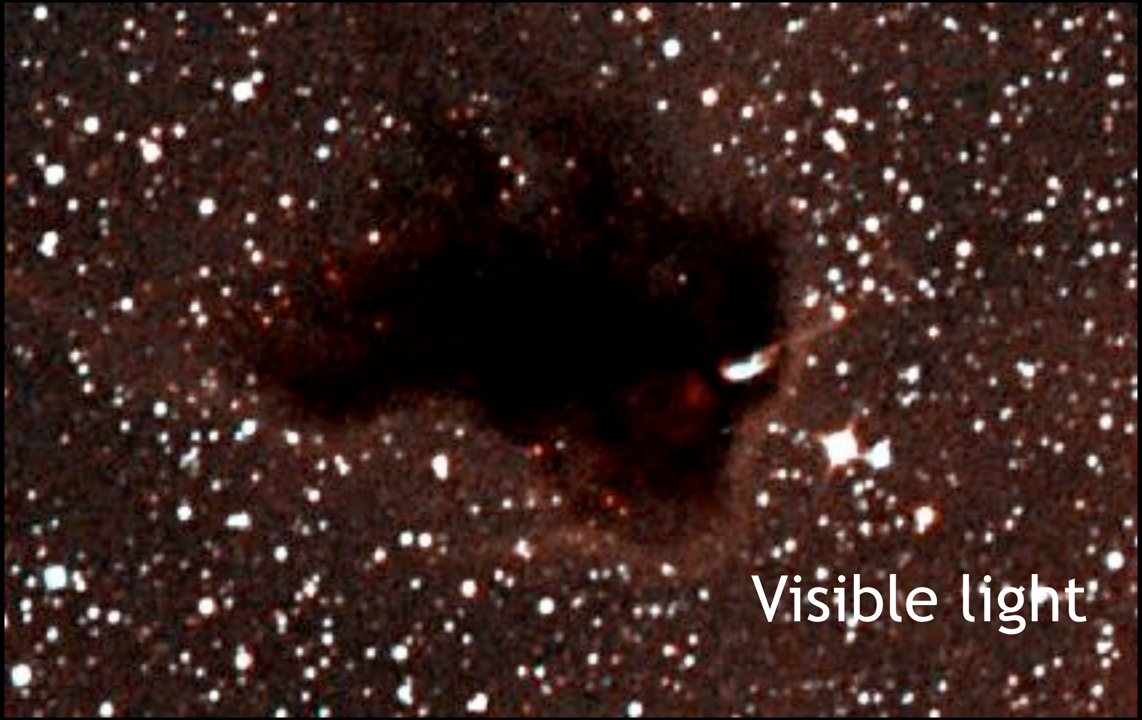
Spitzer Beyond: The incredible continuing adventures of the Spitzer Space Telescope

Sean Carey
Manager, Spitzer Science Center
IPAC/Caltech

Why Infrared?

Why Infrared?

Objects colder than stars give off infrared light



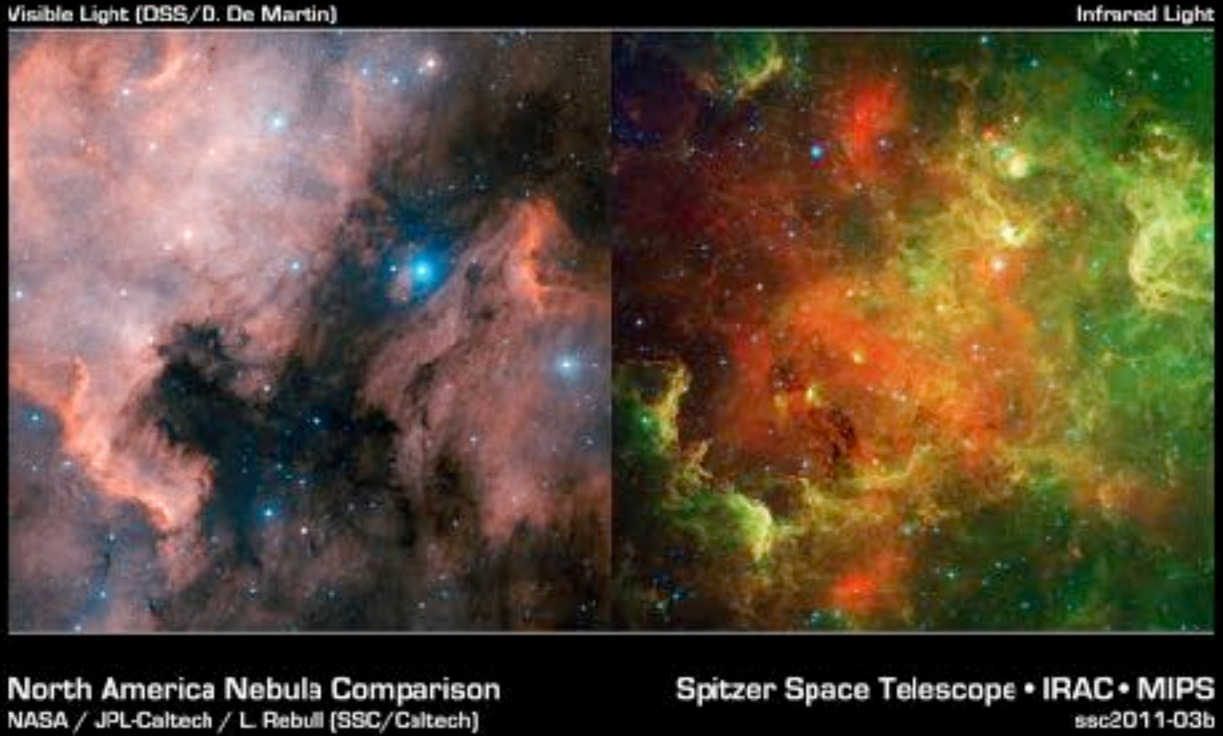
Why Infrared?

Objects colder than stars give off infrared light

- Protostars
- Planets
- Asteroids and Comets

Why Infrared?

Easier to see through dust in the infrared



Why Infrared?

Easier to see objects in the early Universe

Reddish blobs are distant galaxies

Why Infrared?

Easier to see objects in the early Universe

Light from objects gets progressively redder with distance due to expansion of Universe

Reddish blobs are distant galaxies

The Spitzer Space Telescope

Spitzer launched 25 August 2003

Last of NASA's Great Observatories Program

Expected lifetime 5 years

Cryogenic mission ended 15 May 2009

Warm mission science started 27 July 2009 and is still going!

The Spitzer Space Telescope was named after Lyman Spitzer

Expert in the interstellar medium

The Spitzer Space Telescope was named after Lyman Spitzer

Expert in the interstellar medium

First to think of a telescope in space

ASTRONOMICAL ADVANTAGES

OF AN

EXTRA-TERRESTRIAL OBSERVATORY

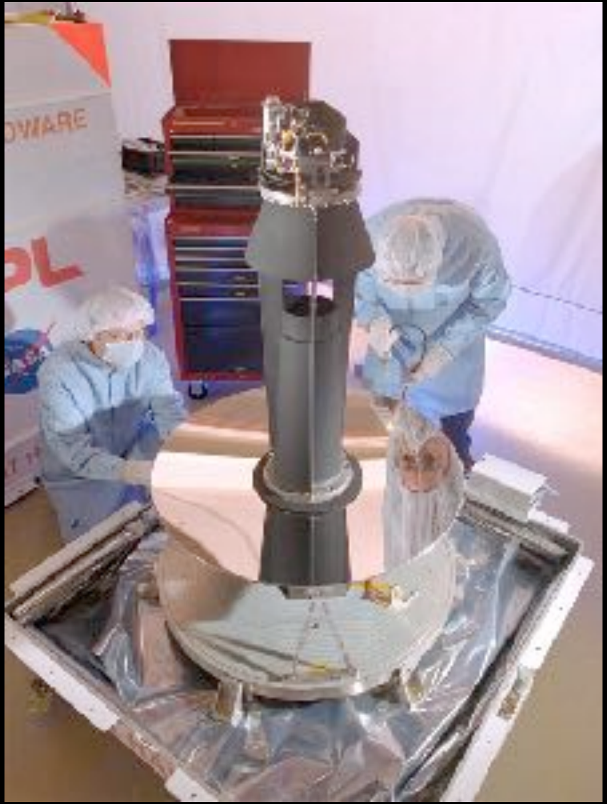
LYMAN SPITZER, Jr.

This study points out, in a very preliminary way, the results that might be expected from astronomical measurements made with a satellite vehicle. The discussion is divided into three parts, corresponding to three different assumptions concerning the amount of instrumentation provided. In the first section it is assumed that no telescope is provided; in the second a 10-inch reflector is assumed; in the third section some of the results obtainable with a large reflecting telescope, many feet in diameter, and revolving about the earth above the terrestrial atmosphere, are briefly sketched.

1990 reprinting of his 1946 article

The Spitzer Space Telescope

85 cm infrared telescope

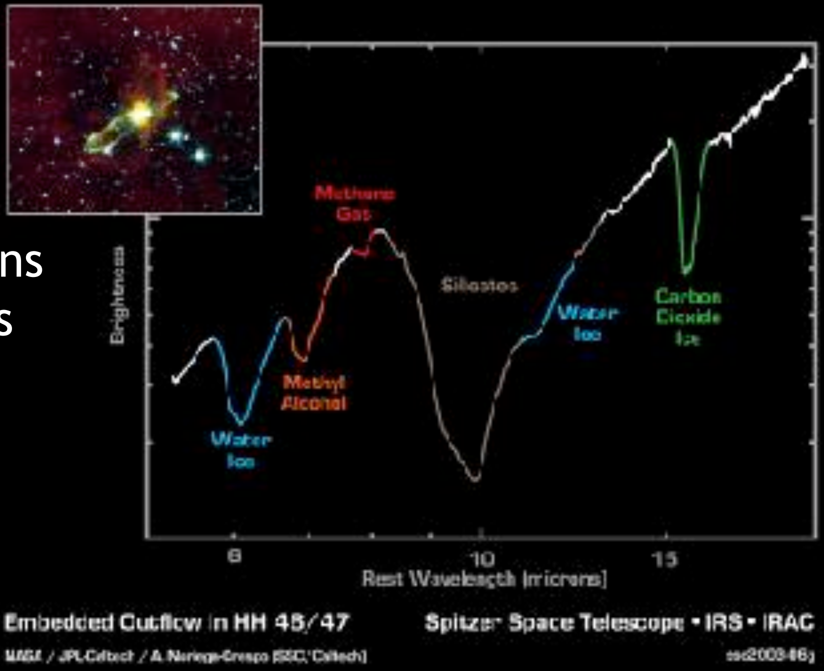


The Spitzer Space Telescope

85 cm infrared telescope

3 instruments

set of 4 cameras from 3-9 microns
spectrographs from 5-38 microns
cameras at 24, 70, 160 microns



