



Jet Propulsion Laboratory
California Institute of Technology

Exoplanets in Our Galaxy

Ray Lemus, Business Manager

NASA Exoplanet Exploration Program

CL#TBD

URSTBD

Thursday, May 25, 2017

Plainview Charter School

Ms. Anna Gaiter's

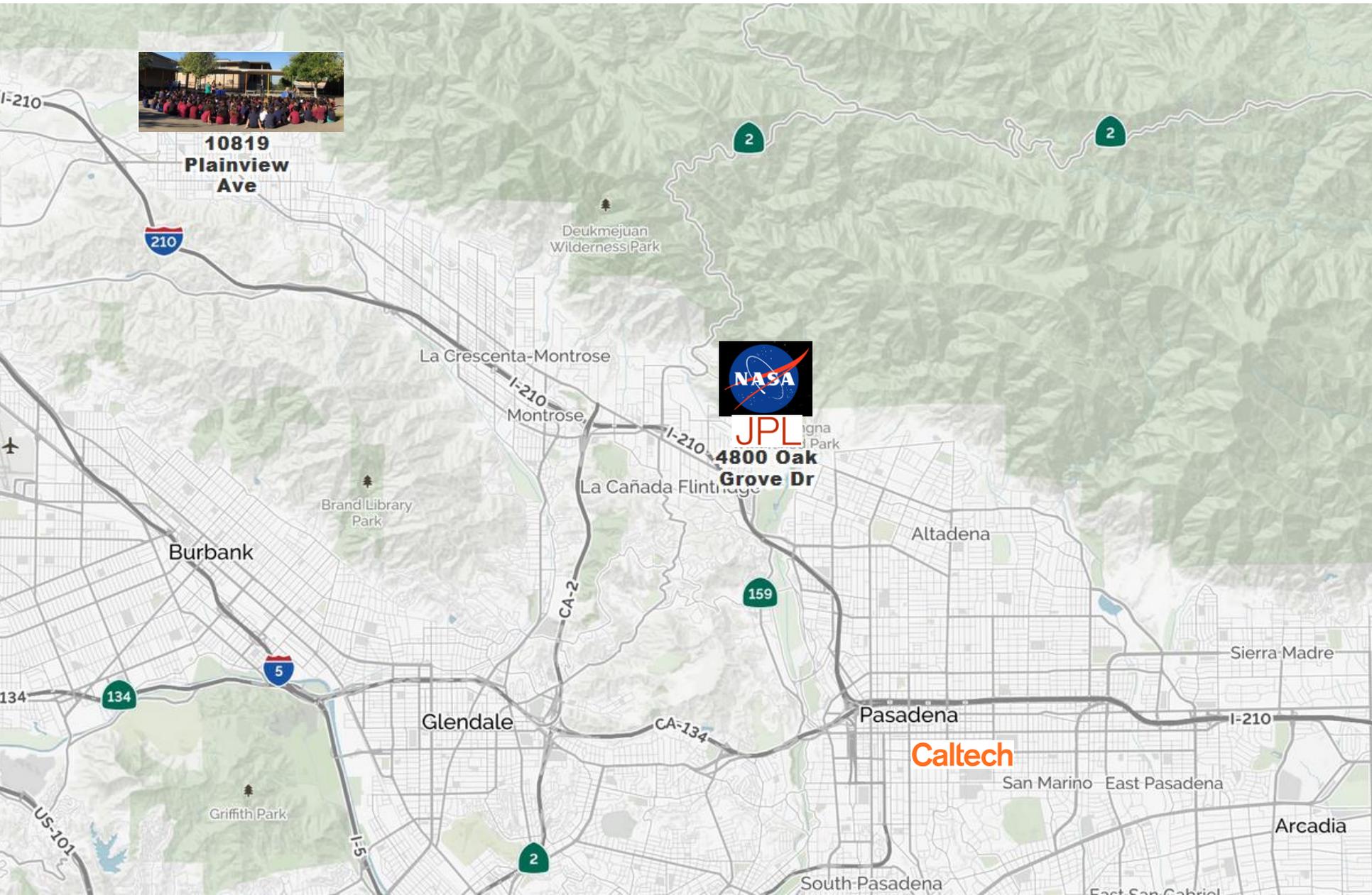
3rd Grade Class

Tujunga, CA

Agenda

- **NASA's ExoPlanet Exploration Program**
 - **NASA and JPL**
 - **Purpose**
 - **Kepler's Amazing Results**
 - **How to Find Exoplanets**
 - **Take Away Message**





JPL has expertise in:

- Science
- Engineering
- Technology
- Programs/projects



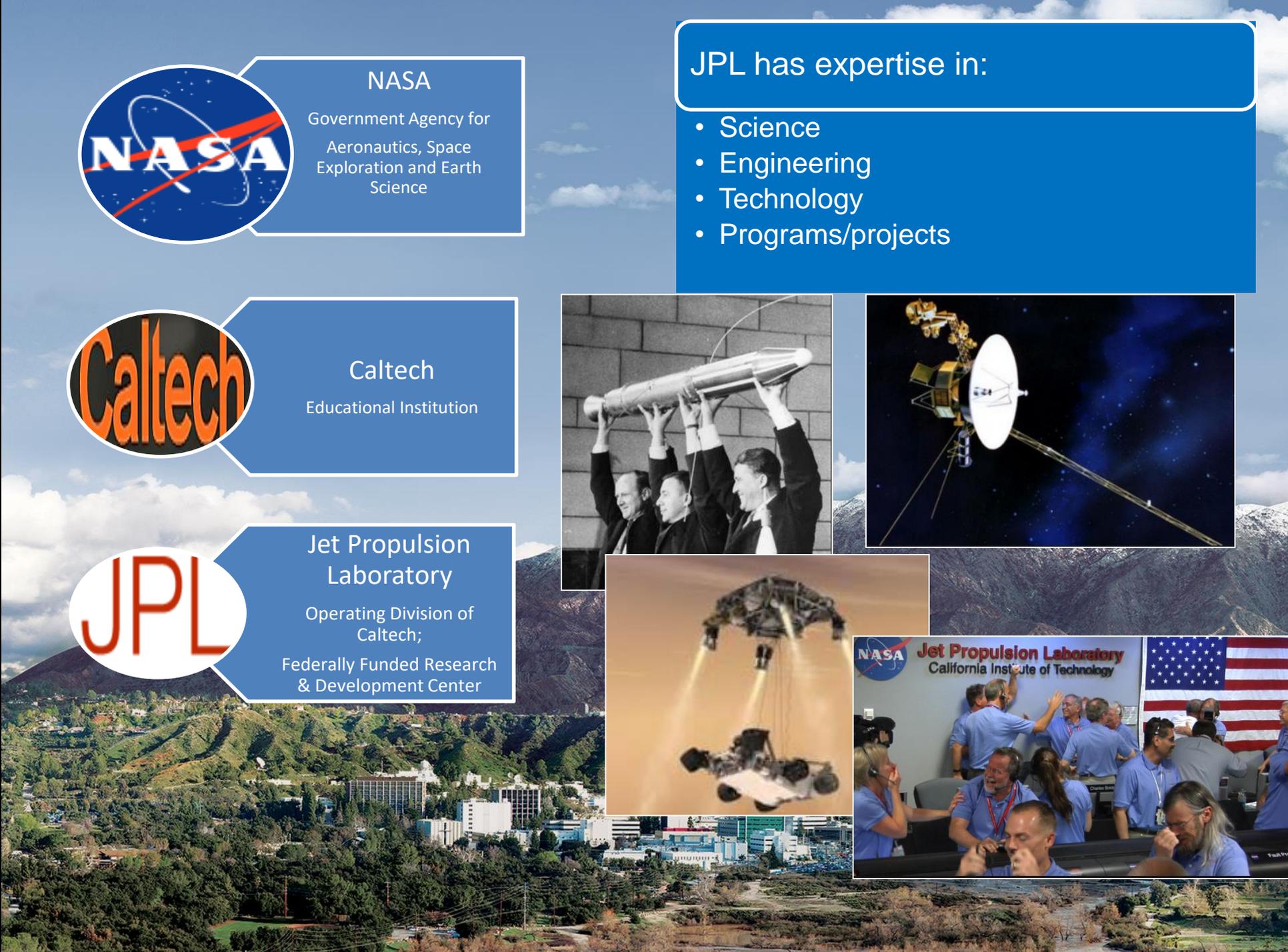
NASA
Government Agency for
Aeronautics, Space
Exploration and Earth
Science



