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Sandia National Laboratories

SAND2015-9919PE

How many planets are there in the universe?

Brent Jones

Sandia National Laboratories

Presentation to Ms. Montoya's 2nd grade class

Georgia O'Keefe Elementary School

November 13, 2015

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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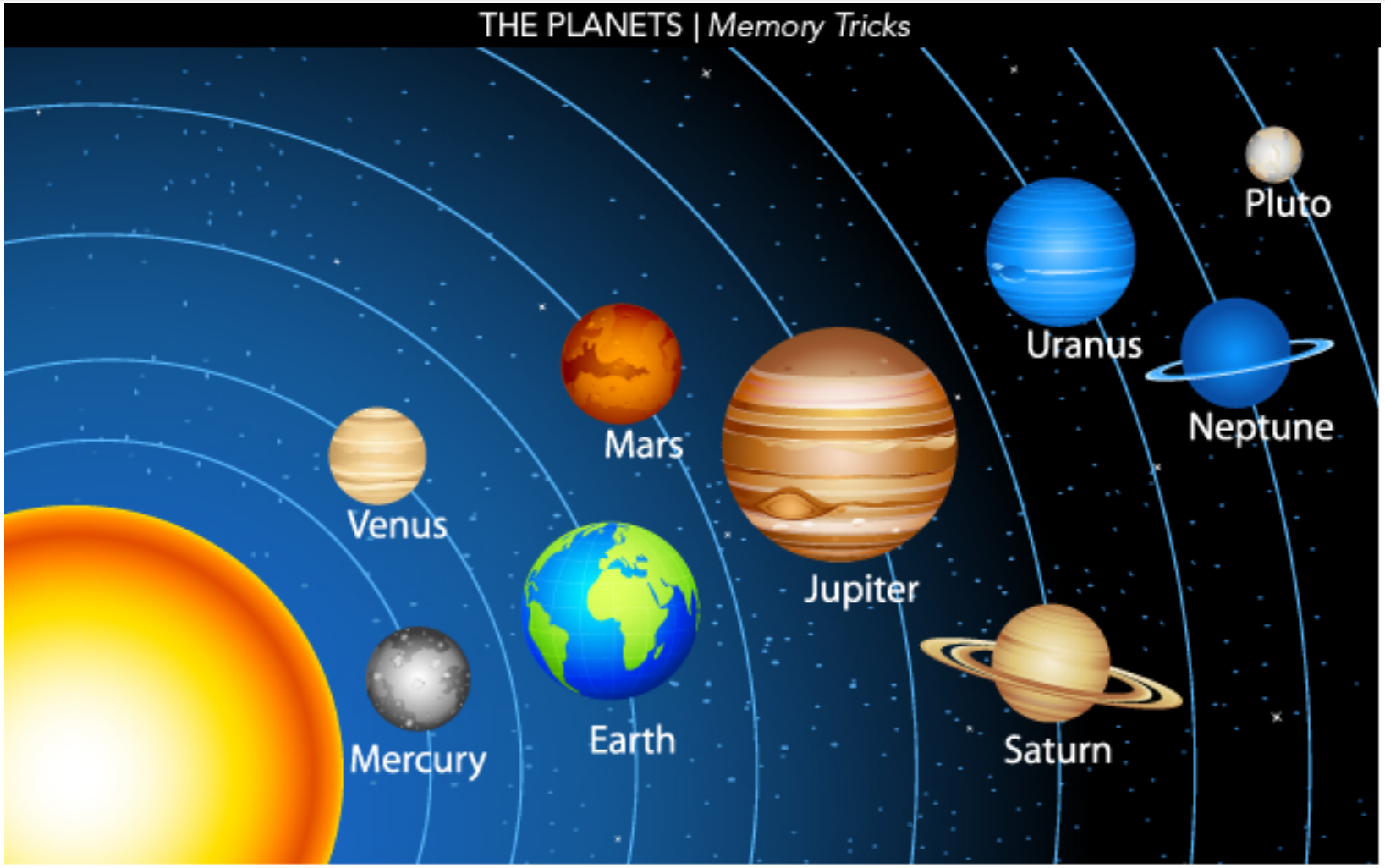
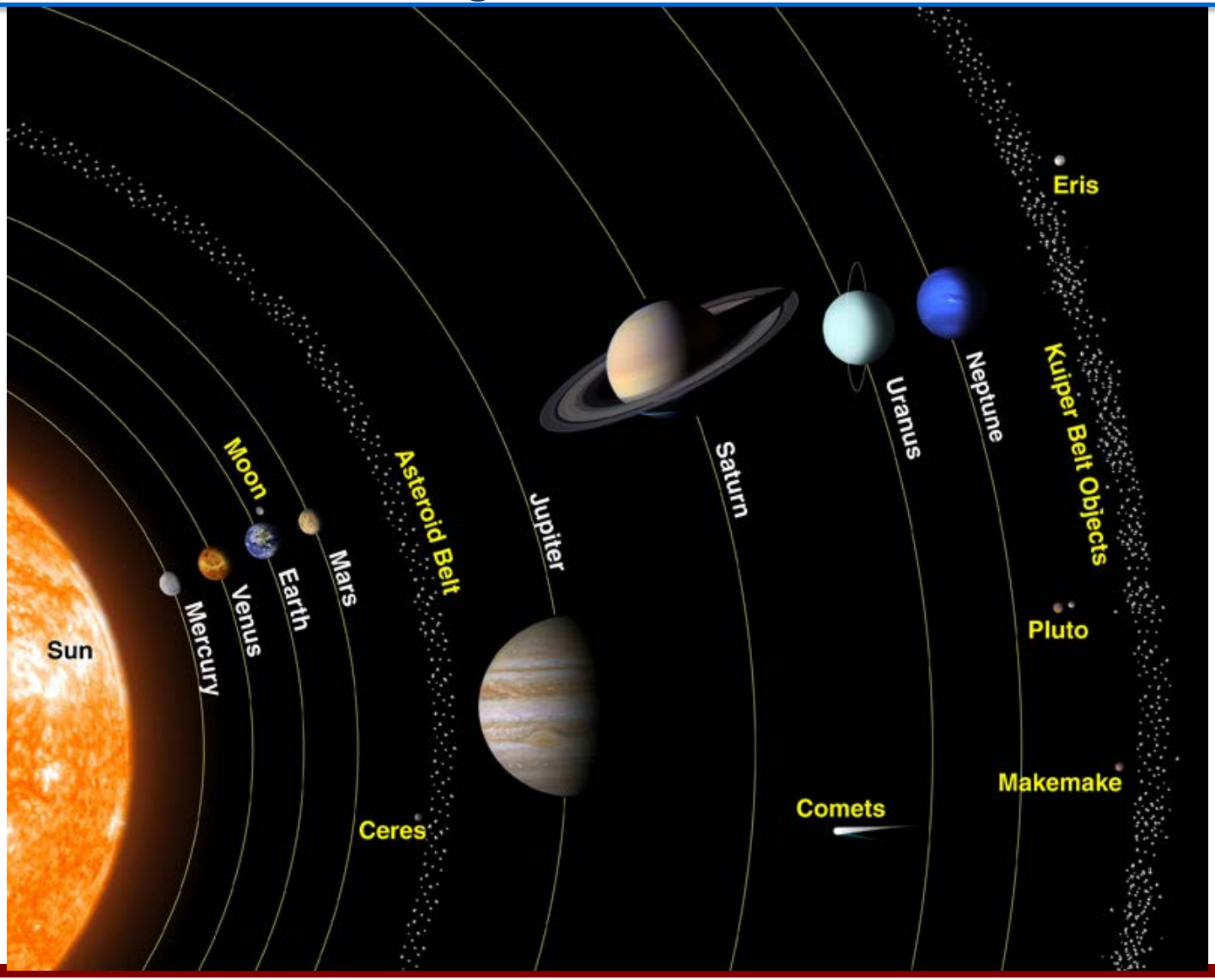
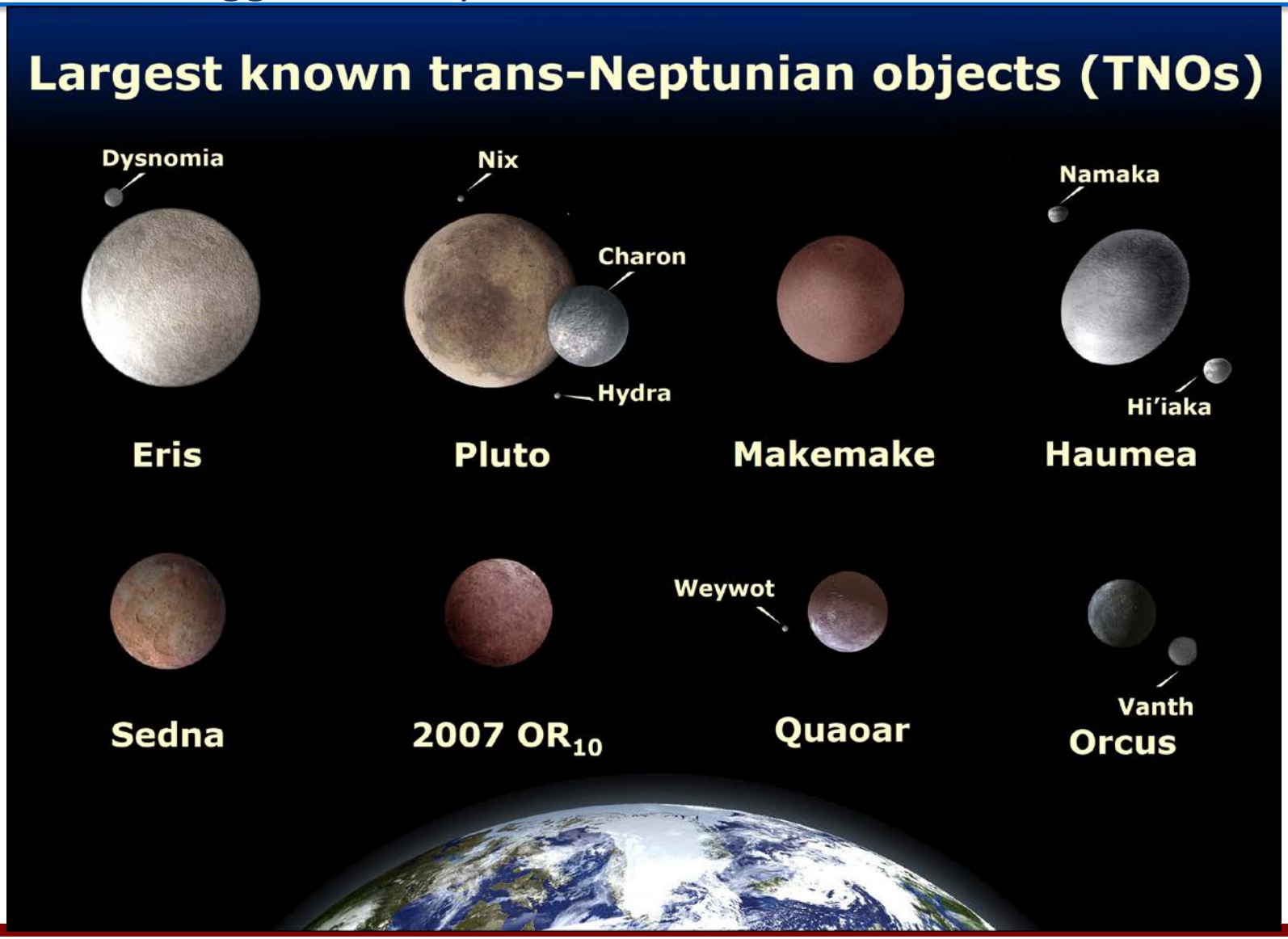
Our solar system has nine planets…or is it eight?