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Earth-trailing orbit around the sun

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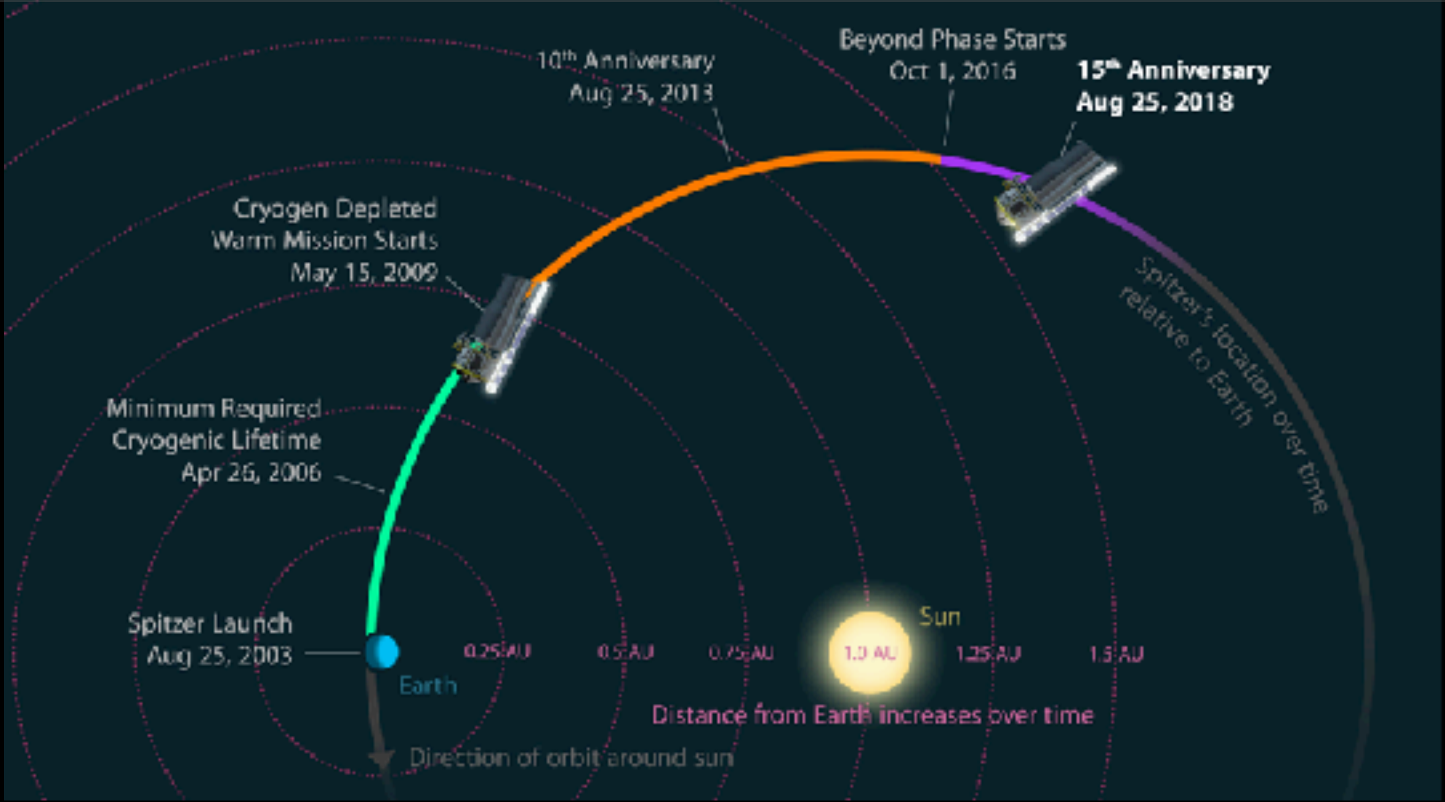
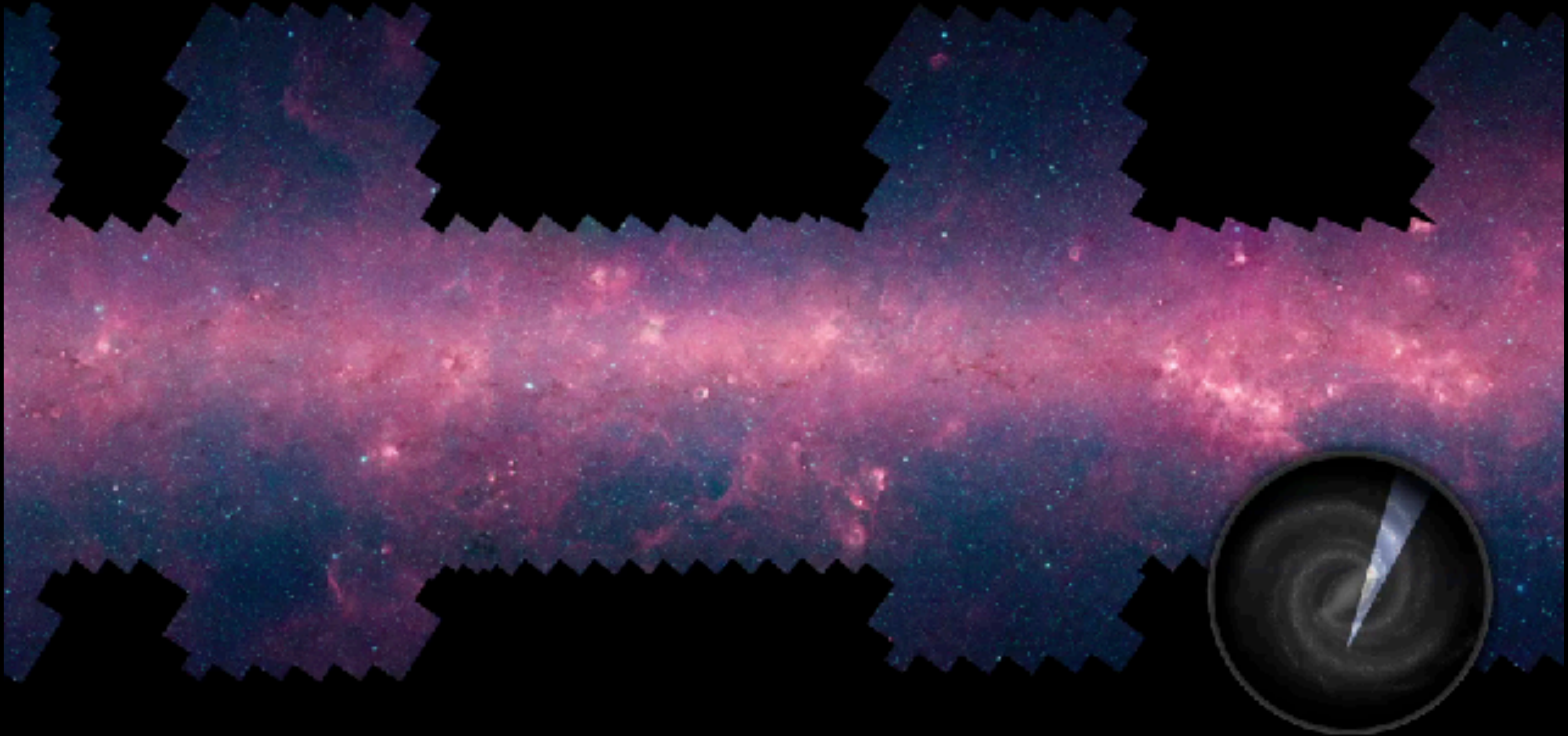
Earth-trailing orbit around the sun