Caltech
Educational Institution



**Jet Propulsion
Laboratory**
Operating Division of
Caltech;
Federally Funded Research
& Development Center



Idaho Public Television: Science Trek



Filming for Idaho Public Television: Science Trek
 Tiffany Meshkat and Nick Siegler took part in a filmed Q&A for an exoplanets-themed episode of Idaho Public Television's kids series, Science Trek. Questions were posed by K-7 students.

The episode is scheduled to air in January 2017

- <http://idahoptv.org/sciencetrek/topics/exoplanets/>



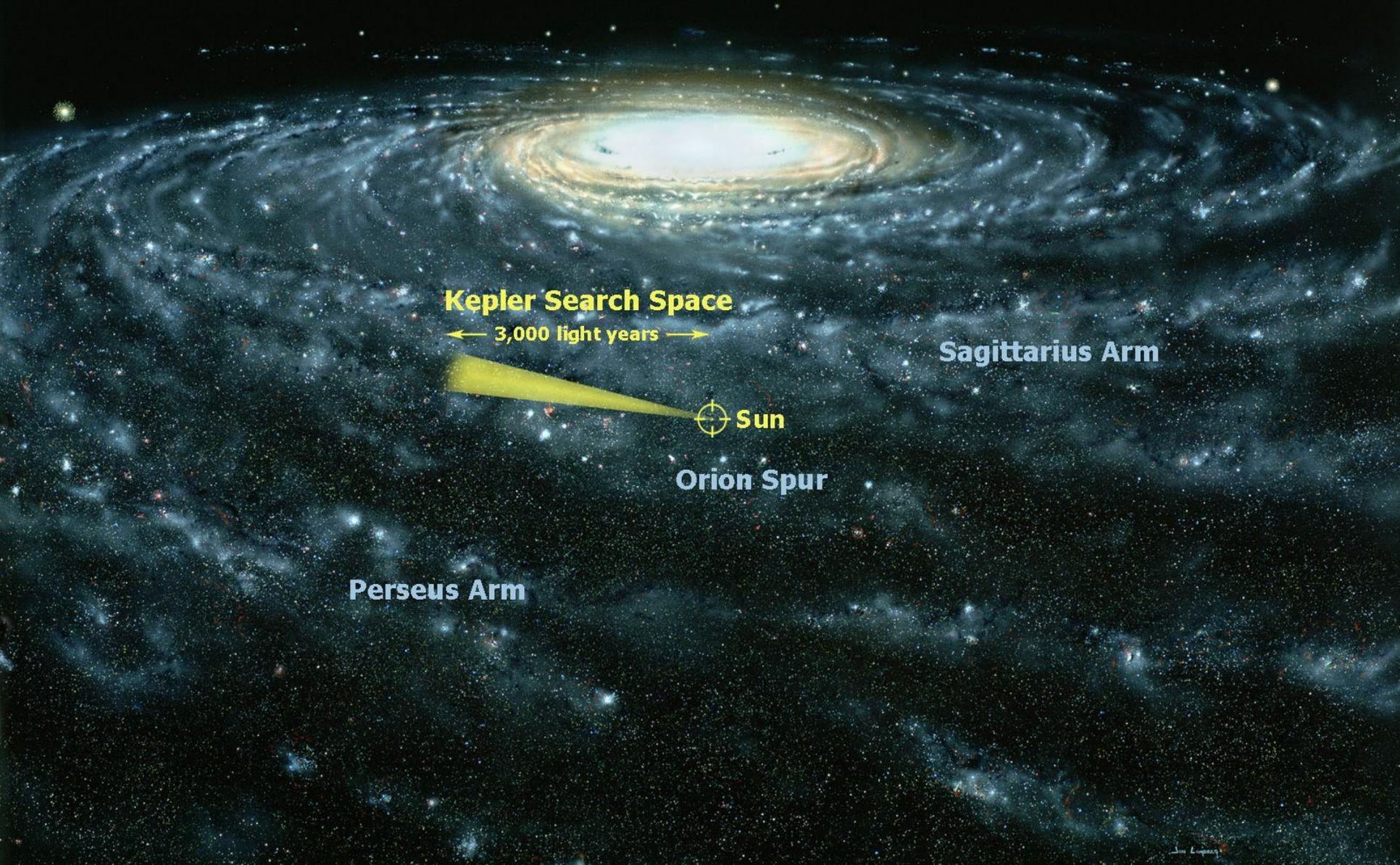
The screenshot shows the website for Science Trek, an exoplanets-themed episode. The page features a navigation menu with options like Home, Contact, and Shop. A search bar is present at the top. The main content area includes a large image of a nebula and a sidebar with a 'Click on a Topic:' menu listing various subjects like Ages Past, Animals, Earth Science, Environment, Human Body, Science Fundamentals, Space, Technology, and Other. The main text area is titled 'Exoplanets' and provides a definition: 'Planets that orbit a star outside our solar system.' It also includes a paragraph about the discovery of exoplanets and a list of resources for further learning, such as 'Facts', 'Links', 'Games', 'Resources', 'Glossary', 'Top 10', and 'Videos'. The footer contains copyright information for Idaho Public Television and the Idaho State Board of Education.