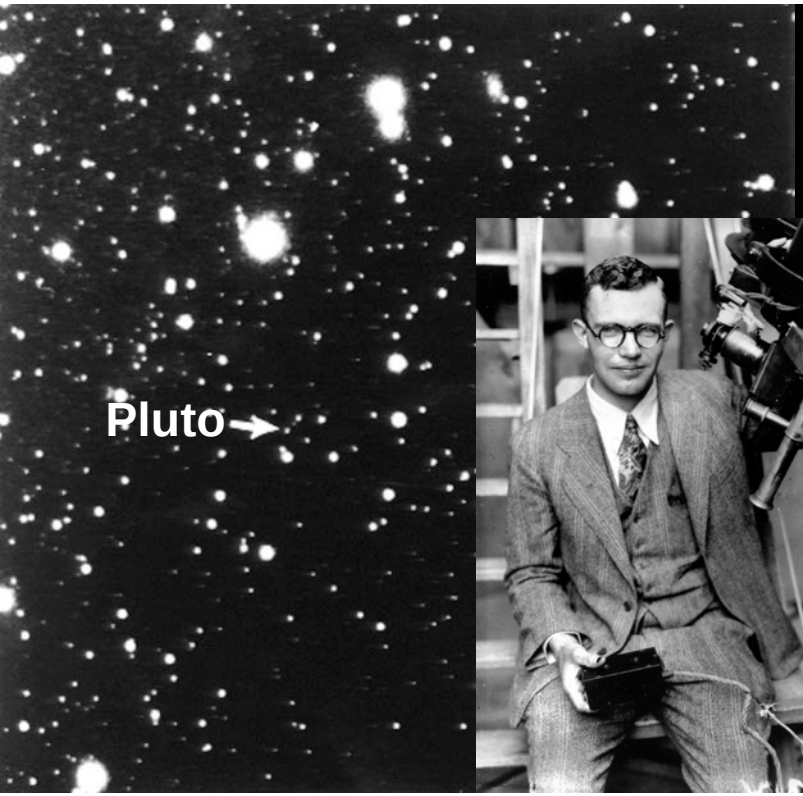
Our solar system has planets, plus dwarf planets, asteroids, comets, solar wind, magnetic fields…and more!