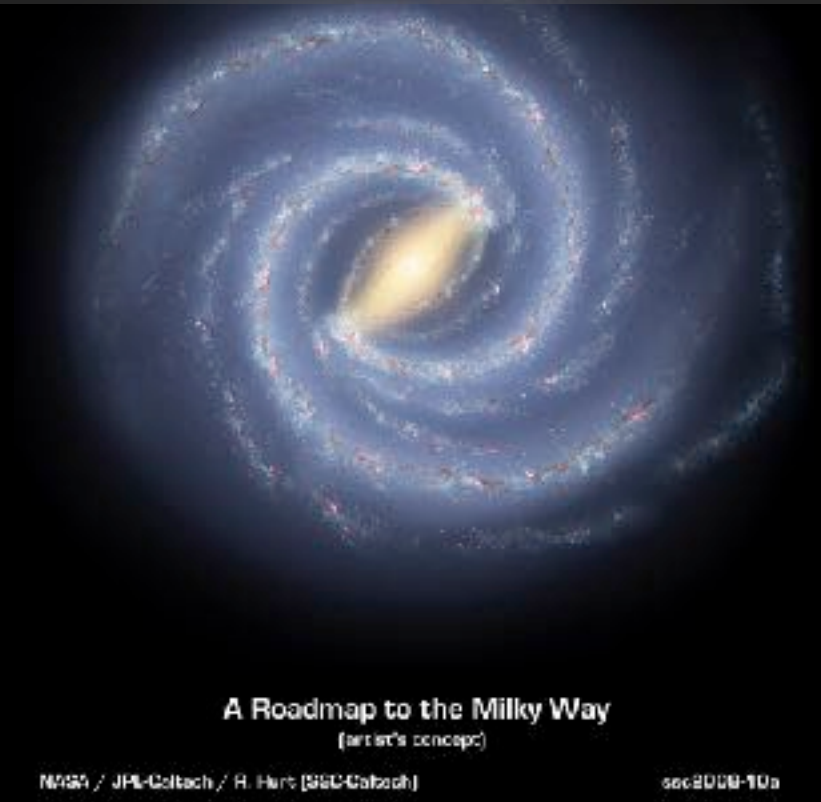
Passive cooling

Spitzer gets farther away from the Earth



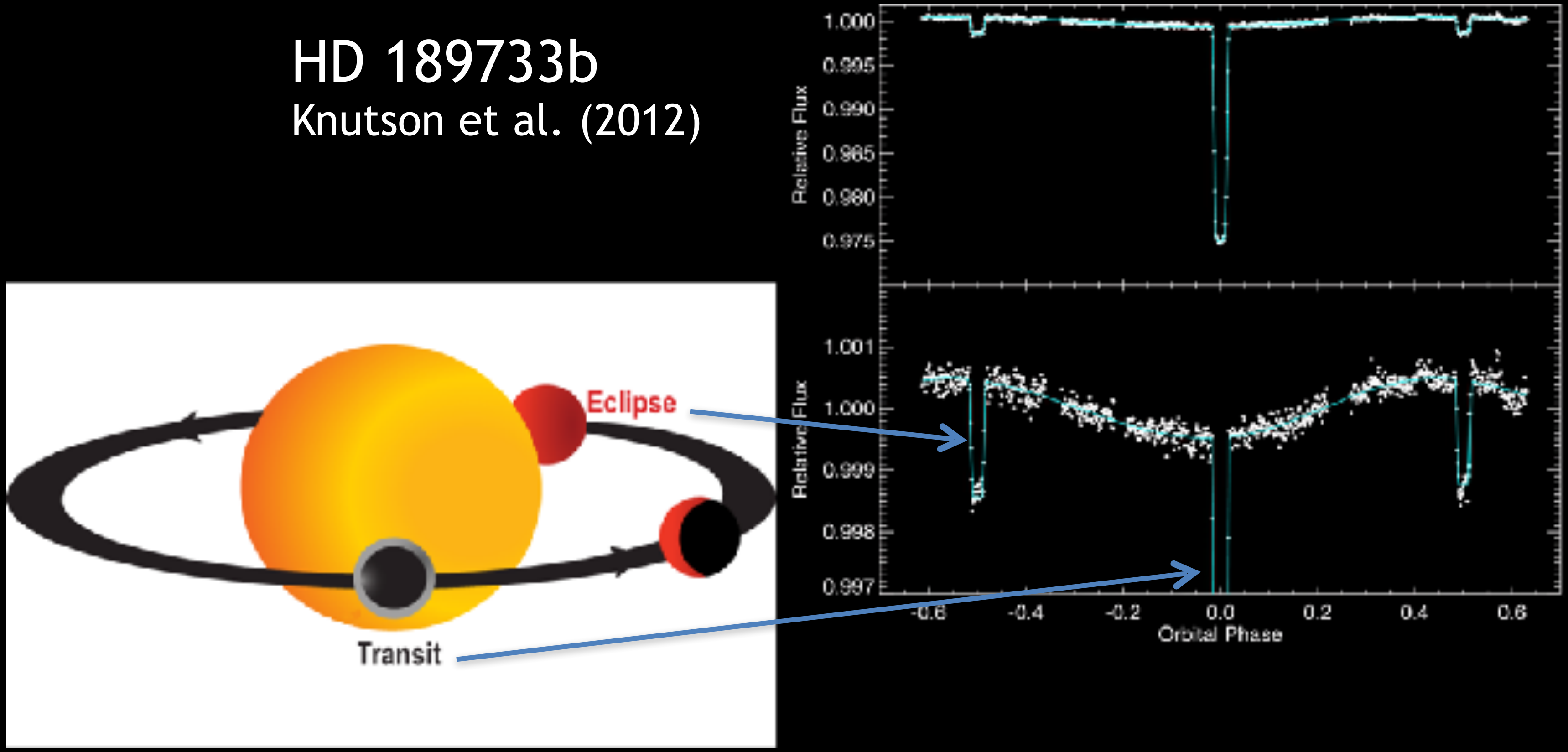


Structure of our Galaxy

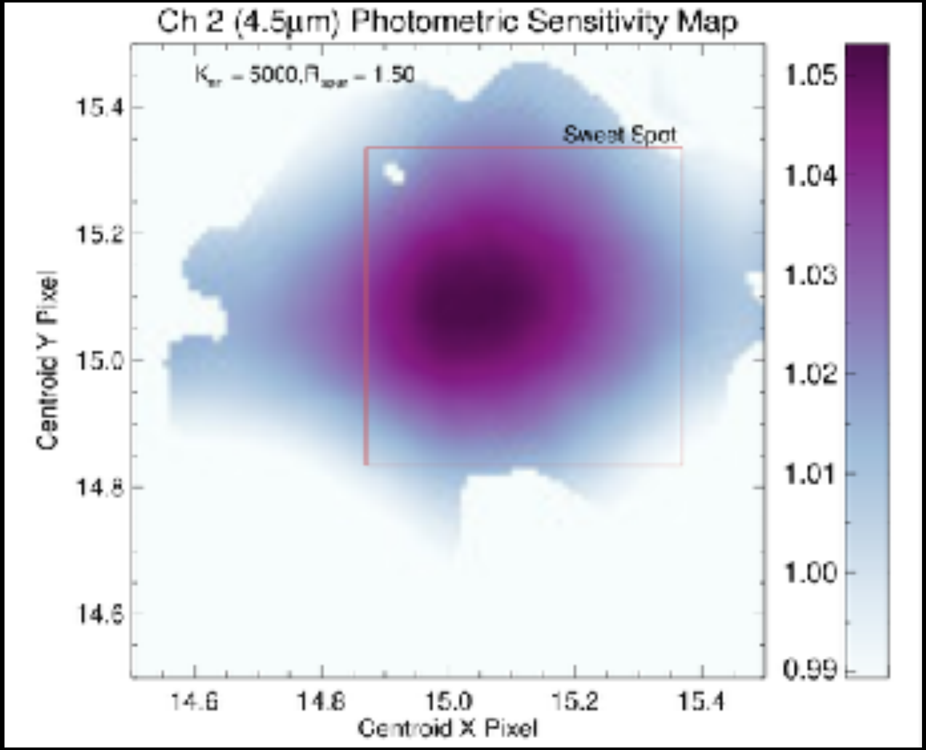


Transiting Exoplanets

HD 189733b
Knutson et al. (2012)



Spitzer was not designed for exoplanets



Ingalls et al.
(2018)

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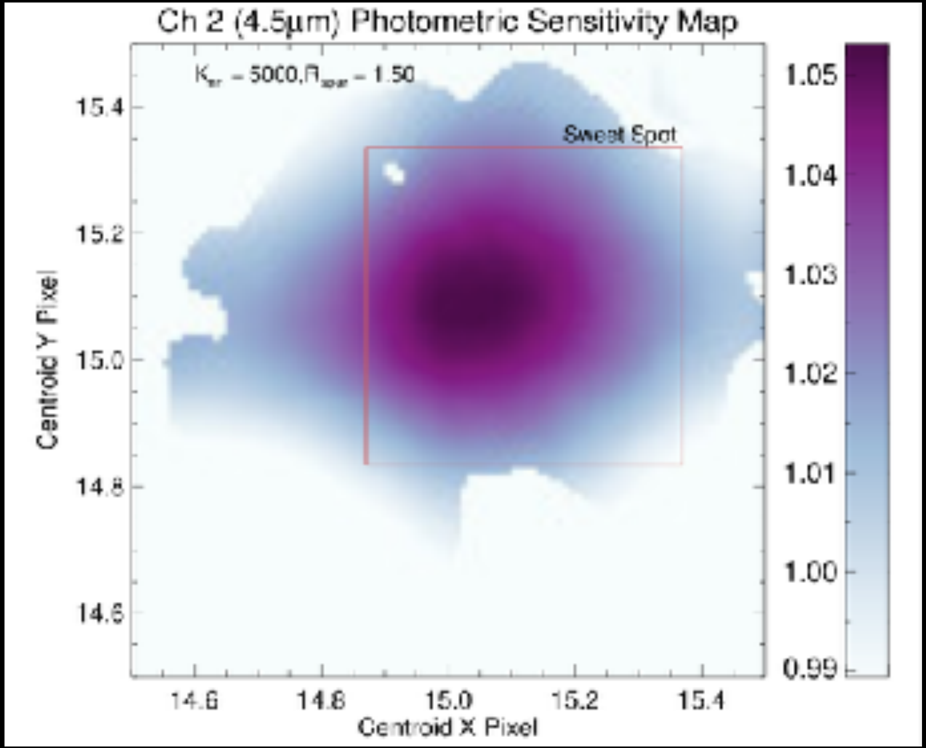

Brightness varies by a few percent with location on camera

Want to measure 0.005% variations to study exoplanets

Ingalls et al. (2018)

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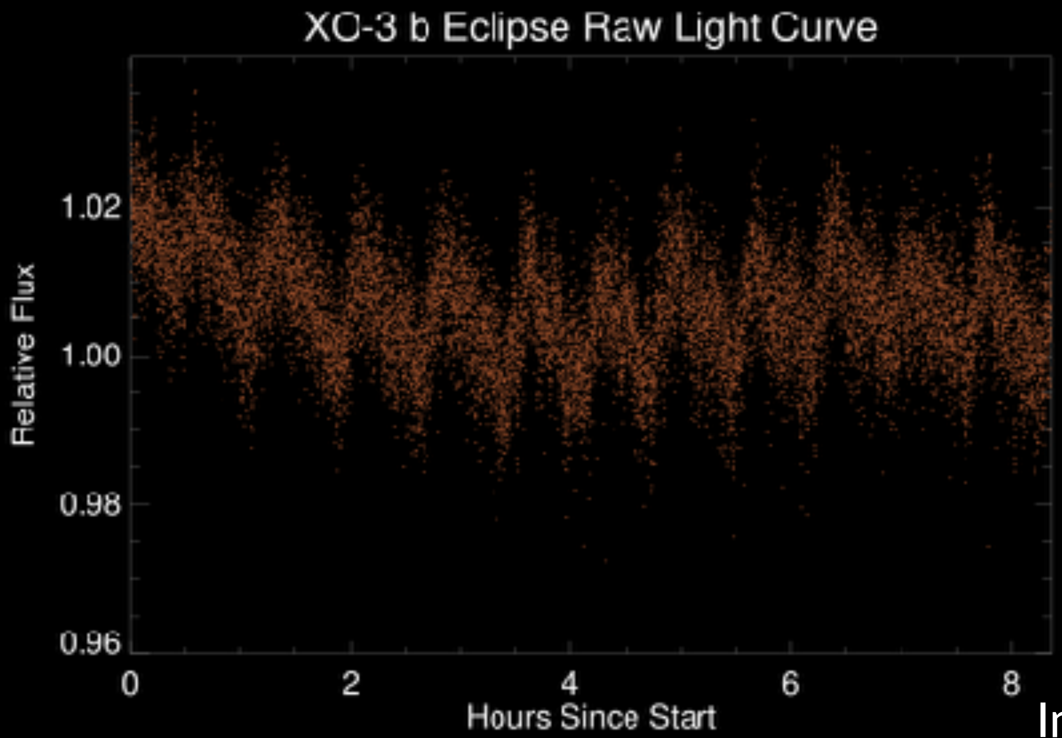
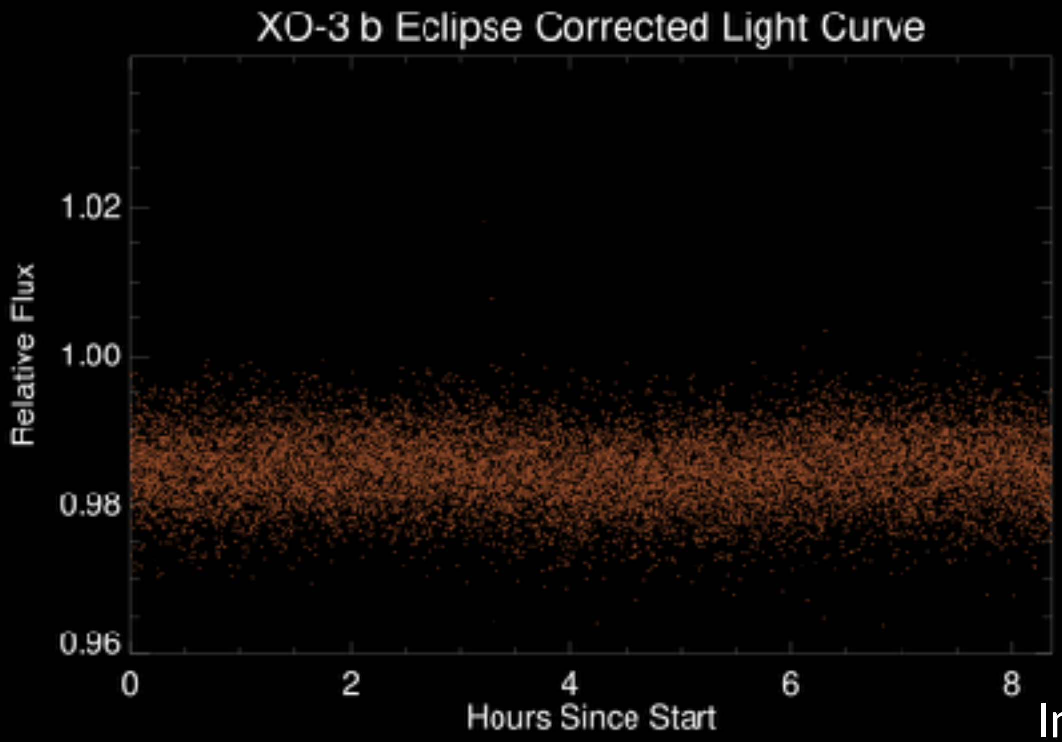