Image Credit: Ross Manges



Milky Way Galaxy





NASA Named Its Planet Finding Telescope After Johannes Kepler



German astronomer Johannes Kepler used mathematics to calculate the path of the planets, finding that they traveled not in circles, as long expected, but in ellipses.

Credit: Johannes Kepler Gesammelte Werke , C. H. Beck, 1937

- Johannes Kepler was born in the late 16th century
- Scientists believed that planets in the solar system traveled in circular orbits around the Earth
- Kepler adamantly defended the idea that planets orbit the sun instead, a heretical idea at the time
- Revealed that their paths were not perfect circles, but rather ellipses
- His descriptions of planetary motions became known as Kepler's laws

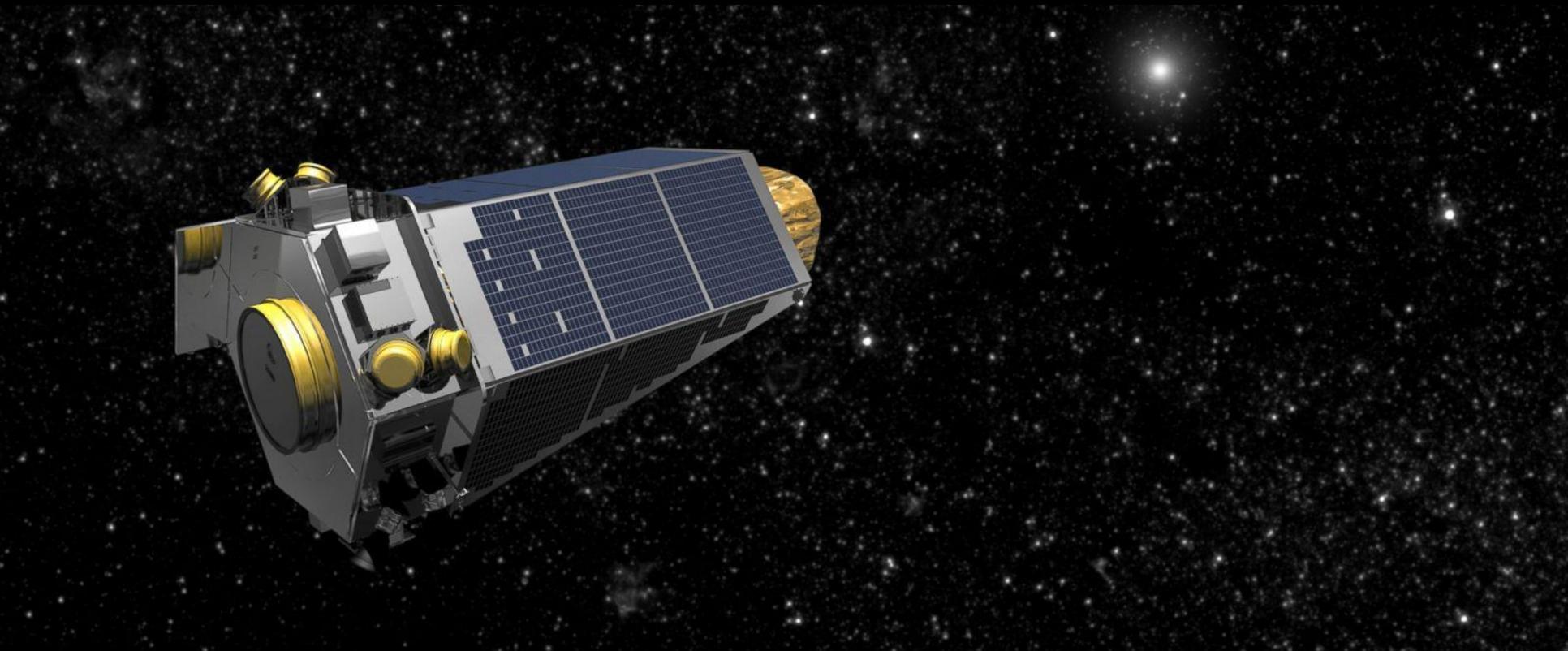
uploaded in HD @



<https://www.youtube.com/watch?v=LkbWF-kDK8Y>

Credit: Marvin the Martian is a character from Warner Bros, Looney Tunes and Merrie Melodies cartoons

NASA's Kepler Space Telescope



Exploring a Galaxy of Worlds While Inspiring our Own

Introducing Baby Kepler! (Cloutier)



Show Me the Planets!
You had me at Habitable



DOB 2/6/16. Age on Earth: (1), Kepler 16b: (1.5), Proxima b (33), Trappist-1b (243)

After meeting the Cloutier family at the Pasadena Astronomy Festival in October 2016, ExoComm brought the family to tour JPL with ExEP Program Manager Gary Blackwood and Steve Howell of Ames on January 17, 2017. A story will follow to be published on the exoplanets.nasa.gov website soon