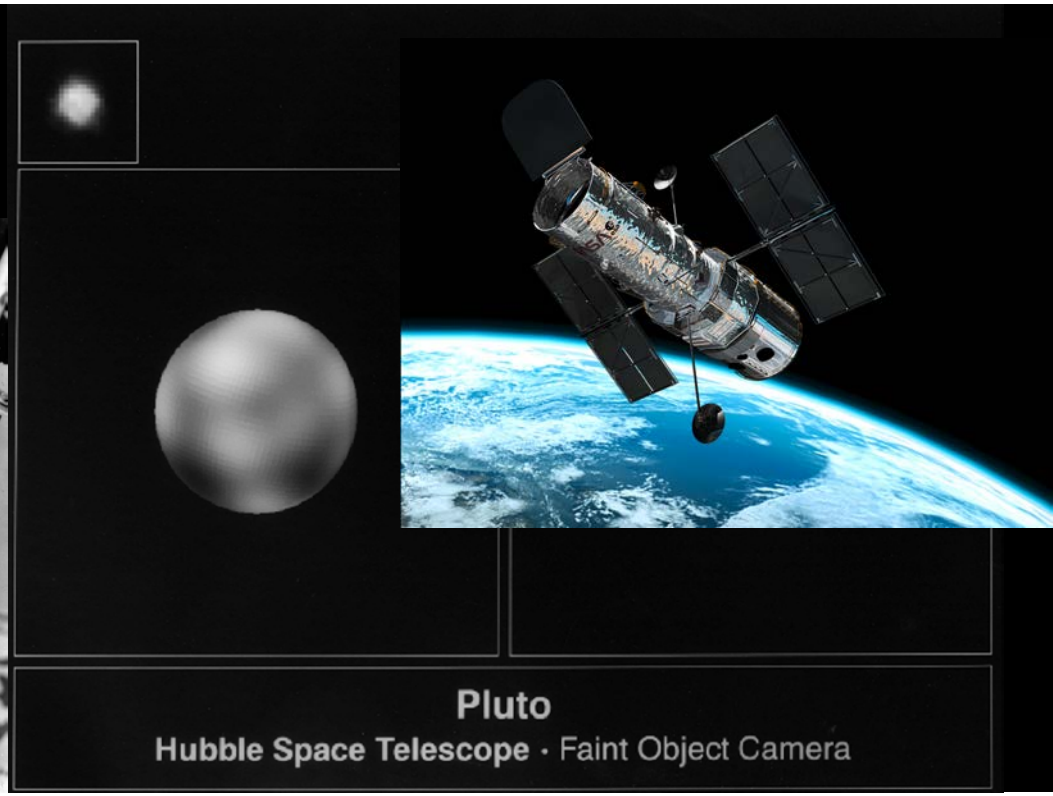


There are many objects in the outer solar system—Eris is a bigger dwarf planet than Pluto



Pluto is so far away, that it is hard to take a good picture of it





- Pluto was discovered in 1930 by Clyde Tombaugh
- In 2006, the International Astronomical Union declared it a dwarf planet (but Pluto is a planet by law in New Mexico)

http://www.theguardian.com/science/gallery/2015/jul/15/pluto-new-horizons-nasa-hubble-images-gallery
https://www.washingtonpost.com/news/morning-mix/wp/2015/07/15/how-a-precocious-11-year-old-girl-gave-pluto-its-name/
http://cdn.spacetelescope.org/archives/images/wallpaper5/hubble_in_orbit1.jpg

The NASA spacecraft New Horizons is exploring the Pluto system

https://www.nasa.gov/mission_pages/newhorizons/main/index.html

The New Horizons spacecraft launched from Cape Canaveral, Florida, in 2006 on an Atlas V rocket

http://www.theatlantic.com/photo/2015/07/the-voyage-of-new-horizons-jupiter-pluto-and-beyond/398408/