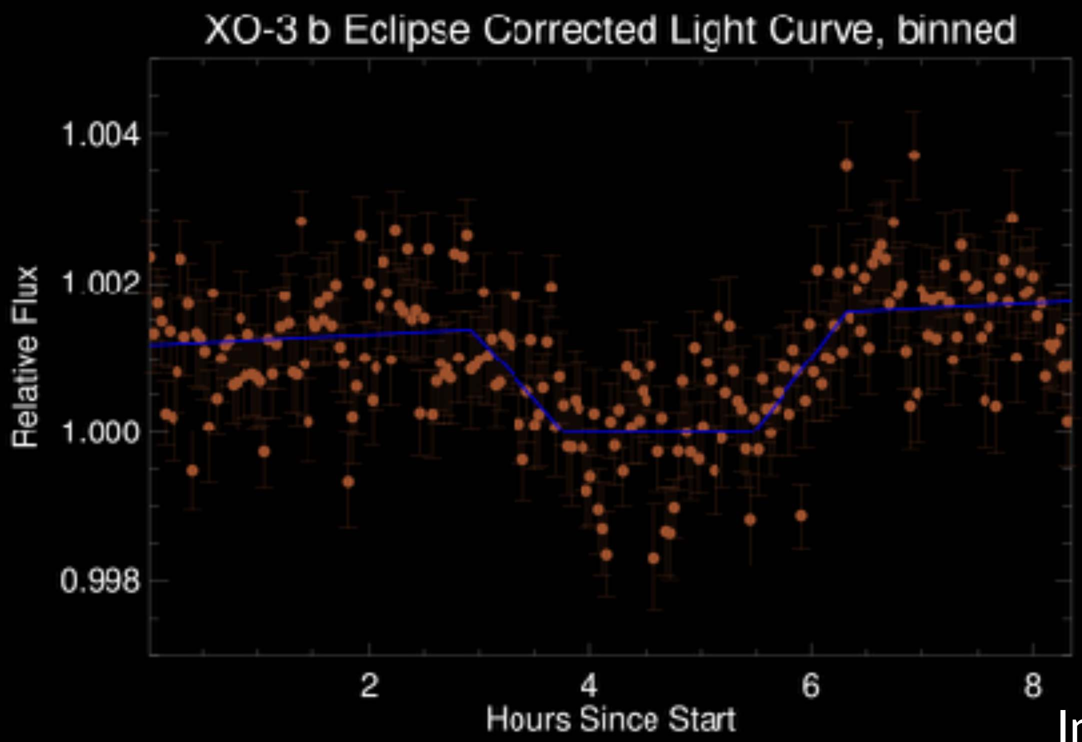
Ingalls et al. (2016)

Clever processing is needed



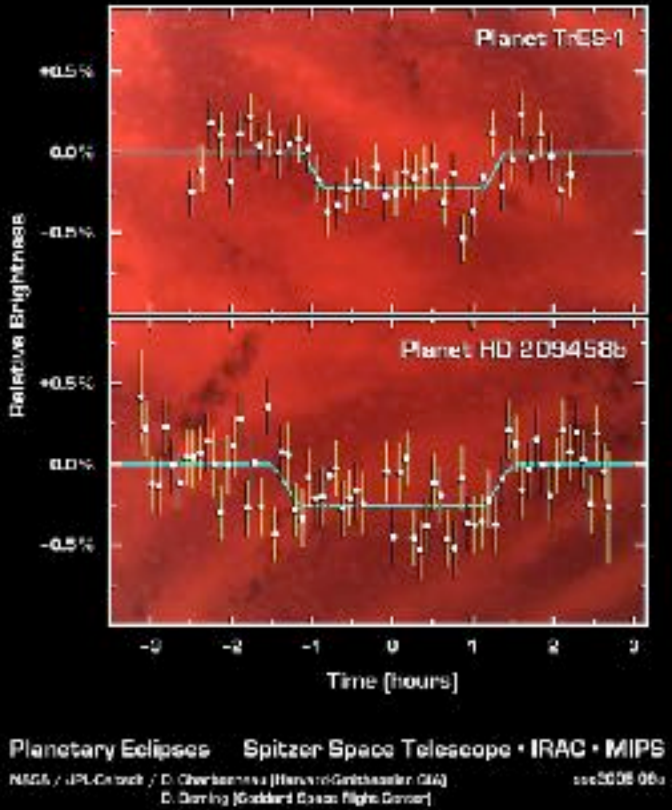
Ingalls et al. (2016)

Average data to reduce noise



Ingalls et al. (2016)

First detections of thermal emission from exoplanets



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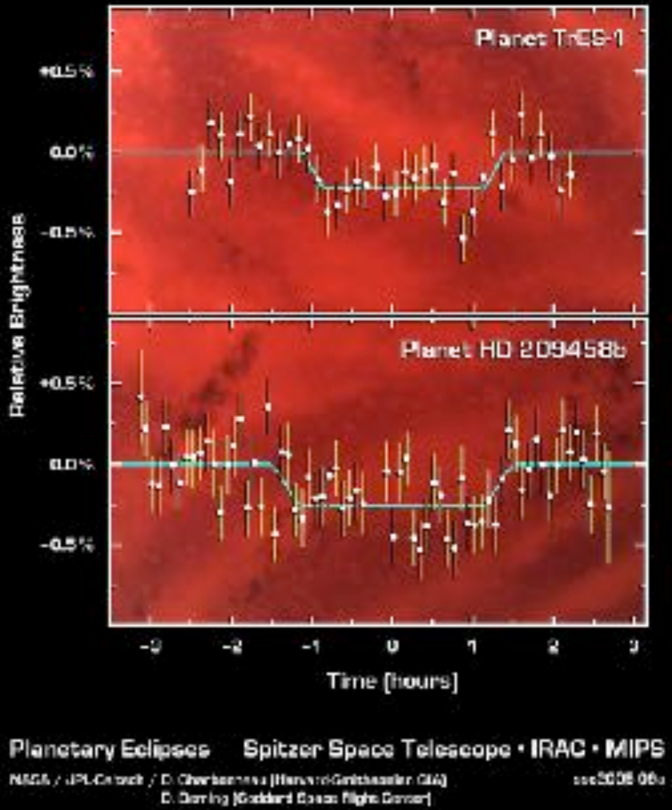

TrES-1
T = 1060 K
Charbonneau et al. (2006)

HD 209458b
T = 1130 K
Deming et al. (2006)

What happened when Spitzer ran out of cryogen

Spitzer heated up from <12 K to 28K

Only 2 cameras on one instrument still work

- 3.6 and 4.5 micron cameras
- Work same as they did before

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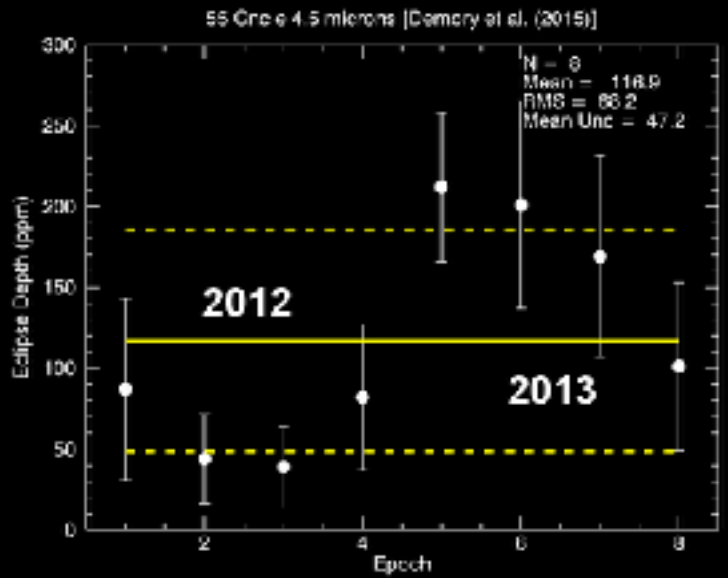
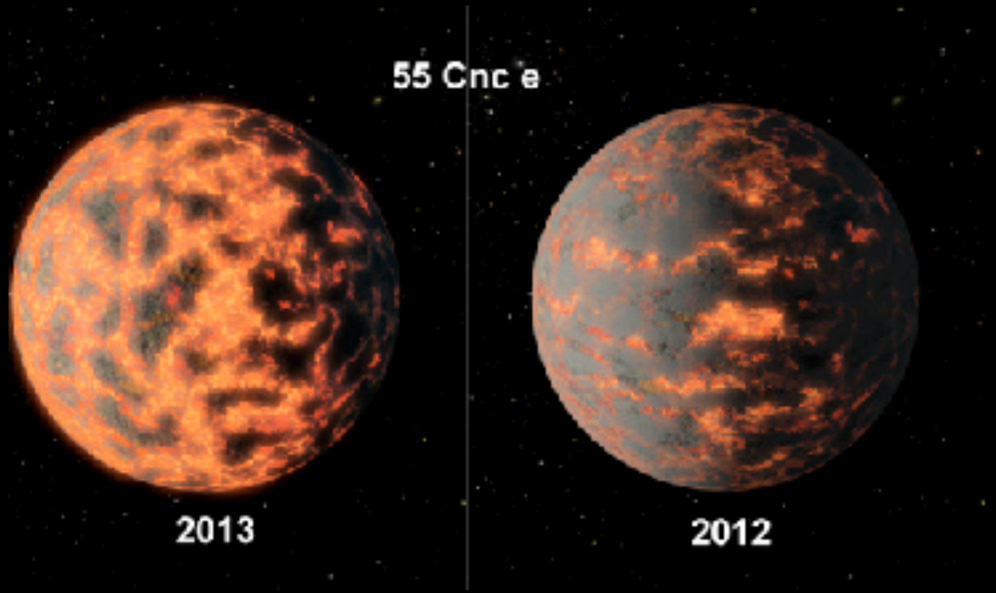
More focus on exoplanets and distant galaxies!

