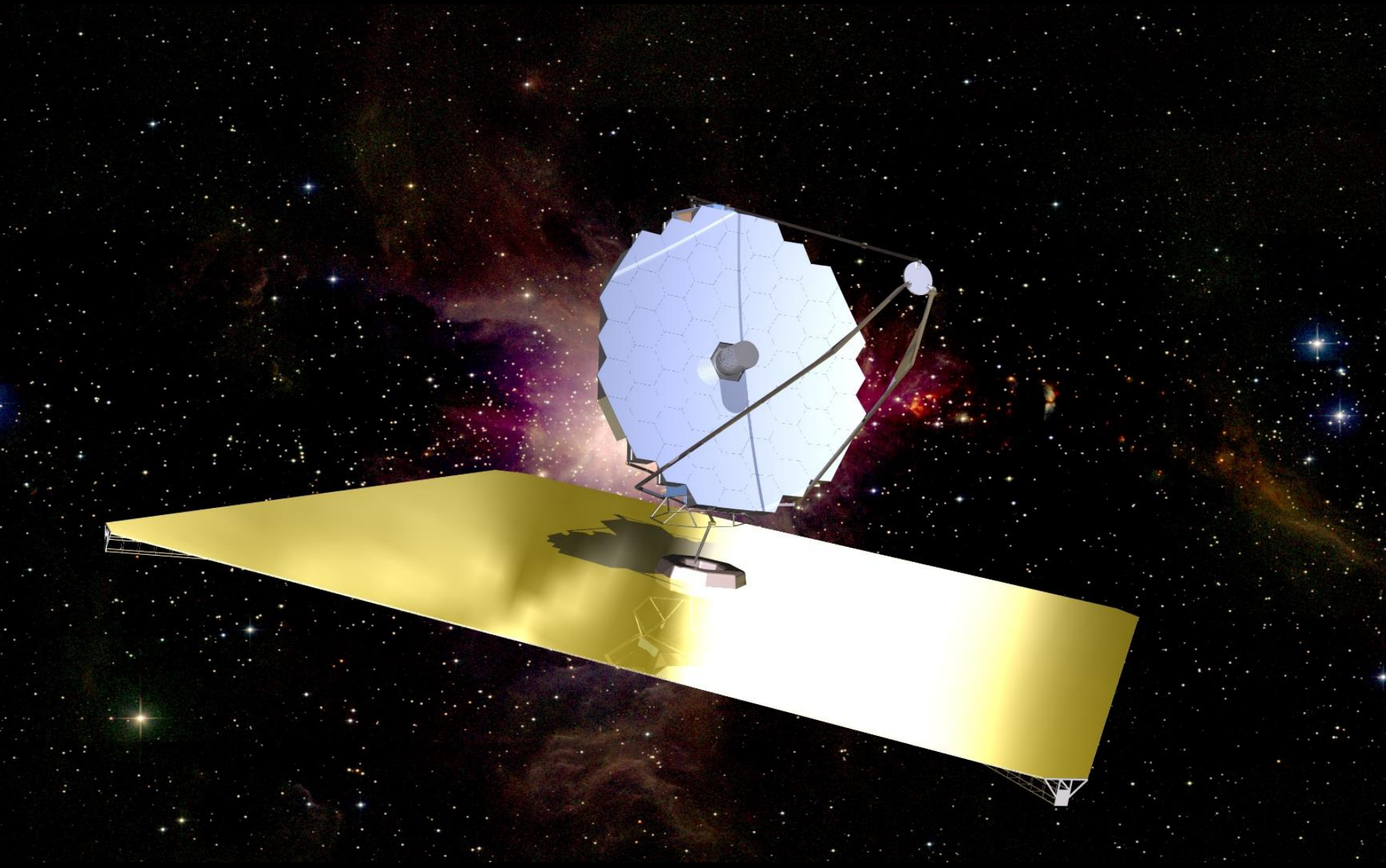
The corona of the Sun

photo: American Museum of Natural History