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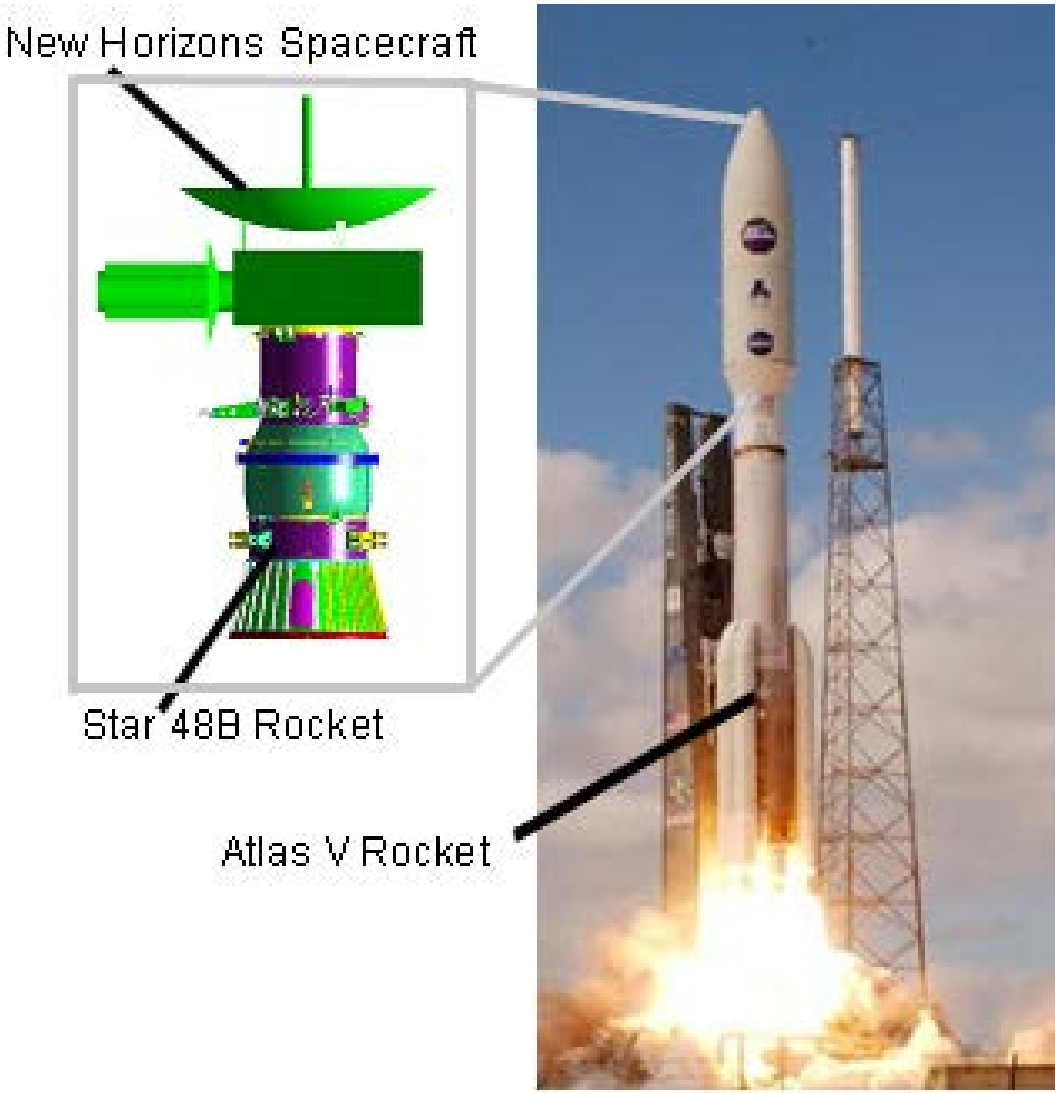
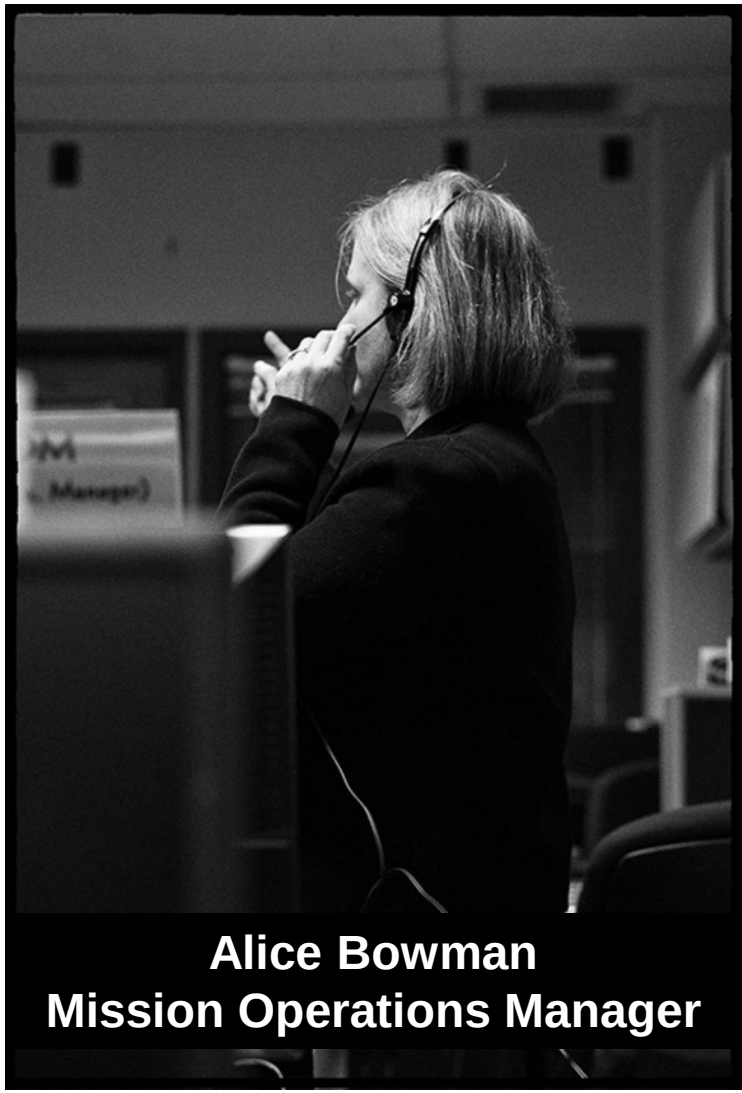
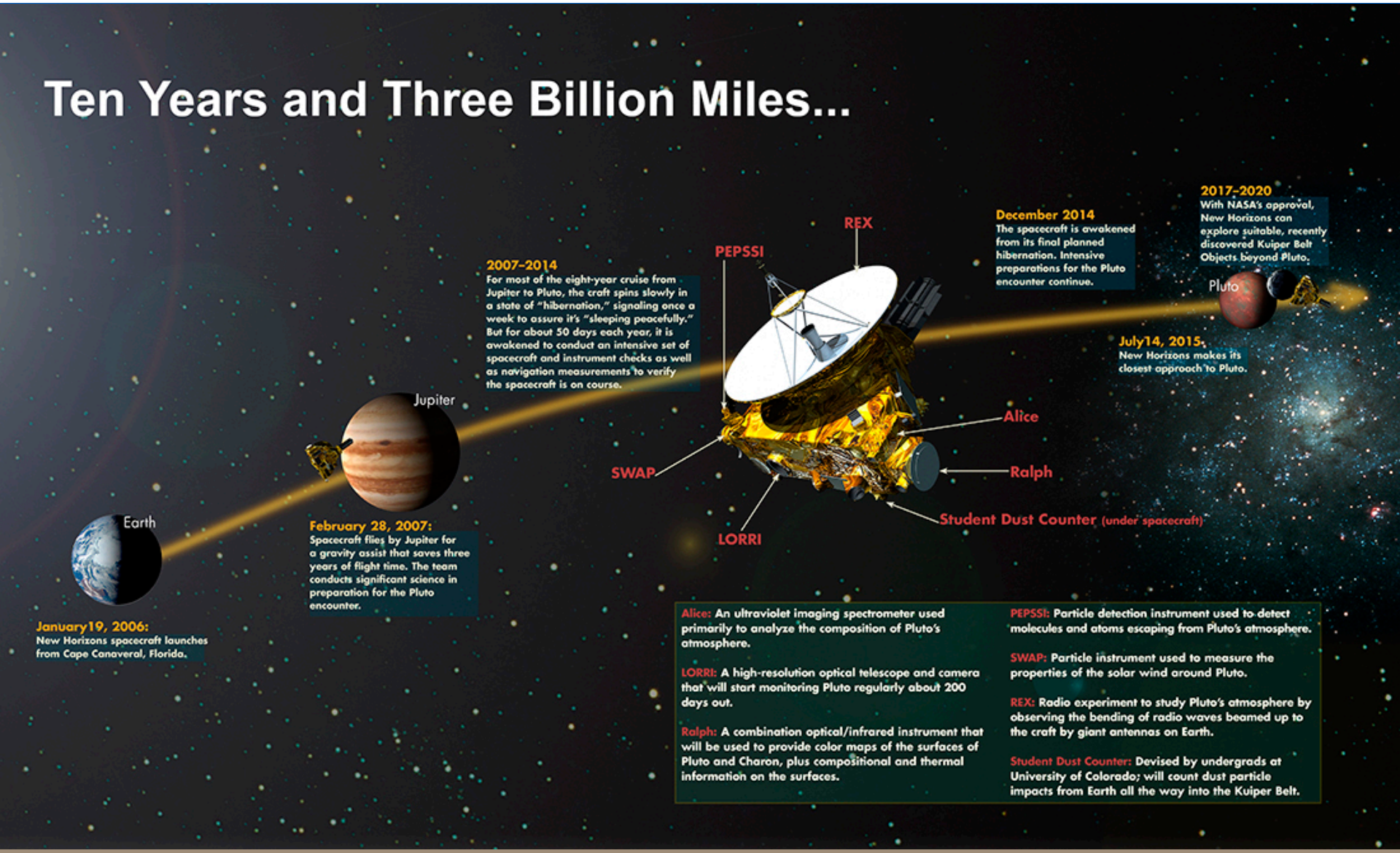