Temperature variations for 55 Cnc e





High T ~ 2800 K

Low T ~ 1300 K

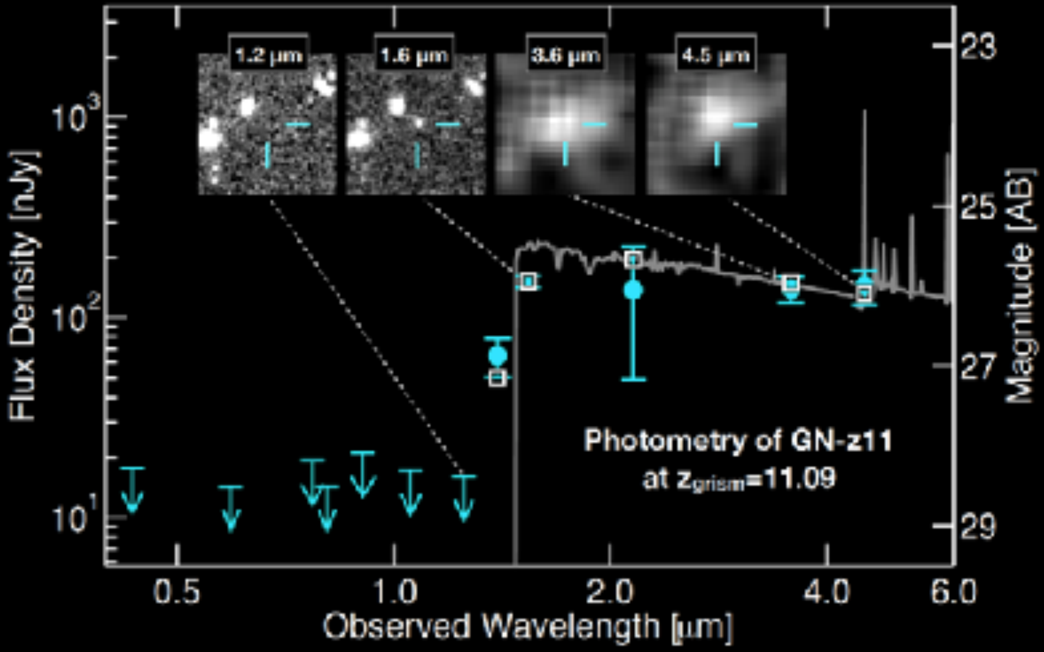
Most distant galaxy

Observed at z=11

13.4 billion years ago

1/100th the mass of the Milky Way

Oesch et al. (2014)



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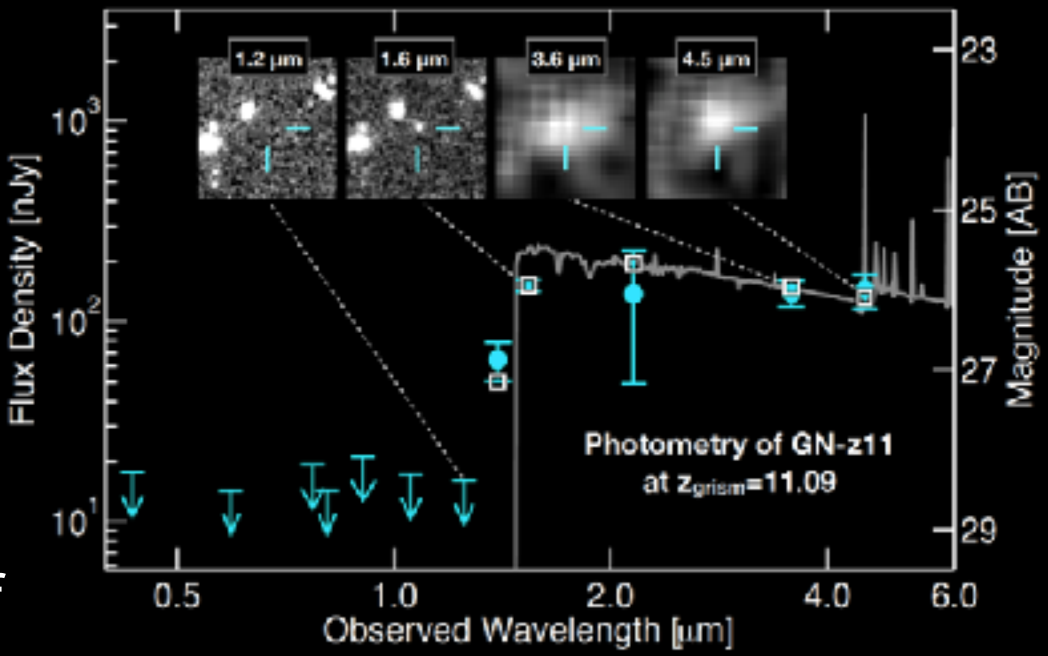
Observed at z=11

13.4 billion years ago

1/100th the mass of the Milky Way

HST gives redshift (time)
Spitzer gives mass/age of stars

Oesch et al. (2014)

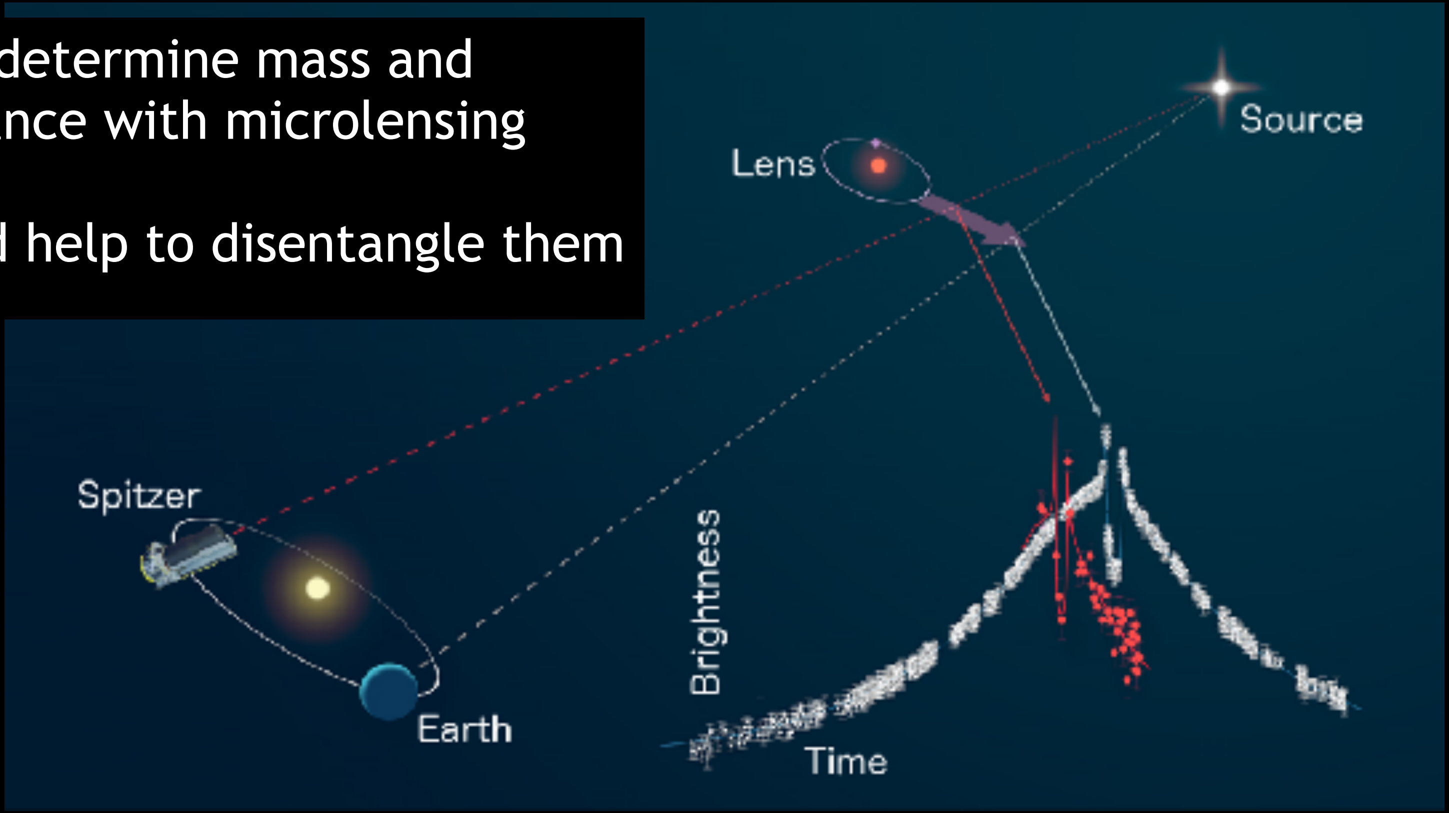


Gravitational Microlensing

Microlensing Parallax

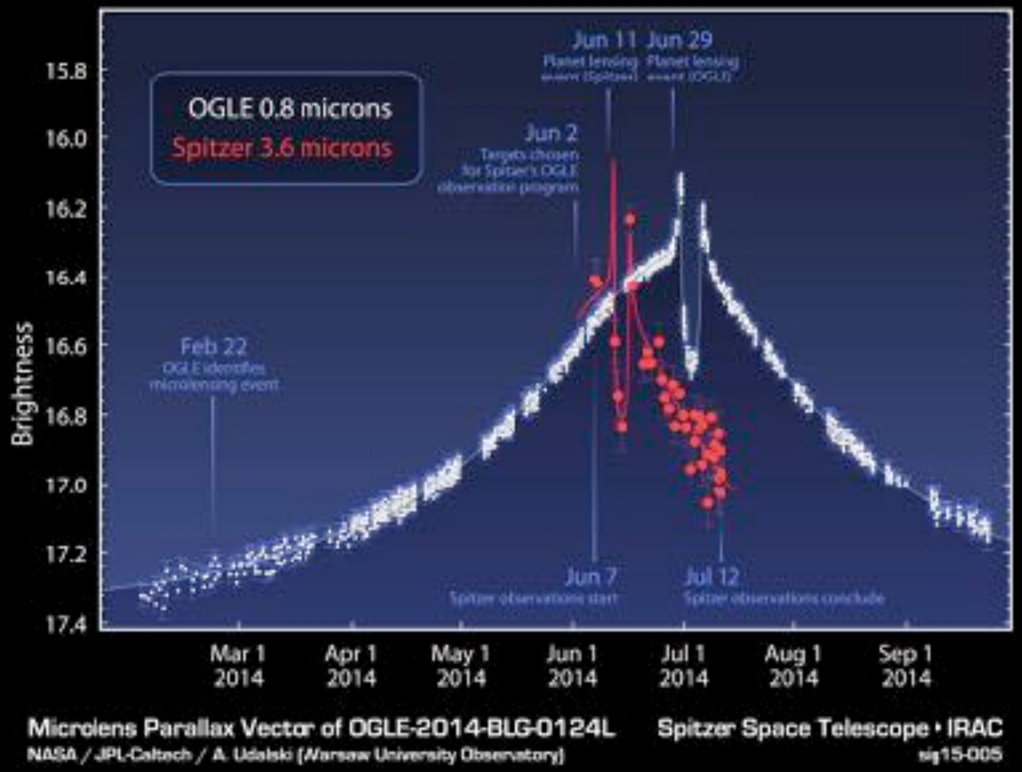
Can determine mass and distance with microlensing