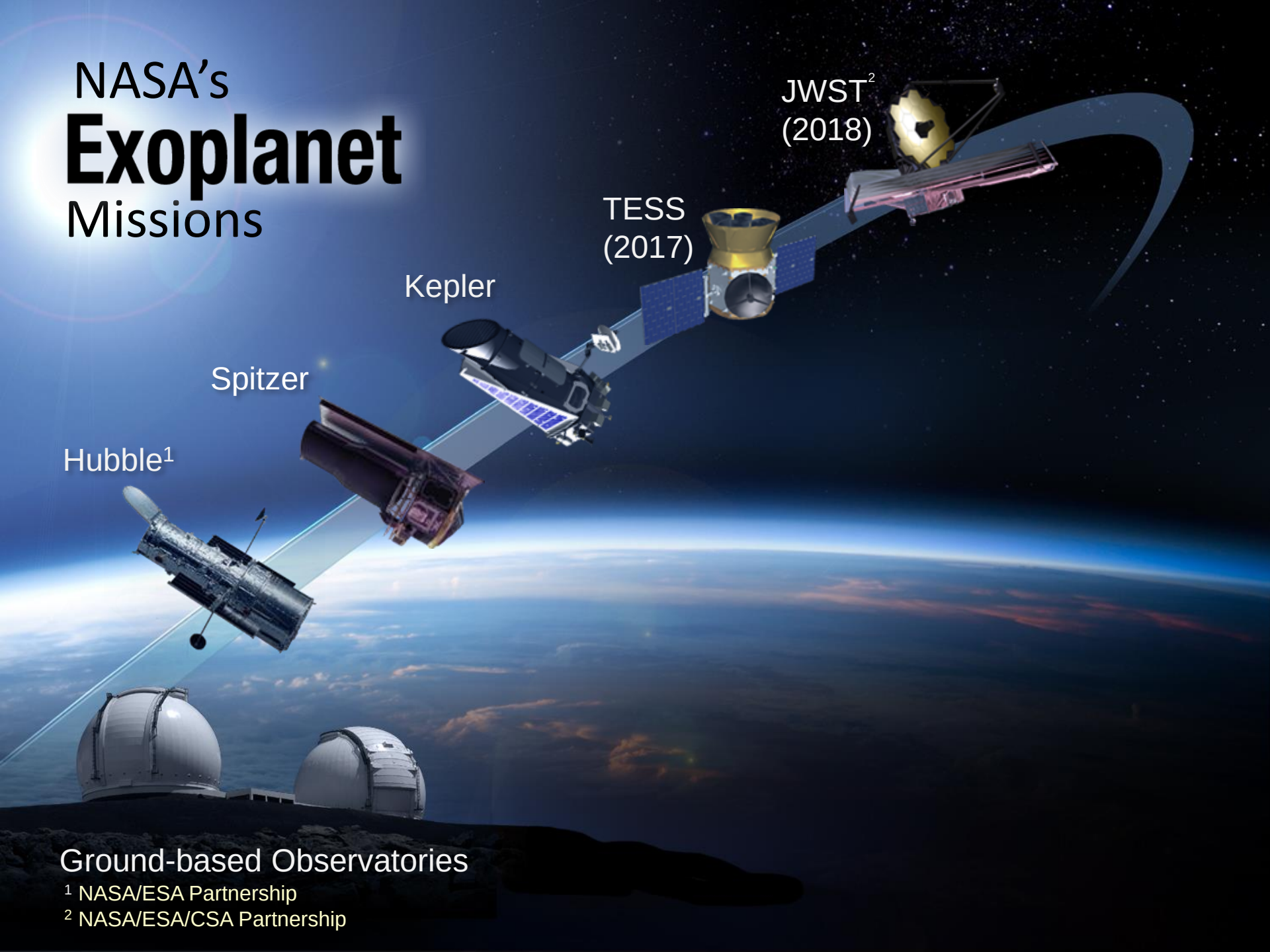
Coronagraph Testbeds at JPL



Future Missions



NASA's Exoplanet Missions