http://pluto.jhuapl.edu/Mission/The-Path-to-Pluto/Mission-Timeline.php
http://earthsky.org/space/these-women-power-new-horizons-pluto-flyby

Complex space missions require planning over decades



http://pluto.jhuapl.edu/Mission/The-Path-to-Pluto/Mission-Timeline.php

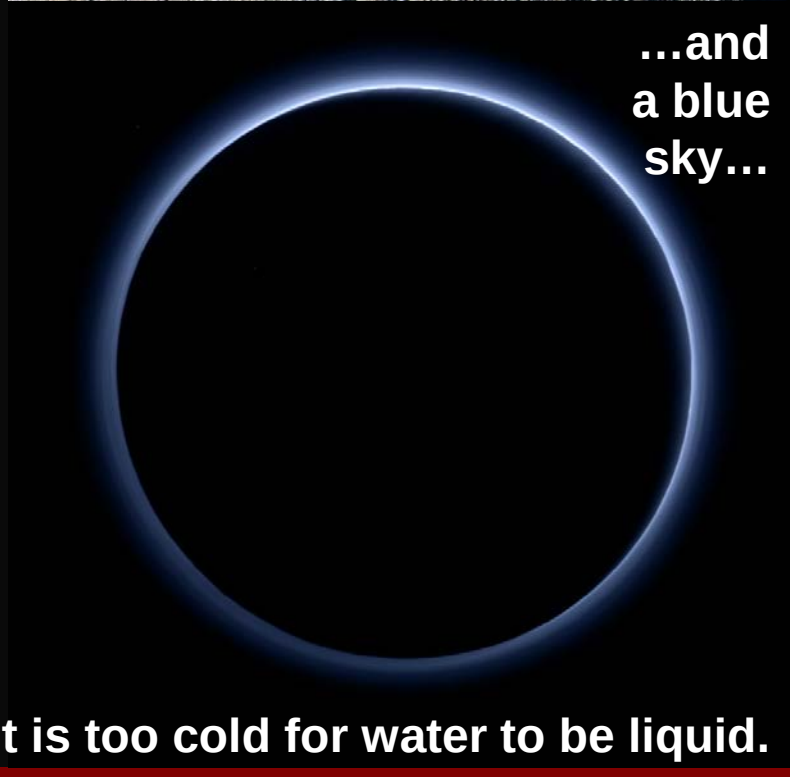
In 2015, New Horizons has returned stunning images of Pluto and its moons…

…and it took teamwork!

https://www.nasa.gov/mission_pages/newhorizons/main/index.html
http://www.space.com/29836-rock-band-styx-pluto-new-horizons.html

Could we live on Pluto?