Transit Technique



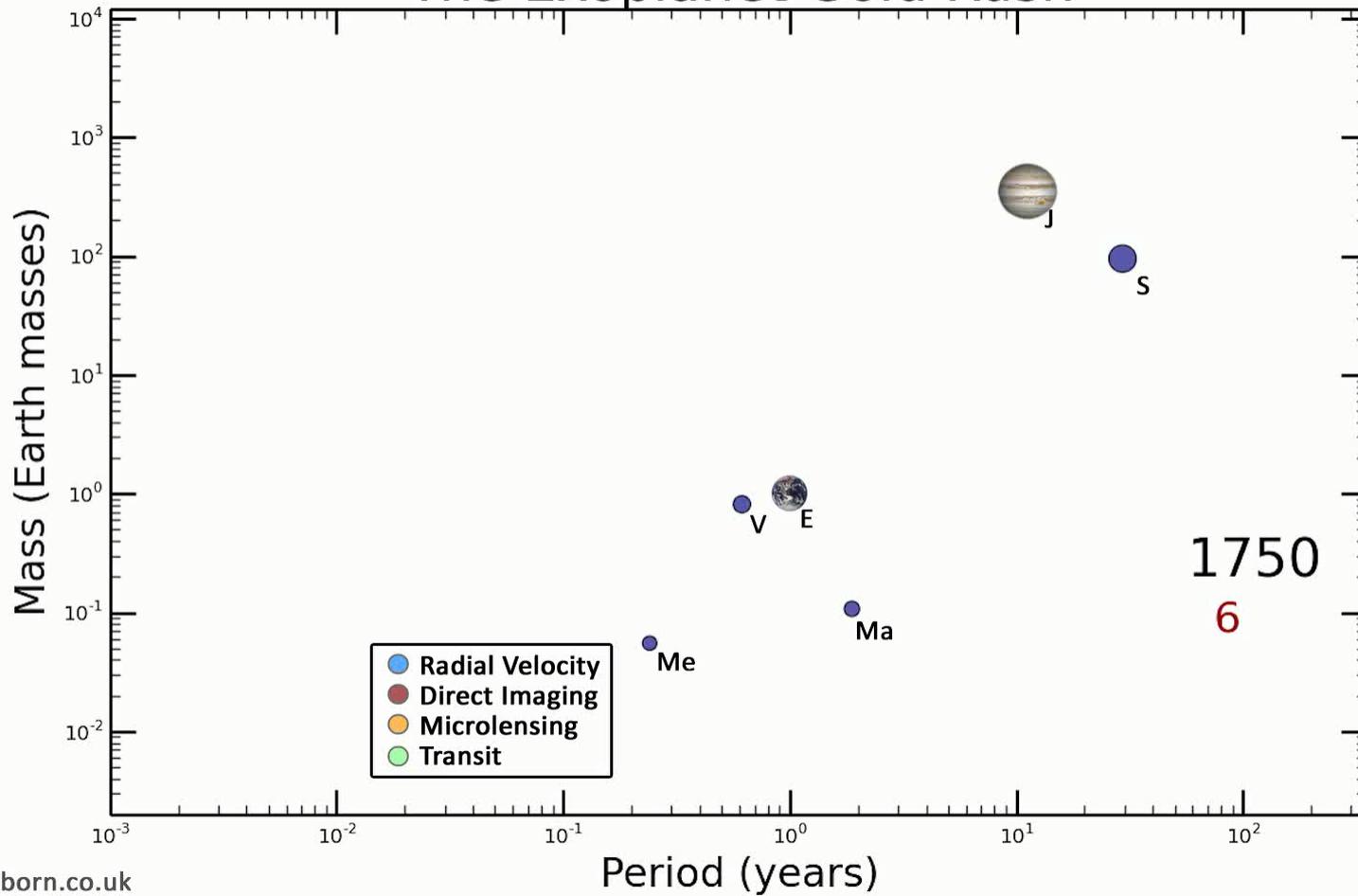
BRIGHTNESS



TIME IN HOURS

Show Me
the
Planets!

The Exoplanet Gold Rush



Kepler's Amazing Results:

1 Planets are diverse

Lava Planets

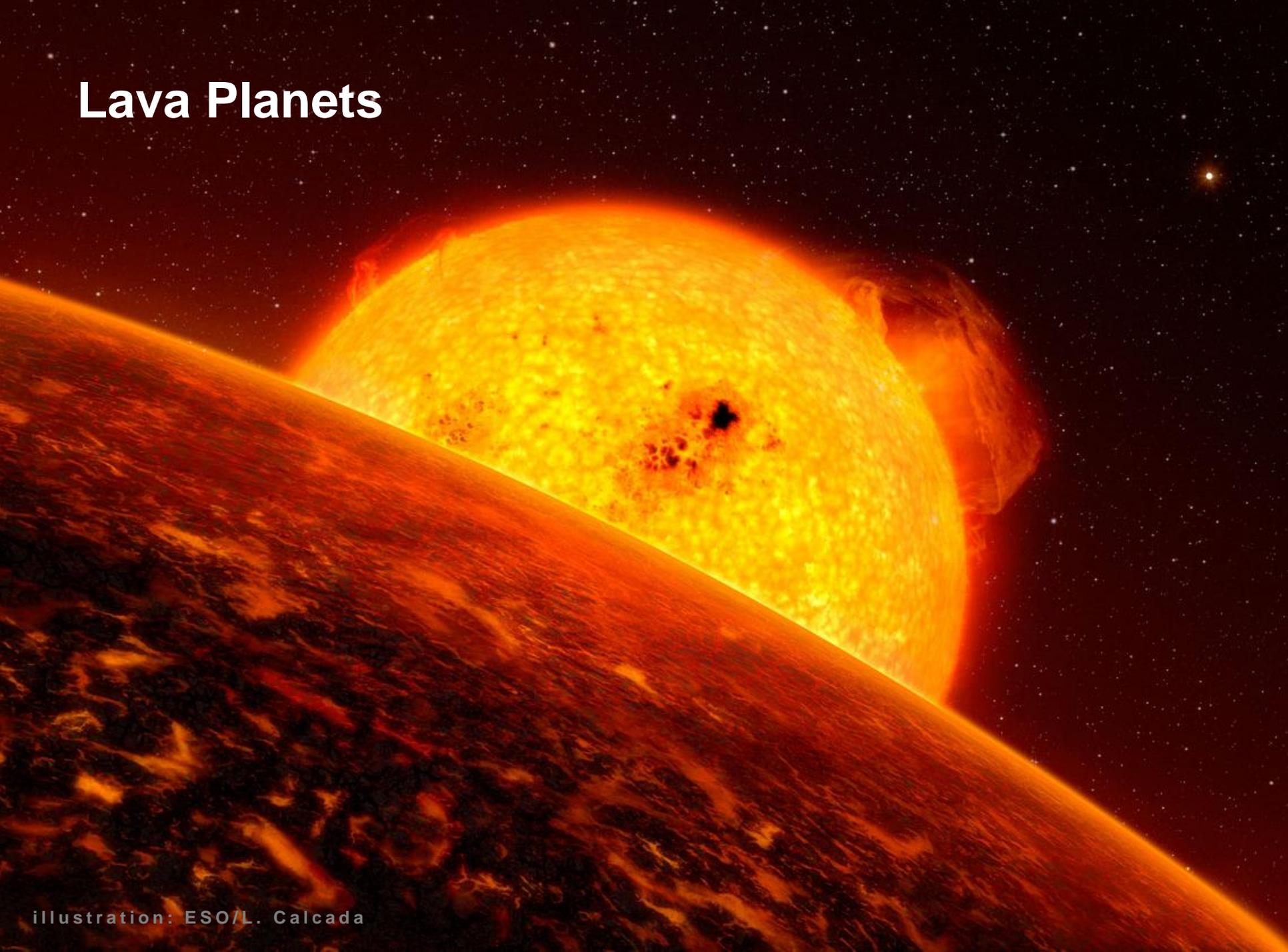
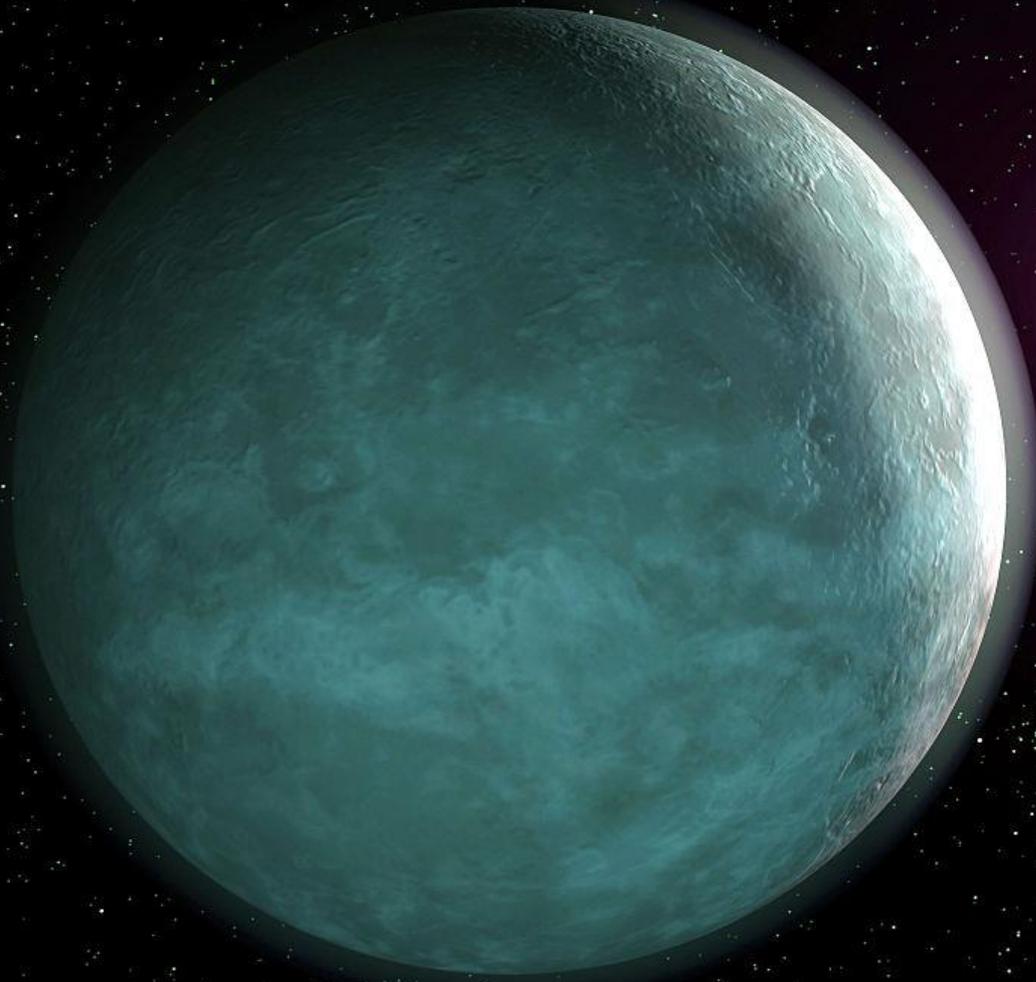