Need help to disentangle them



First microlensing planet with Spitzer

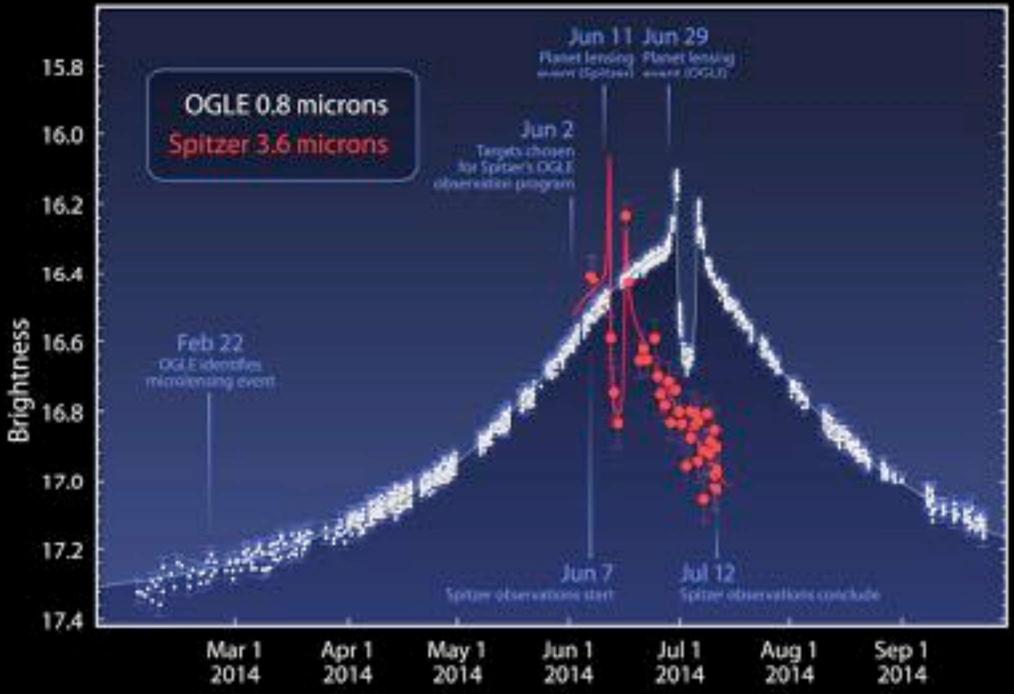
Star mass = 0.7 Solar



First microlensing planet with Spitzer

Star mass = 0.7 Solar

Planet mass = 0.5 Jupiter



Microlens Parallax Vector of OGLE-2014-BLG-0124L   Spitzer Space Telescope • IRAC

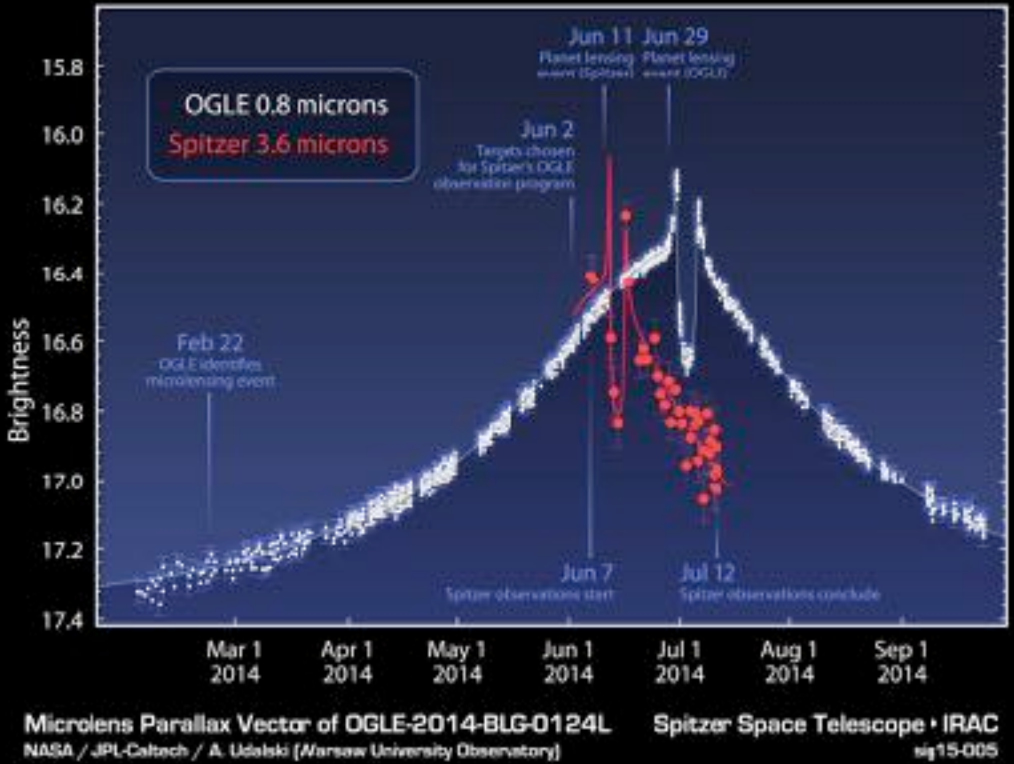
NASA / JPL-Caltech / A. Udalski (Warsaw University Observatory)   sig15-005

First microlensing planet with Spitzer

Star mass = 0.7 Solar

Planet mass = 0.5 Jupiter

Planet distance from star = 3.1 au



TRAPPIST-1 facts

Star discovered in 2000

Distance = 39.6 light years

Star mass = 0.08 Solar

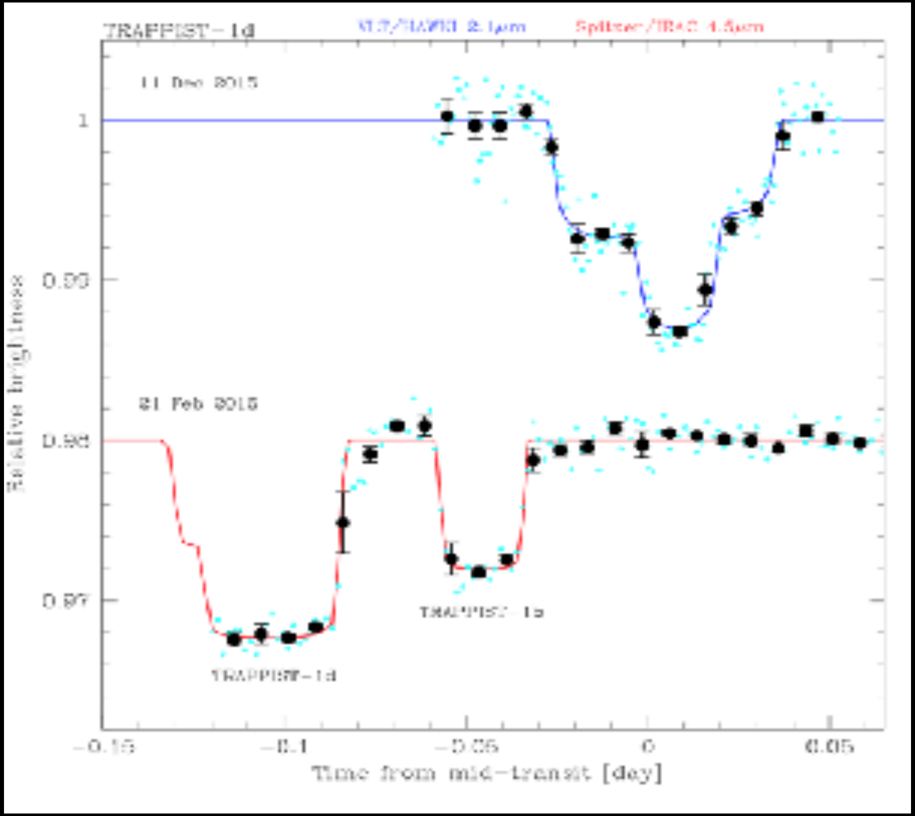
Star radius = 1.1 Jupiter radii

Star temperature = 2500 K

4000x brighter in IR

Artist concept (T. Pyle, JPL/Caltech)