[1] NASA/ESA Partnership
[2] NASA/ESA/CSA Partnership

Transit Spectroscopy

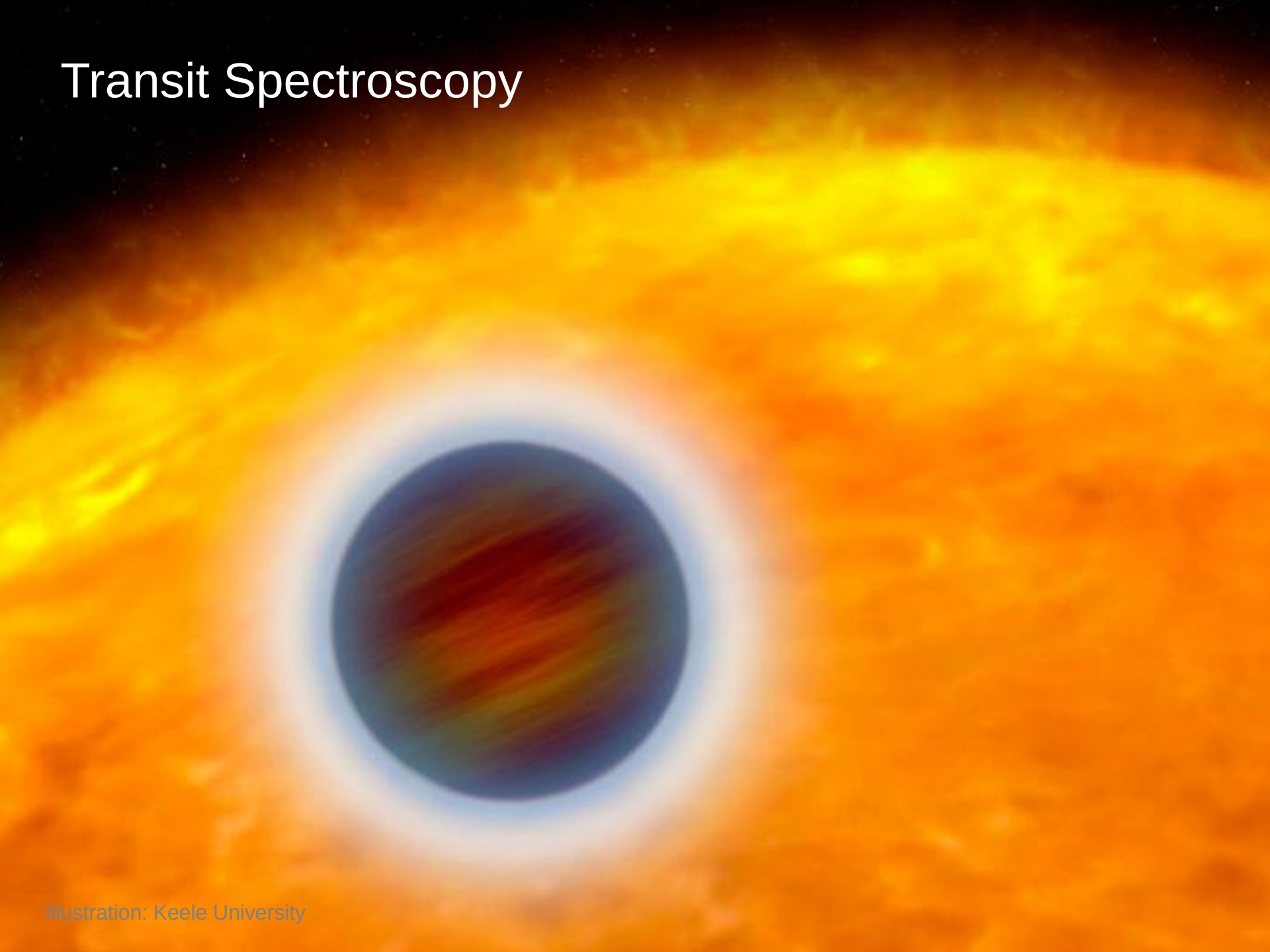
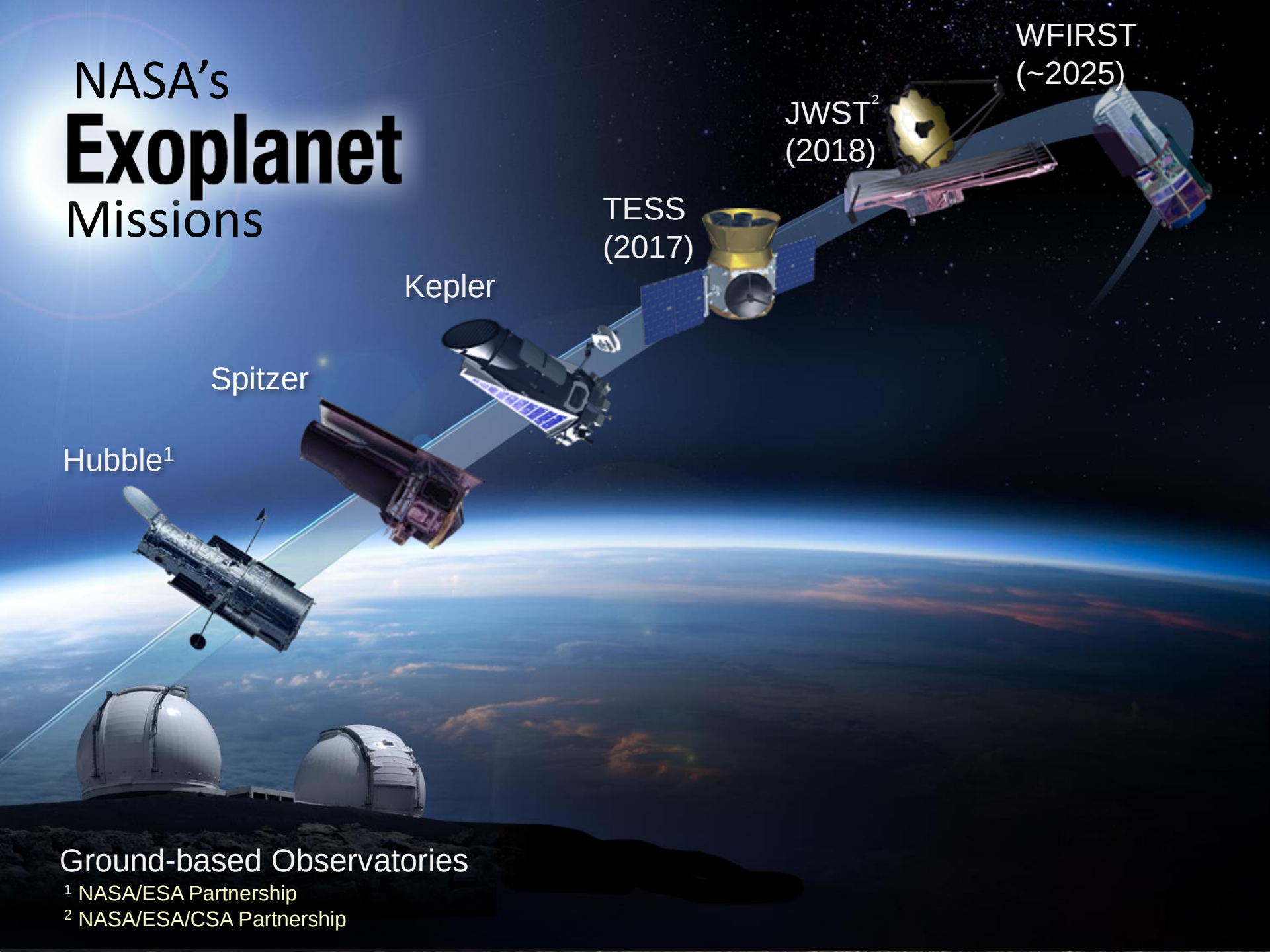
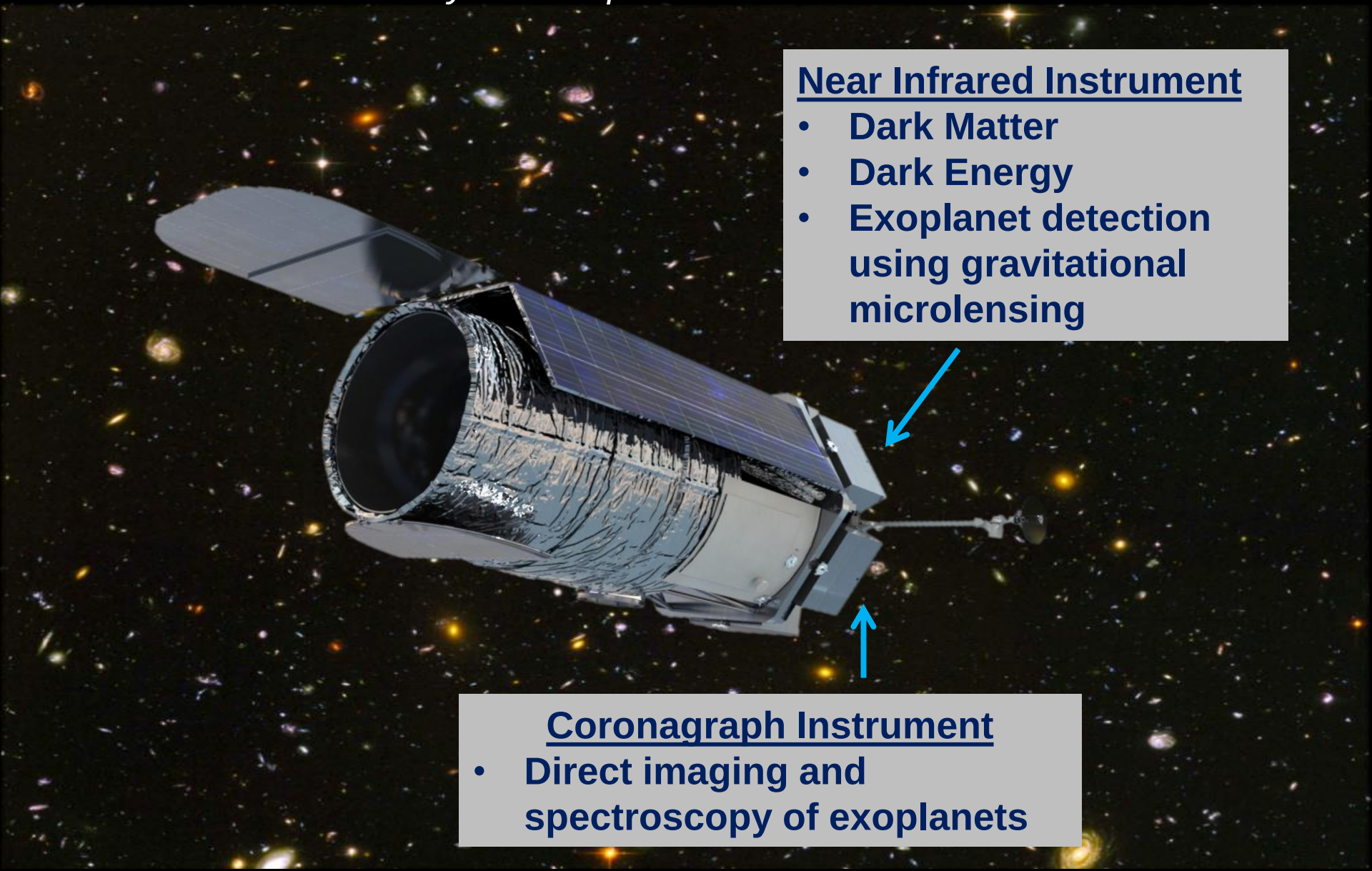