illustration: ESO/L. Calçada

Ice Planets

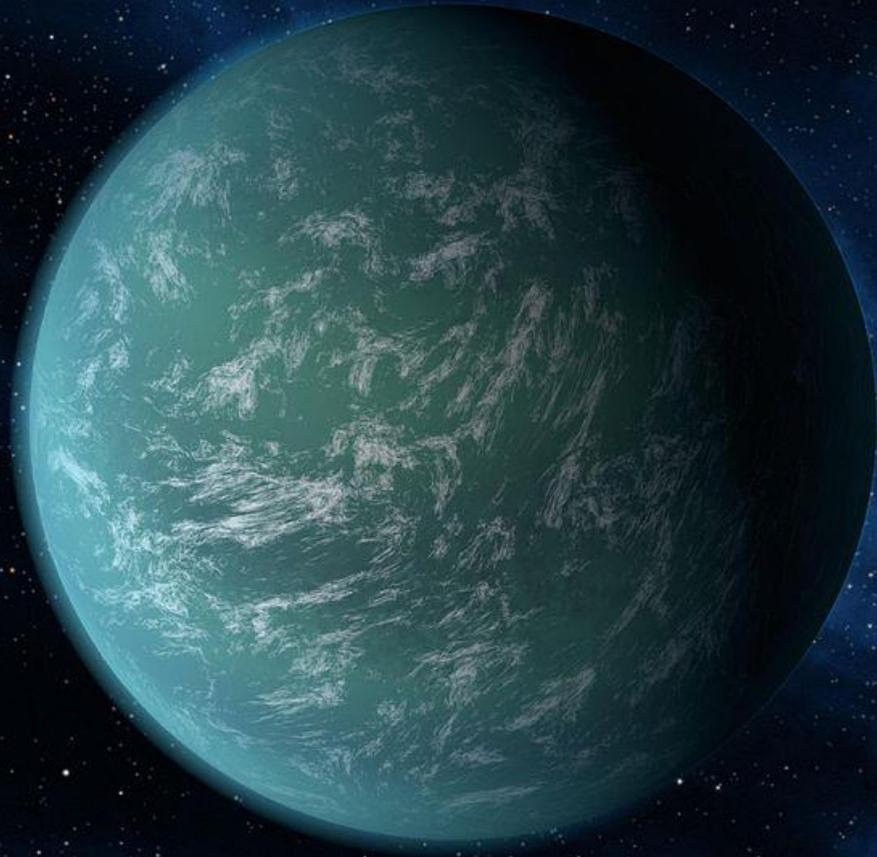


Planets with two stars





Water Worlds



Nomad planets not bound to any star at all!



Kepler's Amazing Results:

2

On average there is at least one planet for each star in our Galaxy

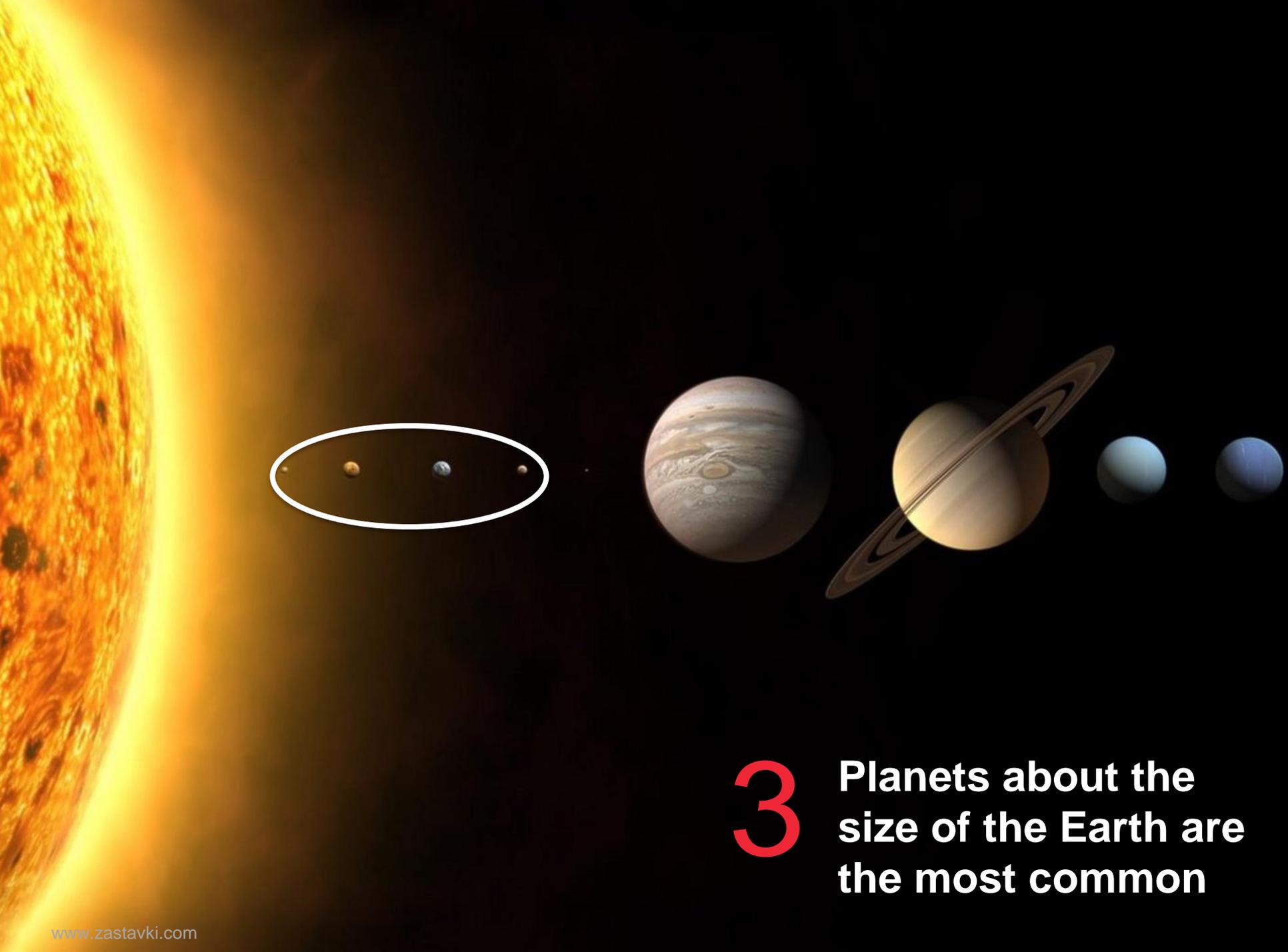
(and likely more...)

▪

> 200 billion exoplanets
in our Milky Way Galaxy







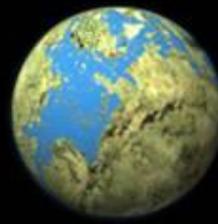
3

Planets about the size of the Earth are the most common

Many of the new planets get too hot or too cold to support life.



Too hot!



Just right!



Too cold!

tens of billions

HABITABLE ZONE

Just Right



4

Planets about the size of the Earth that orbit in the Habitable Zone of their stars are common

A Familiar Habitable Zone



Credit: Luc Forsyth

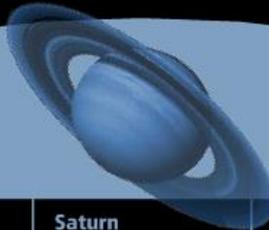
Summary of Kepler's Amazing Results:

- 1** Planets are diverse
- 2** On average there is at least one planet for each star in our Galaxy
- 3** Planets about the size of the Earth are the most common
- 4** Planets about the size of the Earth that orbit in the Habitable Zone of their stars are common.

Within Our Solar System

Outside Our Solar System

1 Select a destination:



Moon
Earth satellite body
Distance: 220,968 miles

Mars
Terrestrial planet
Distance: 34 million miles

Saturn
Gas giant
Distance: 741.2 million miles

Proxima Centauri
Closest star
Distance: 4.28 light years

Epsilon Eridani
Extrasolar System
Distance: 10.3 light years

2 Select a vehicle:



Automobile
60 mph

Bullet Train
160 mph

Boeing 757
600 mph

Voyager
10.5 miles/second

Starship
light-speed

3 Plan Trip! ▶

You will arrive at your destination in...

4.28 years

*Unfortunately, the technology for travel at this speed is not currently available!

Travel time is given from an Earth observer's perspective

▶ Go to PlanetQuest

<https://exoplanets.nasa.gov/interactable/5/index.html>

Show Me
the
Planets!