Pluto has icy mountains…

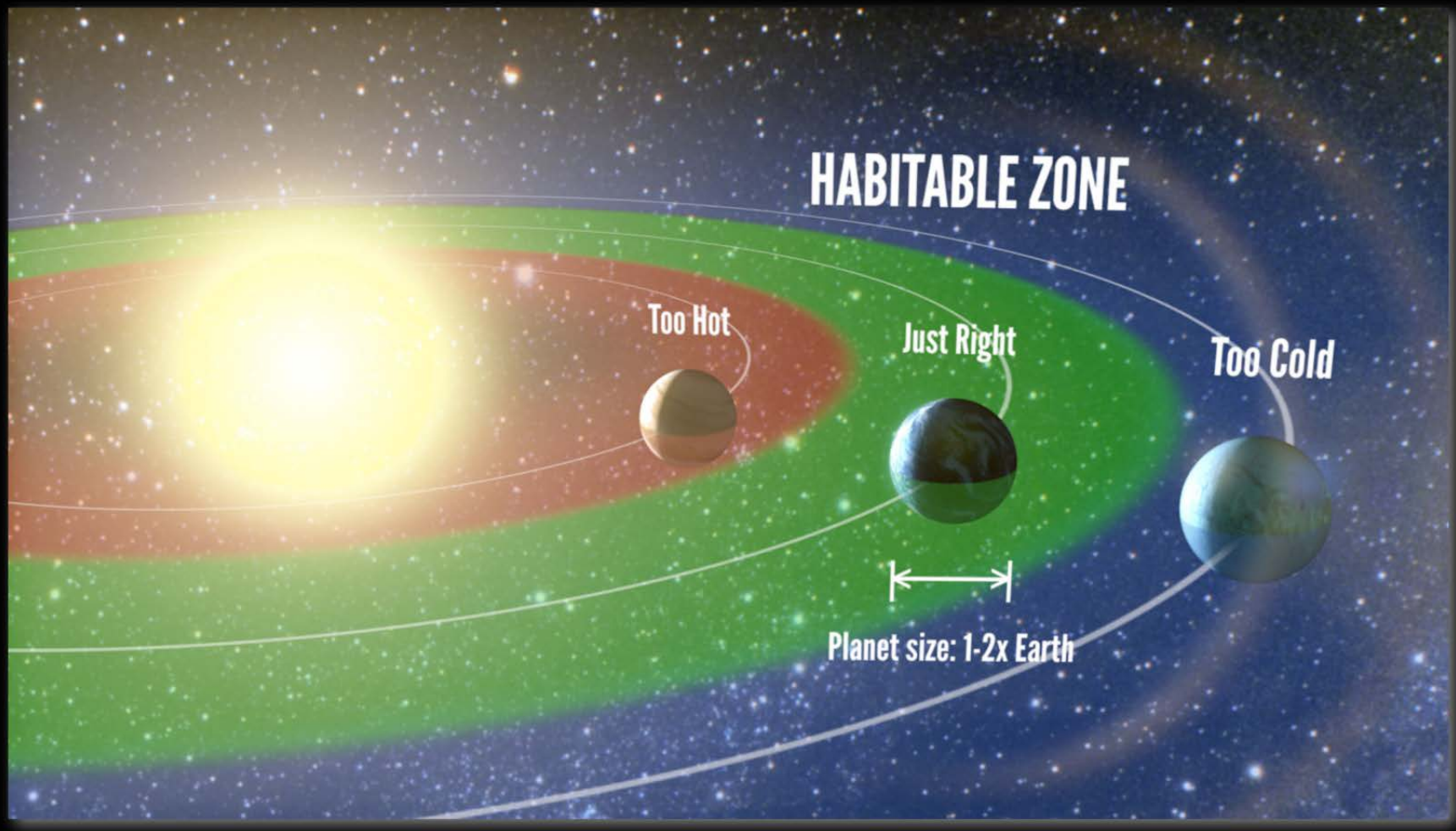


…and a blue sky…

…but it is too cold for water to be liquid.