Illustration: Keele University


NASA's
Exoplanet
Missions
WFIRST
(~2025)
JWST[2]
(2018)
TESS
(2017)
Kepler
Spitzer
Hubble[1]
Ground-based Observatories
[1] NASA/ESA Partnership
[2] NASA/ESA/CSA Partnership

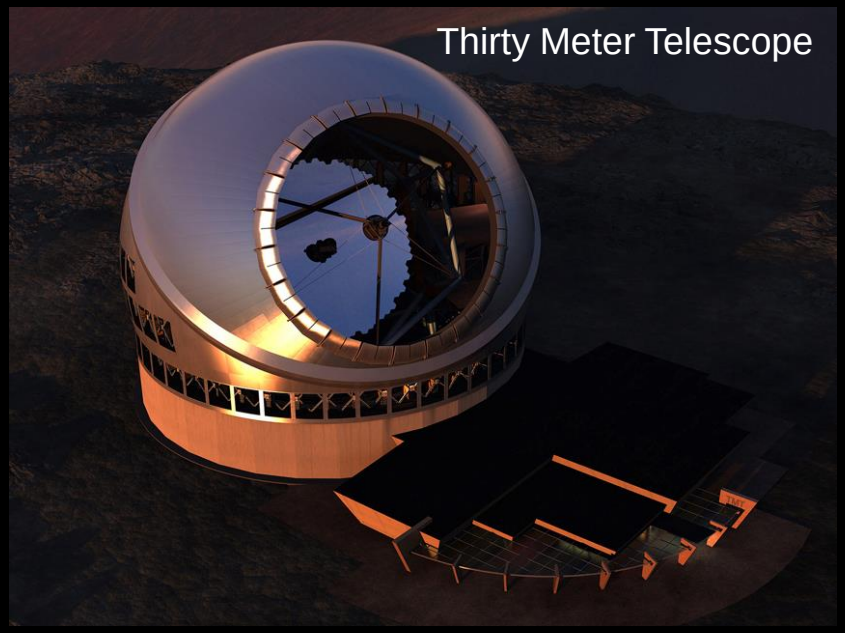
WFIRST

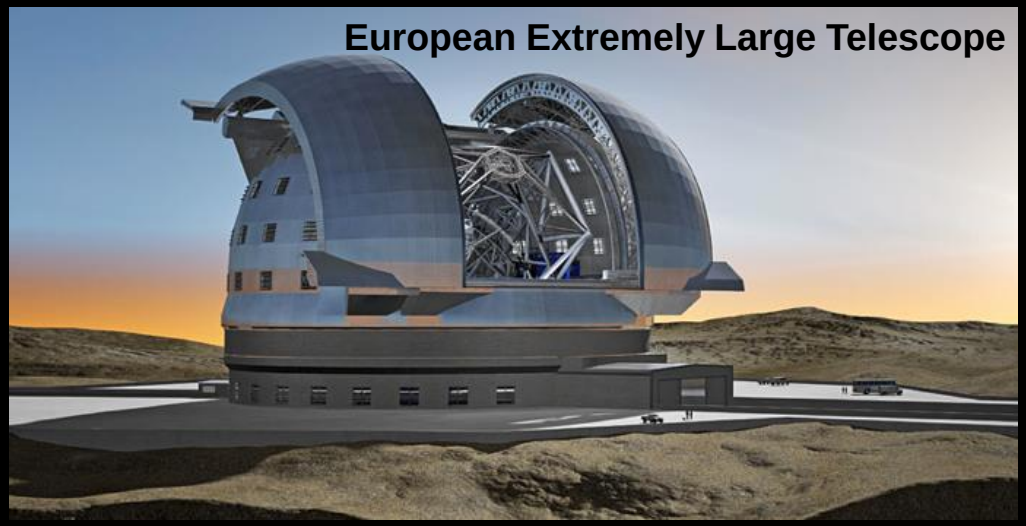
Wide-Field Infrared Survey Telescope



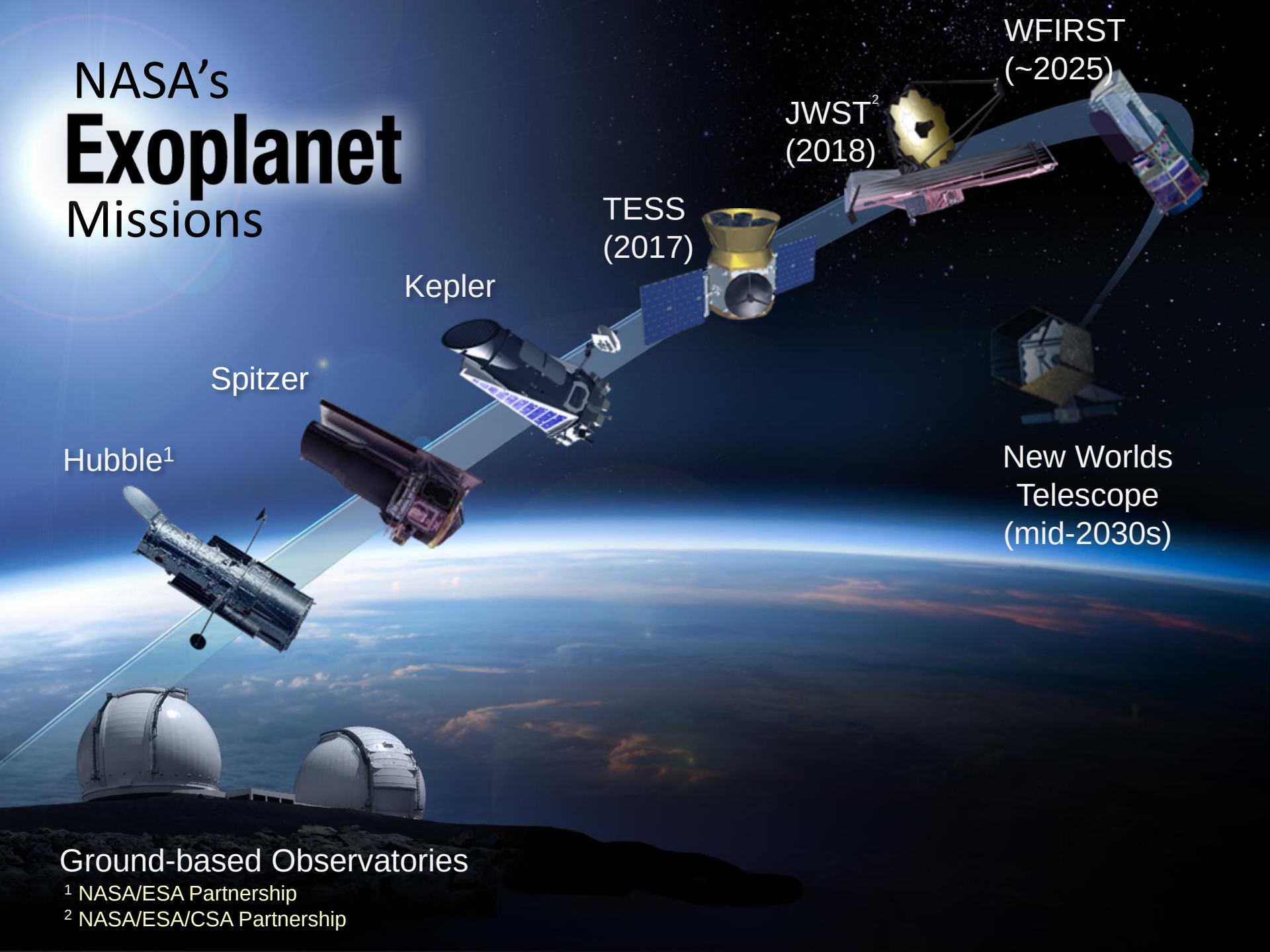
New Ground-Based Extremely Large Telescopes