firefly



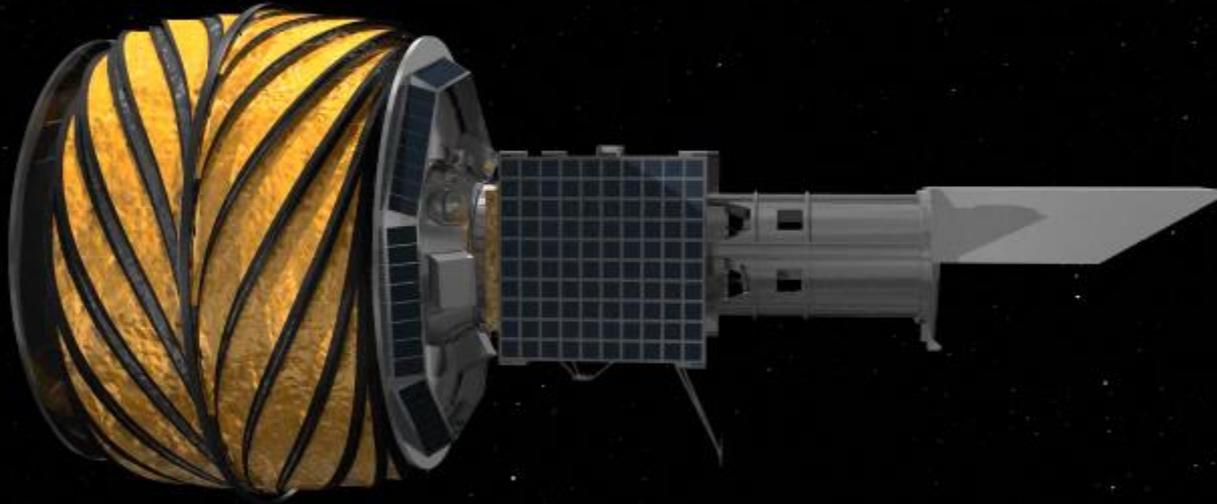




JPL



1. Starshade Animation

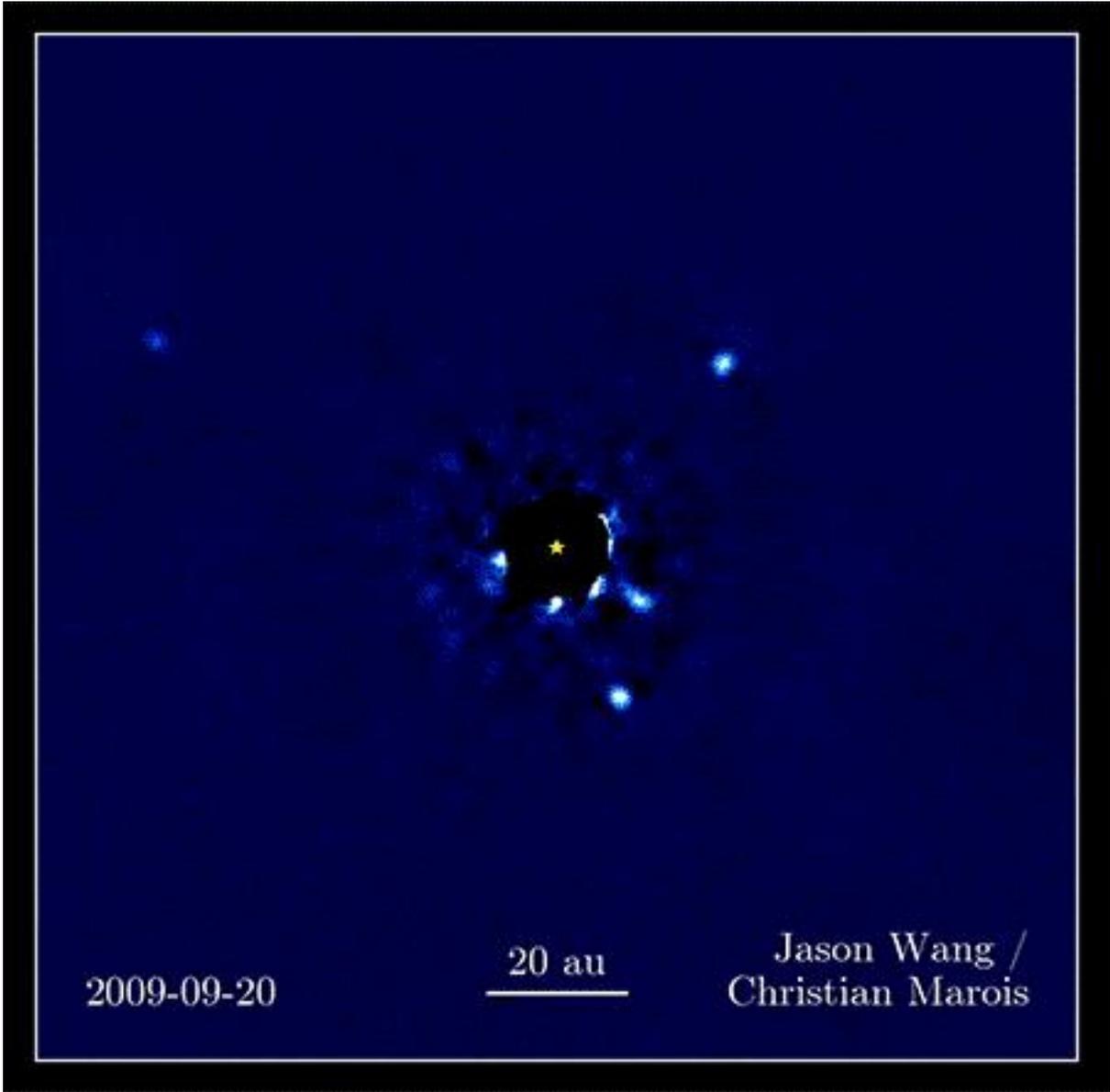


Orbital Motion of Four Giant Planets around HR 8799

Directly Imaged and Remarkable



ExoPlanet Exploration Program



2009-09-20

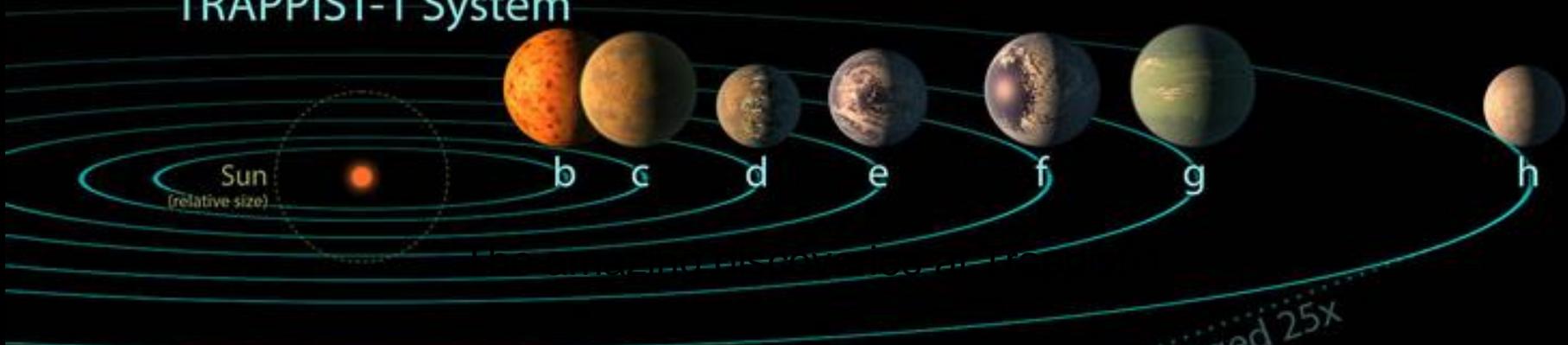
20 au

Jason Wang /
Christian Marois

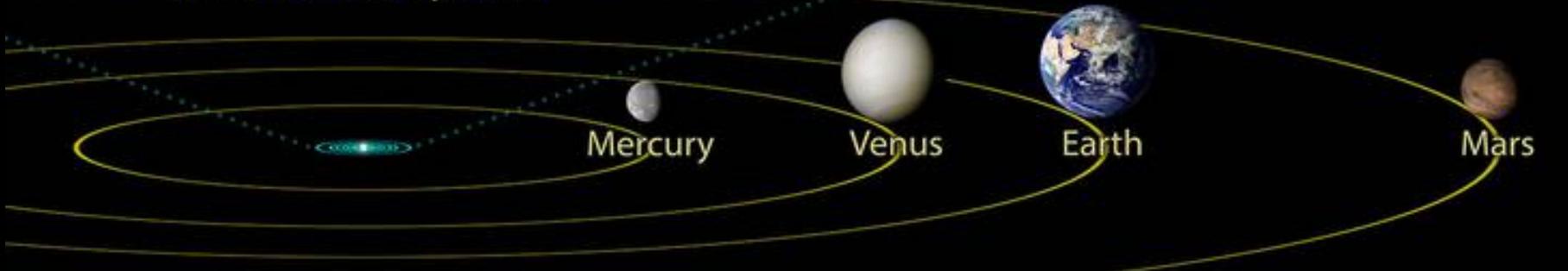
The amazing discoveries at Trappist-1

Planet depictions are artist's concepts

TRAPPIST-1 System

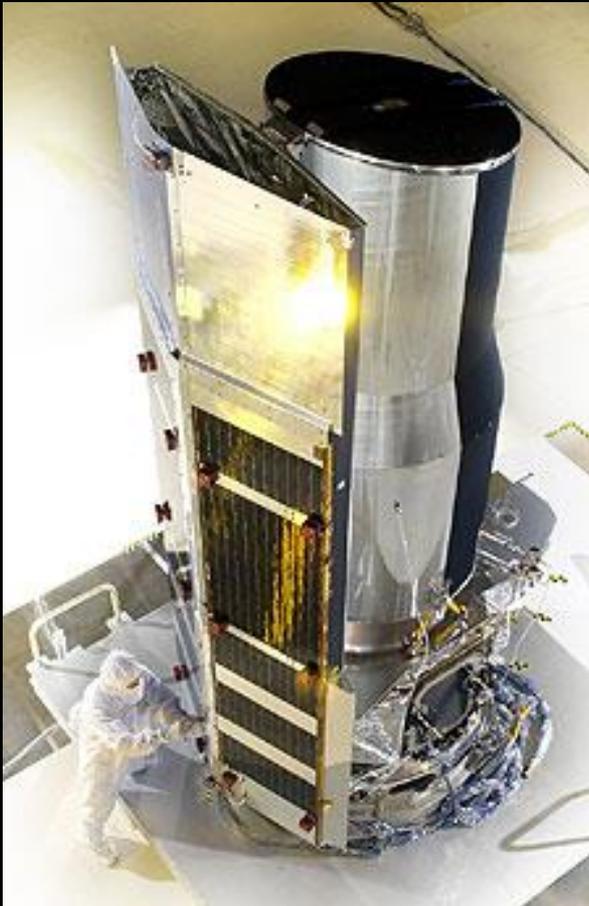


Inner Solar System



Orbits Enlarged 25x

Spitzer: Discovery machine for the Trappist-1 planetary system



- 33.4 inch diameter **infrared** telescope
- Instrumented with 2 cameras and 1 spectrograph
- Launched August 2003
- In 2005 **made first-ever detection of light emitted by an exoplanet**
- Mission development & operations led by JPL