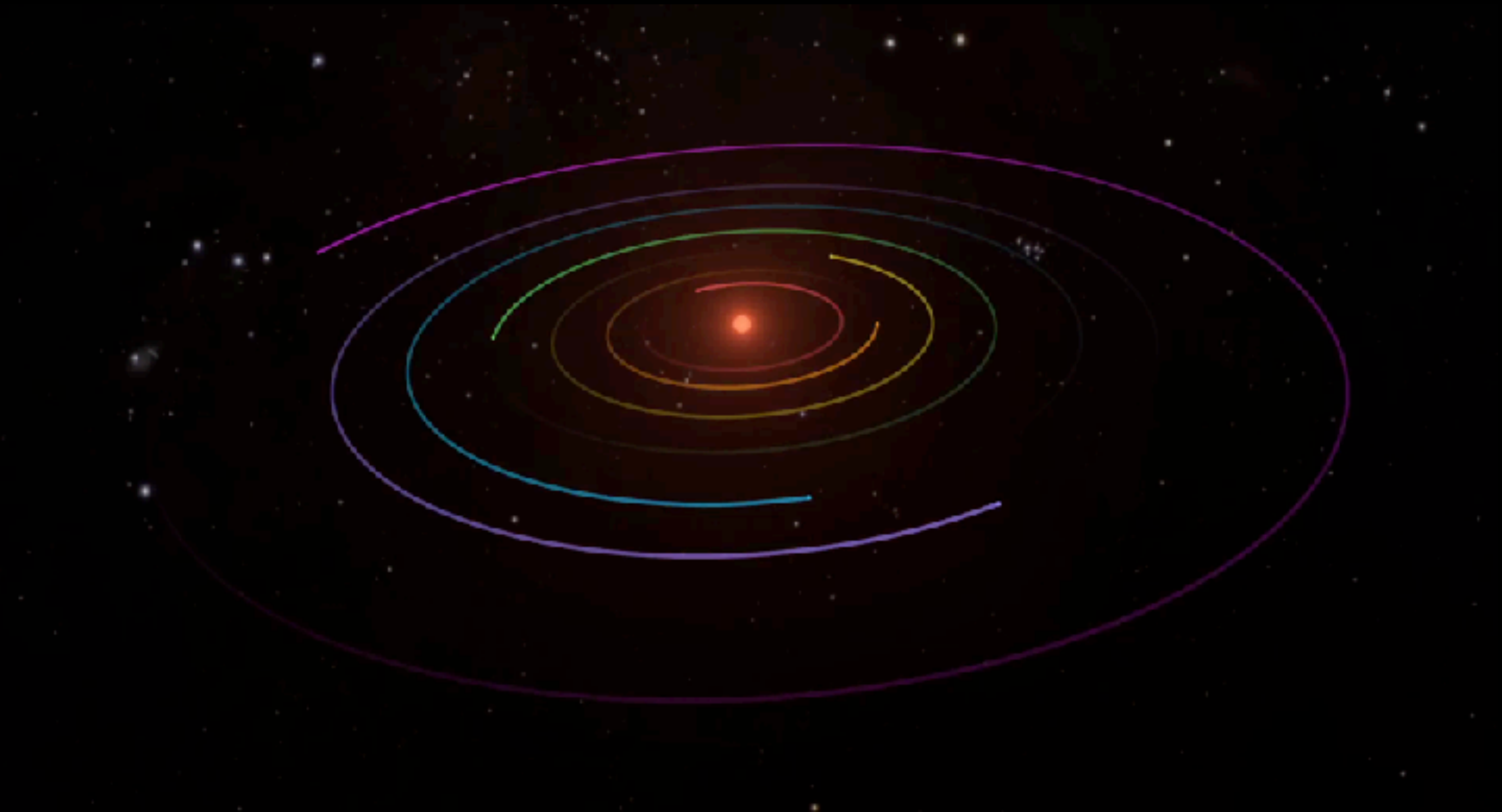
TRAPPIST-1 had weird transits



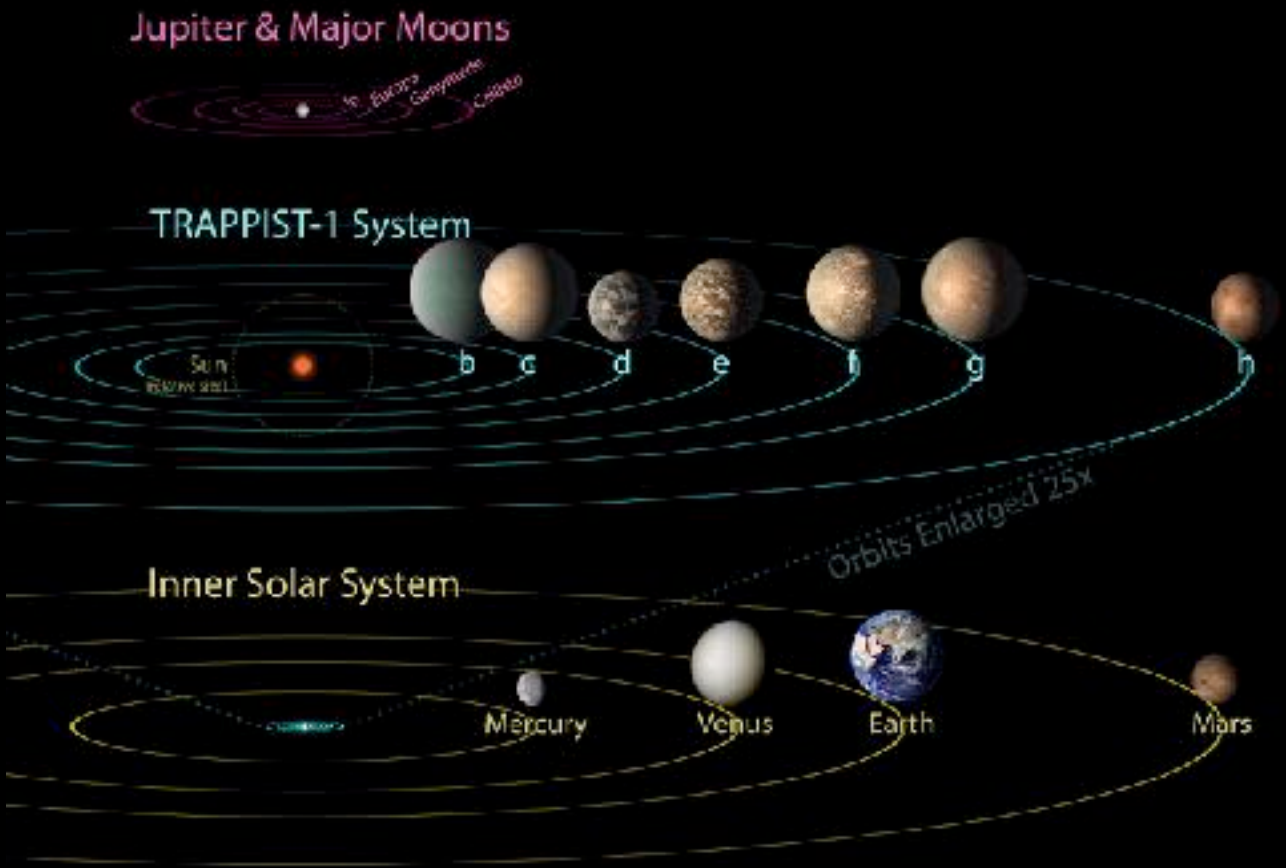
VLT follow-up photometry

Spitzer DDT 21 Feb 2016 (5hrs)

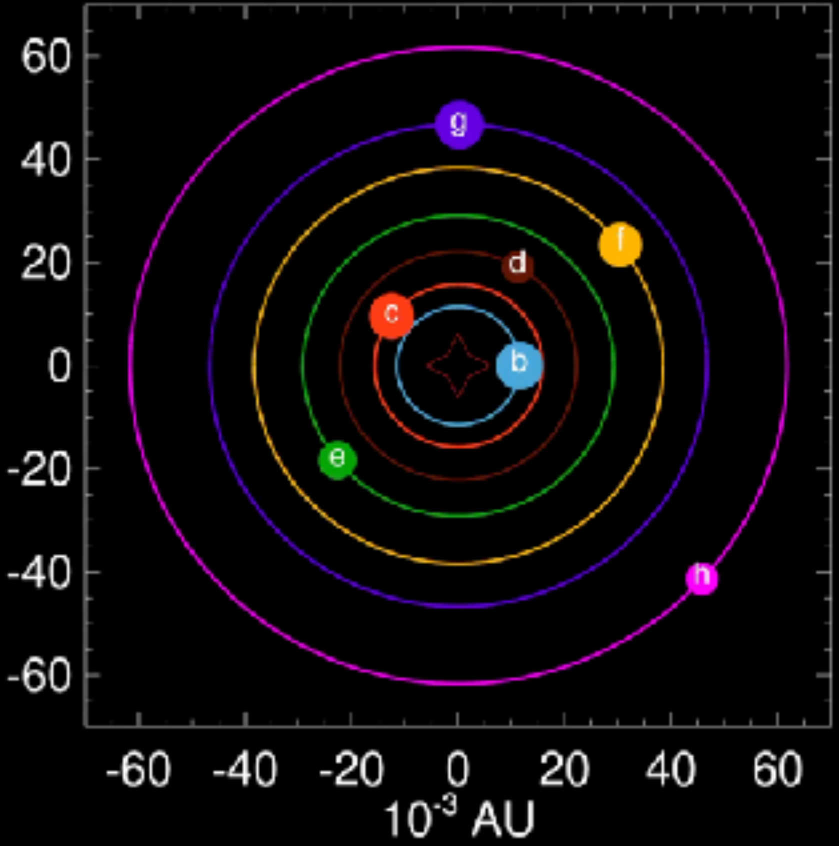
At first, did not understand the light curves!