24 – 40 meters in diameter, 2020's





NASA's Exoplanet Missions

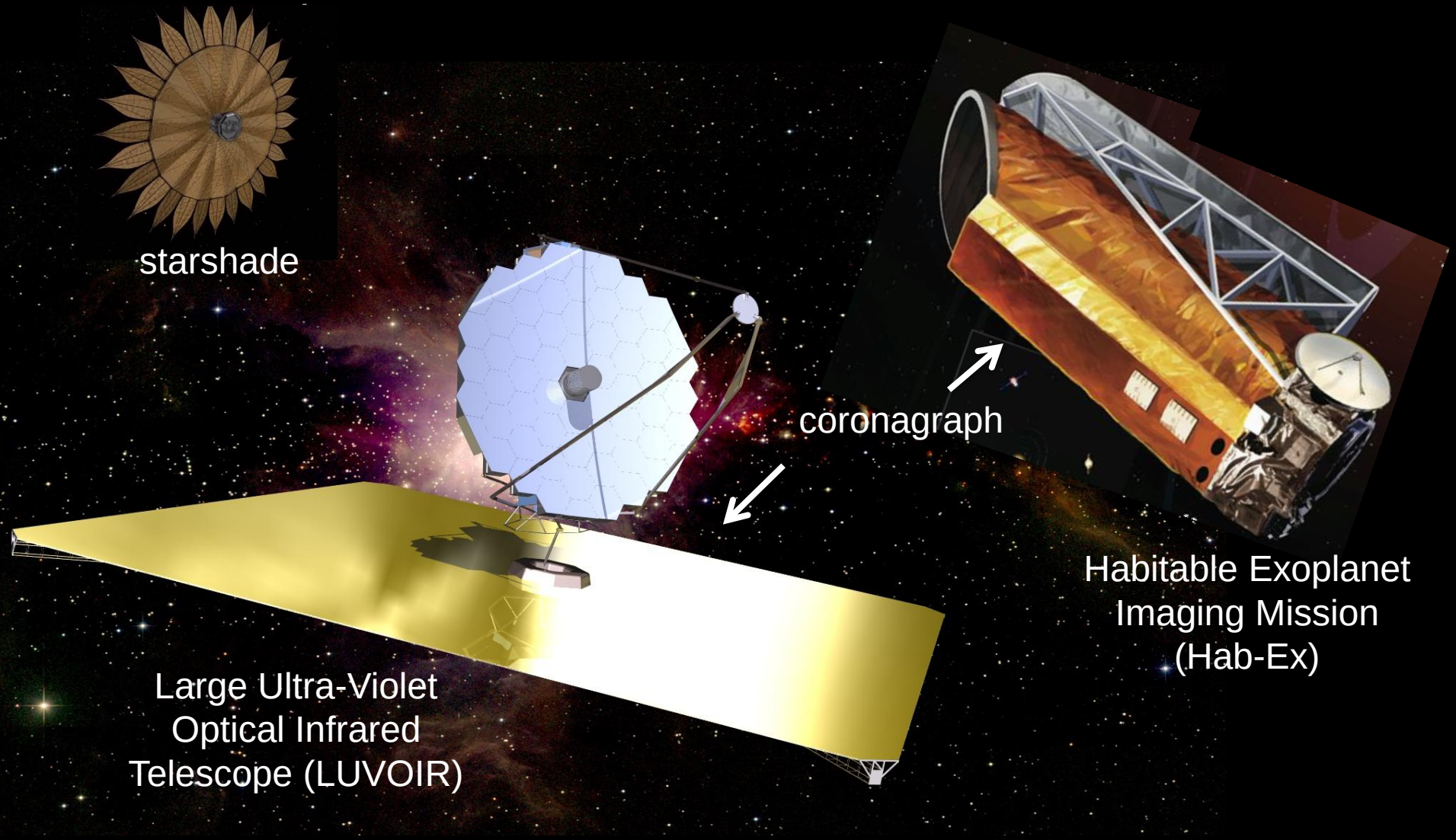


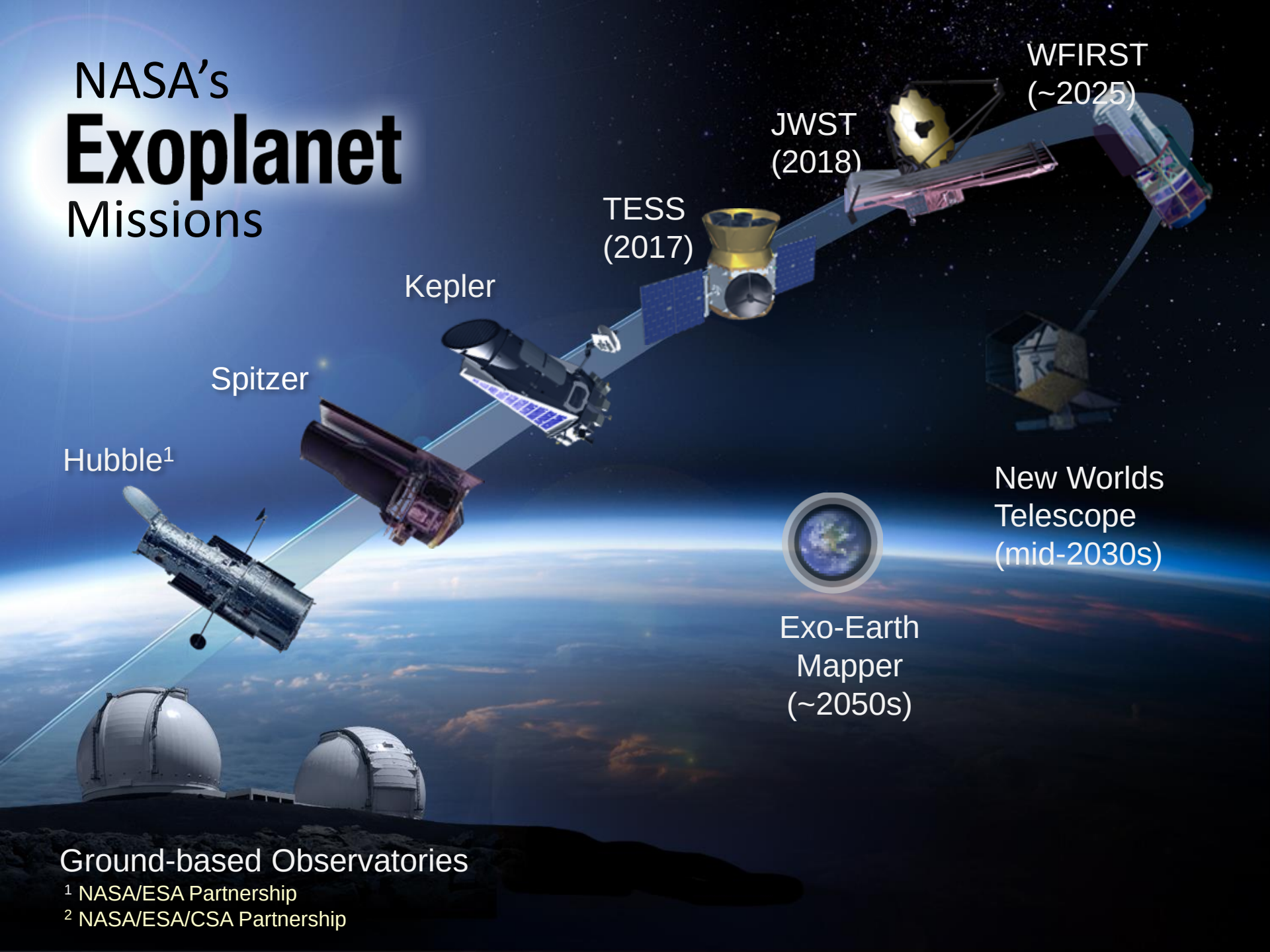
Ground-based Observatories

[1] NASA/ESA Partnership

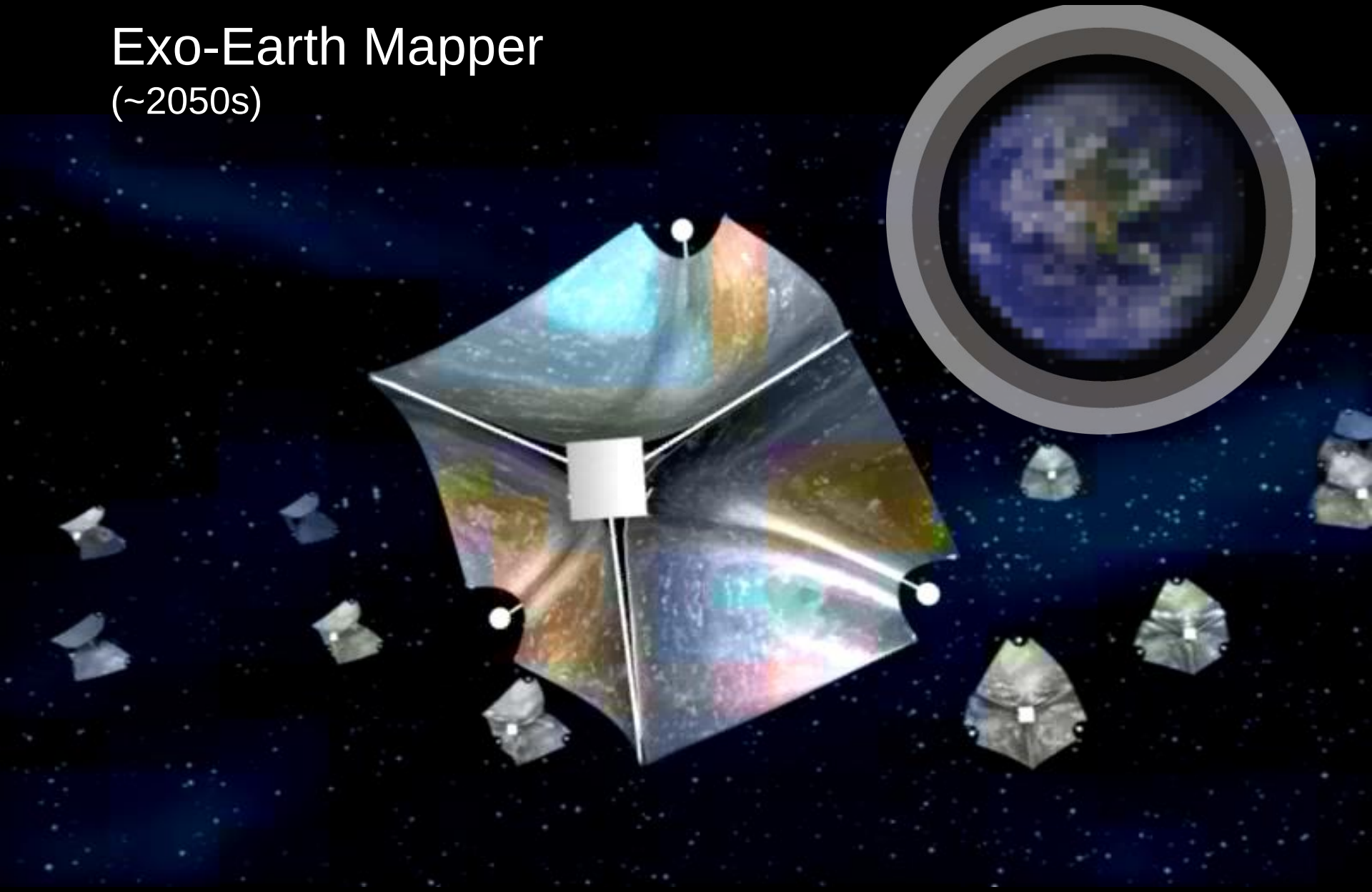
[2] NASA/ESA/CSA Partnership