How Spitzer Observed the Trappist-1 System



More of Kepler's Amazing Results:

1

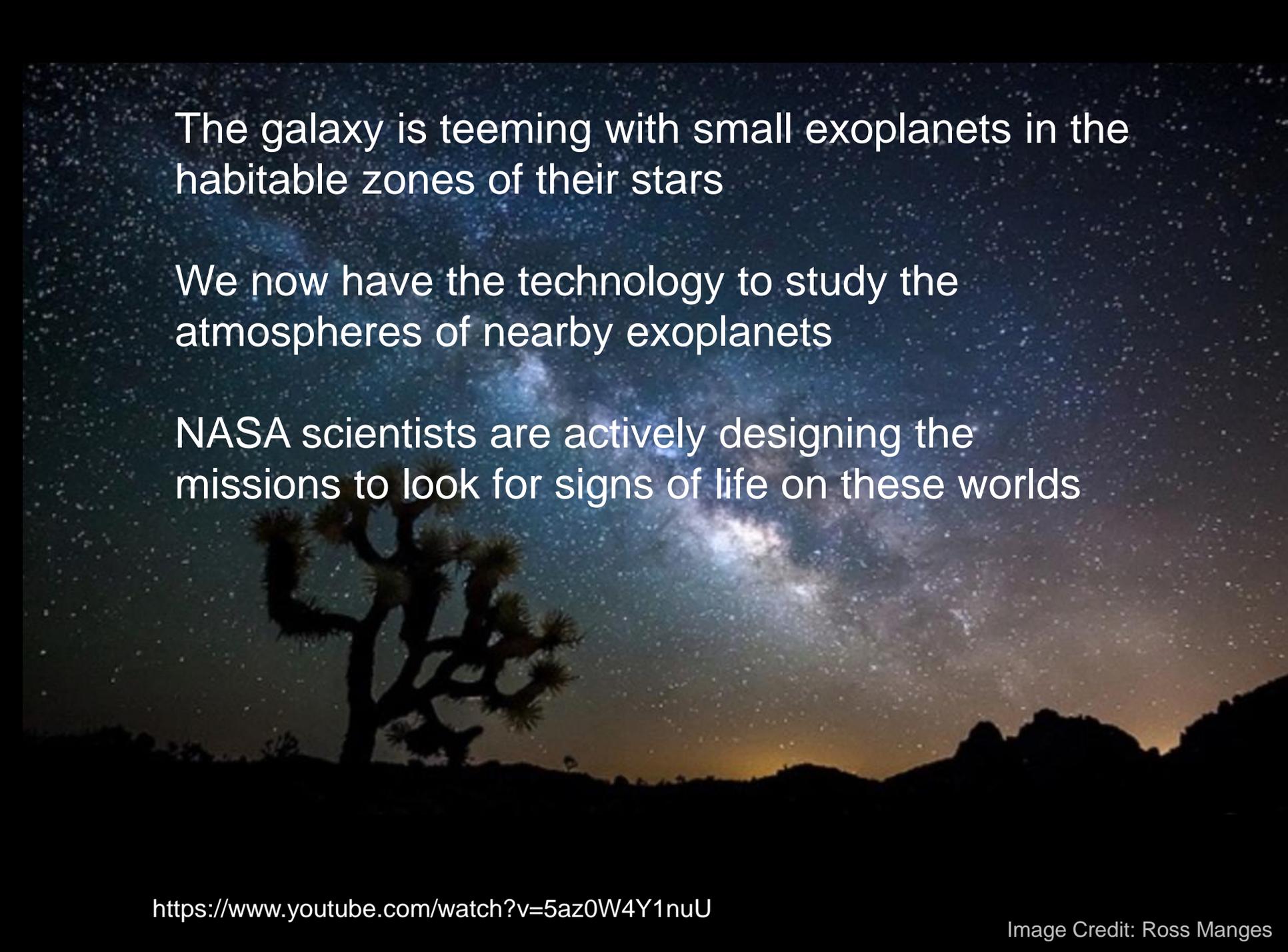
Planets orbiting other stars in the Galaxy are common

2

Planets with sizes between $1/2$ and 2 times Earth are the most common

3

Planets with sizes between $1/2$ and 2 times Earth that orbit in the Habitable Zone of their stars are common

A night sky with the Milky Way galaxy visible, silhouetted against a dark landscape with a Joshua tree.

The galaxy is teeming with small exoplanets in the habitable zones of their stars

We now have the technology to study the atmospheres of nearby exoplanets

NASA scientists are actively designing the missions to look for signs of life on these worlds



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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Massachusetts Institute of Technology

Pennsylvania State University