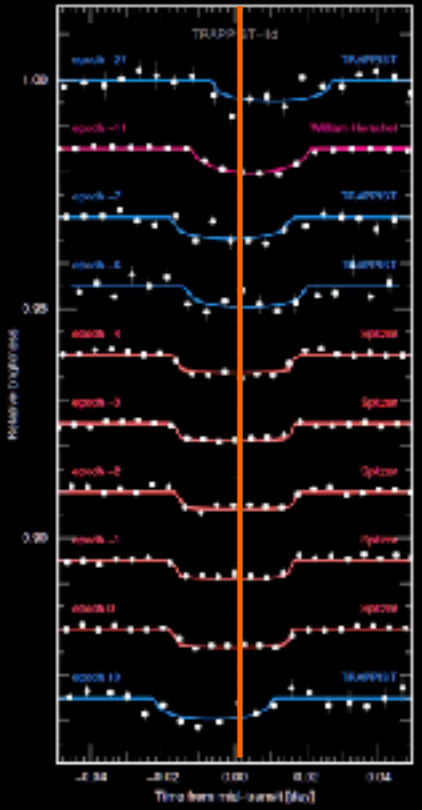


TRAPPIST-1 system is much smaller than ours

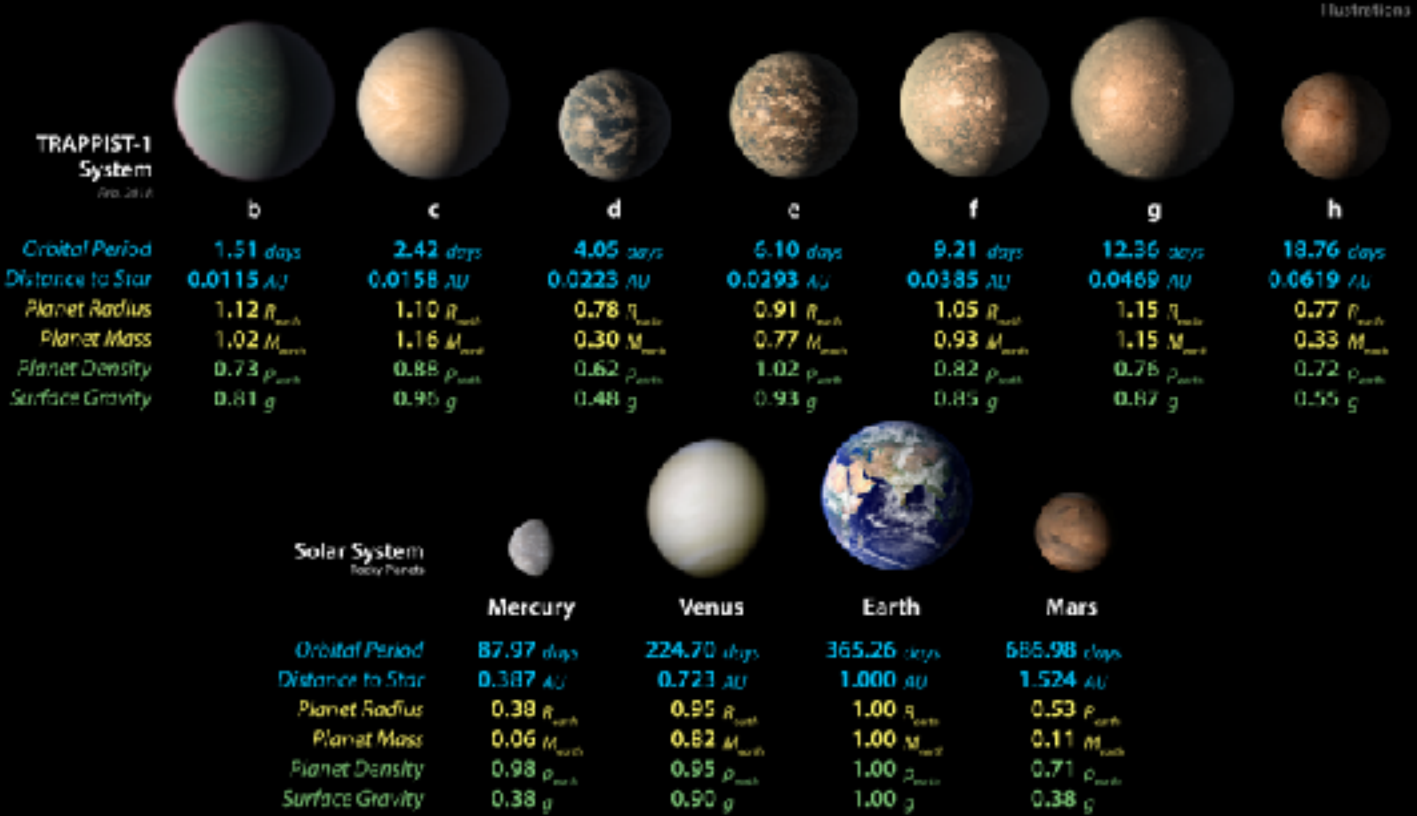


TRAPPIST-1 resonance and transit timing

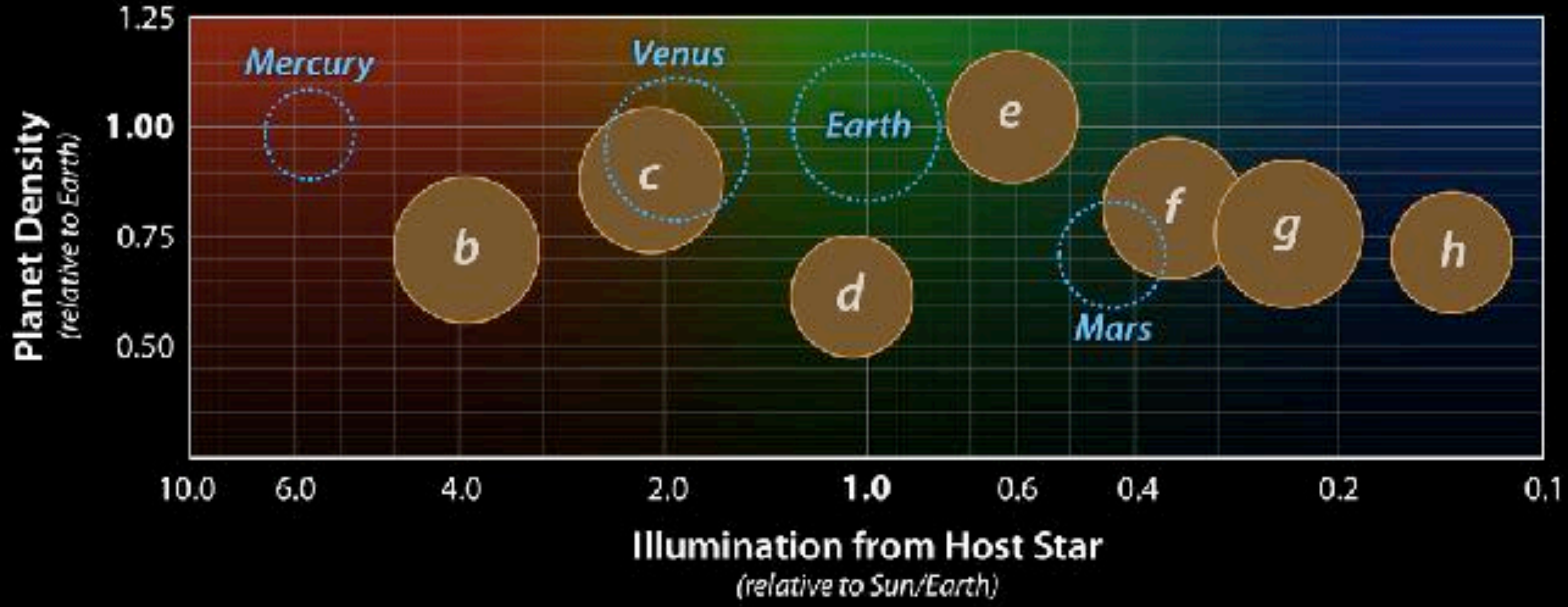




What we know about the TRAPPIST-1 planets

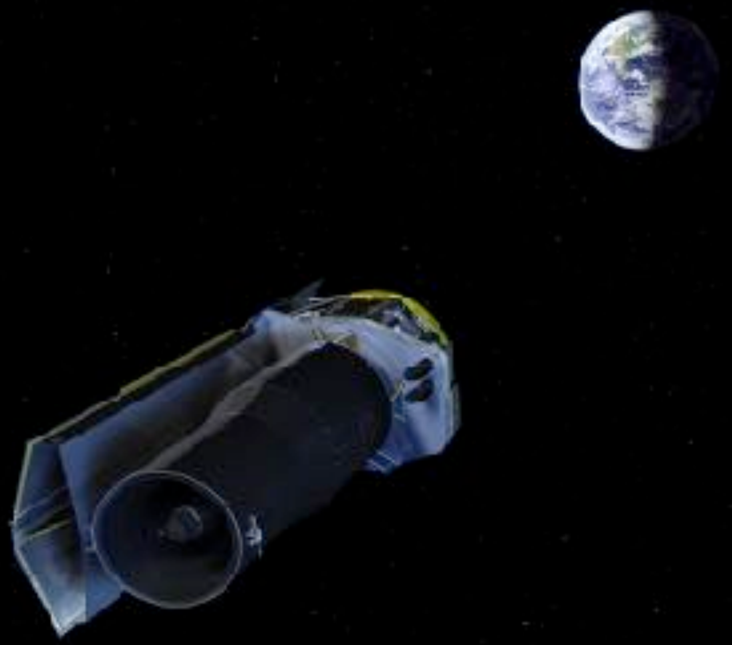


TRAPPIST-1/Solar System Comparison



Looking to the future

Spitzer operations continue until November 2019



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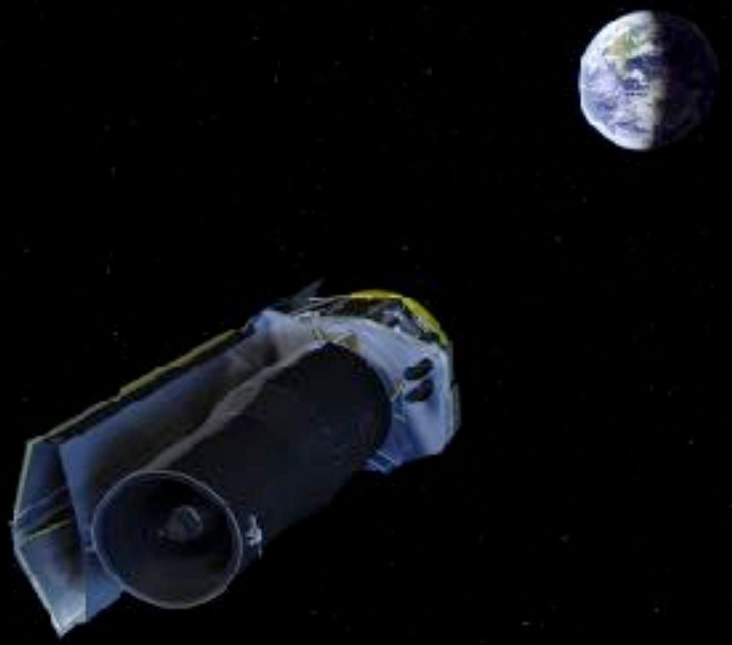
Looking for planets around cooler stars (and brown dwarfs) than TRAPPIST-1



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May measure the mass of an isolated stellar mass black hole

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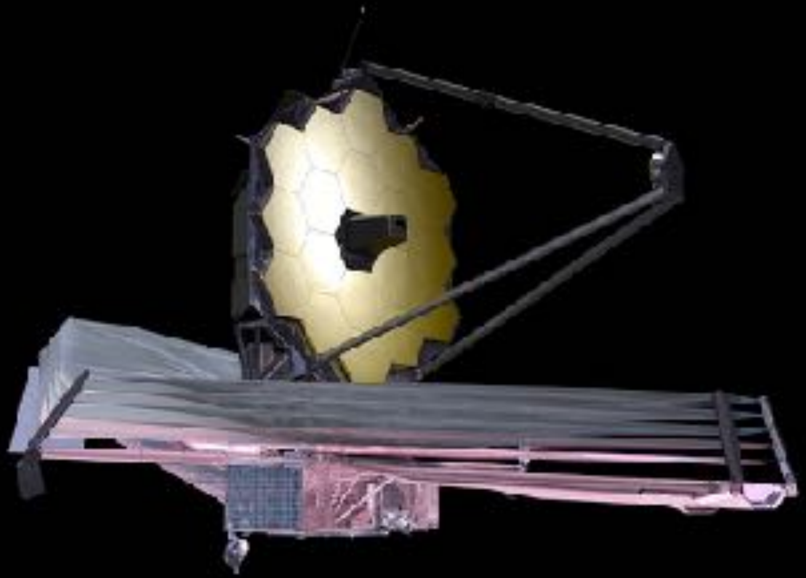
JWST to launch in 2021



Thank you!

For more information
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