Possible New Worlds Exoplanet Telescopes
(mid-2030s)



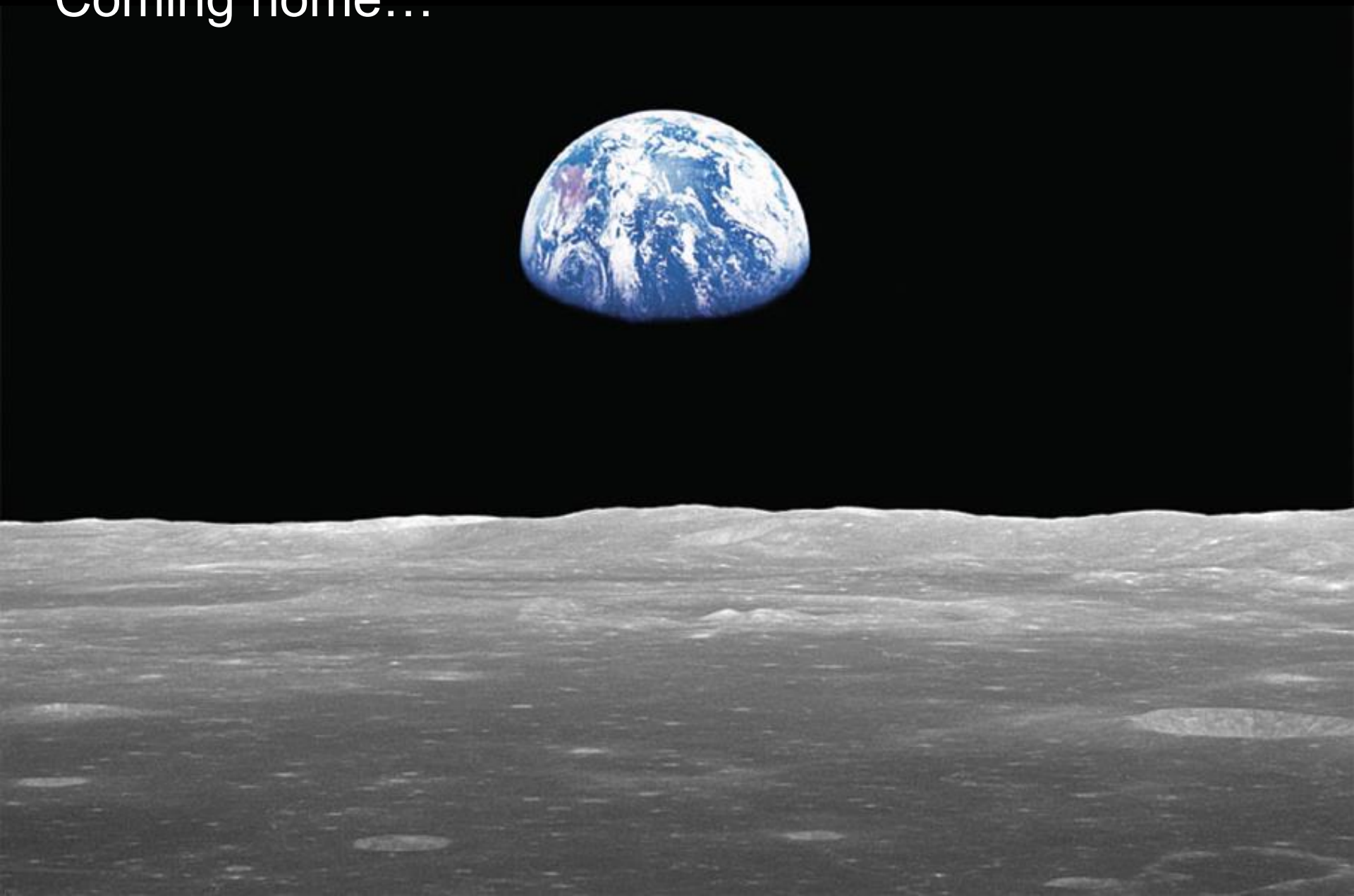

NASA's
Exoplanet
Missions
WFIRST
(~2025)
JWST
(2018)
TESS
(2017)
Kepler
Spitzer
Hubble[1]
New Worlds
Telescope
(mid-2030s)
Exo-Earth
Mapper
(~2050s)
Ground-based Observatories
[1] NASA/ESA Partnership
[2] NASA/ESA/CSA Partnership

Exo-Earth Mapper
(~2050s)



animation: Boeing-SVS video from the TPF-I architecture studies; concept by Antoine Labeyrie

Coming home…



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