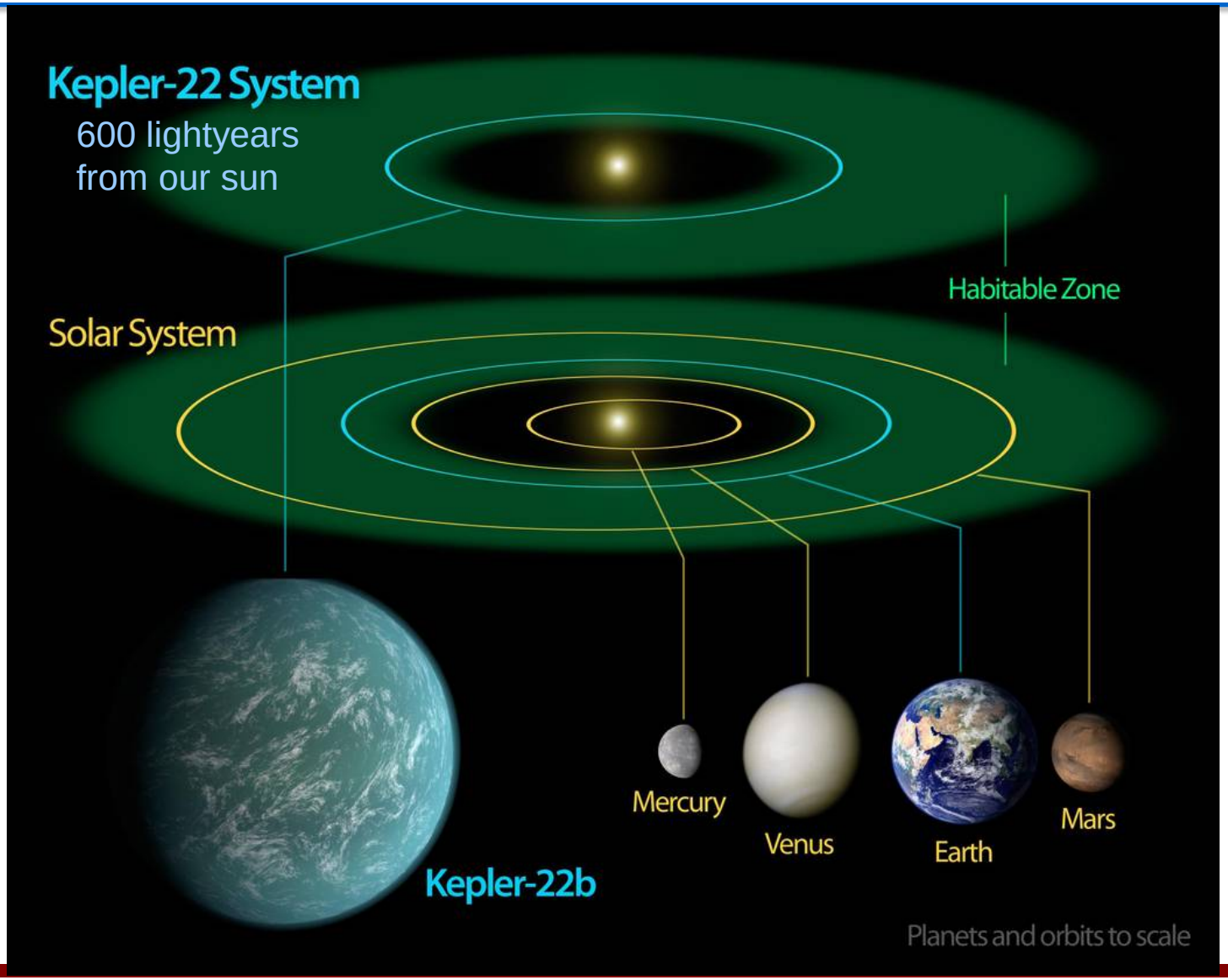
https://en.wikipedia.org/wiki/Pluto#/media/File:Nh-pluto-in-true-color_2x_JPEG.jpg
https://www.nasa.gov/image-feature/the-tartarus-dorsa-mountains-rise-up-along-pluto
http://solarsystem.nasa.gov/news/2015/10/08/new-horizons-finds-blue-skies-and-water-ice-on-pluto

The Goldilocks Zone is a range of distances from a star where life might exist



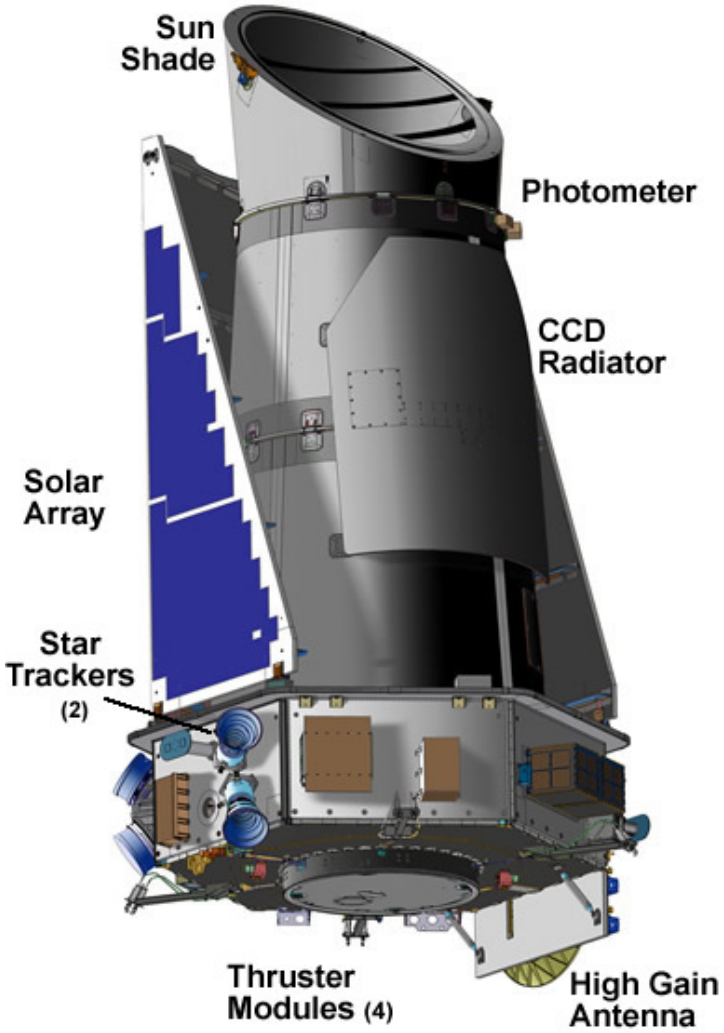
The habitable zone corresponds to the range of orbital distances where liquid water can exist on a planet's surface.

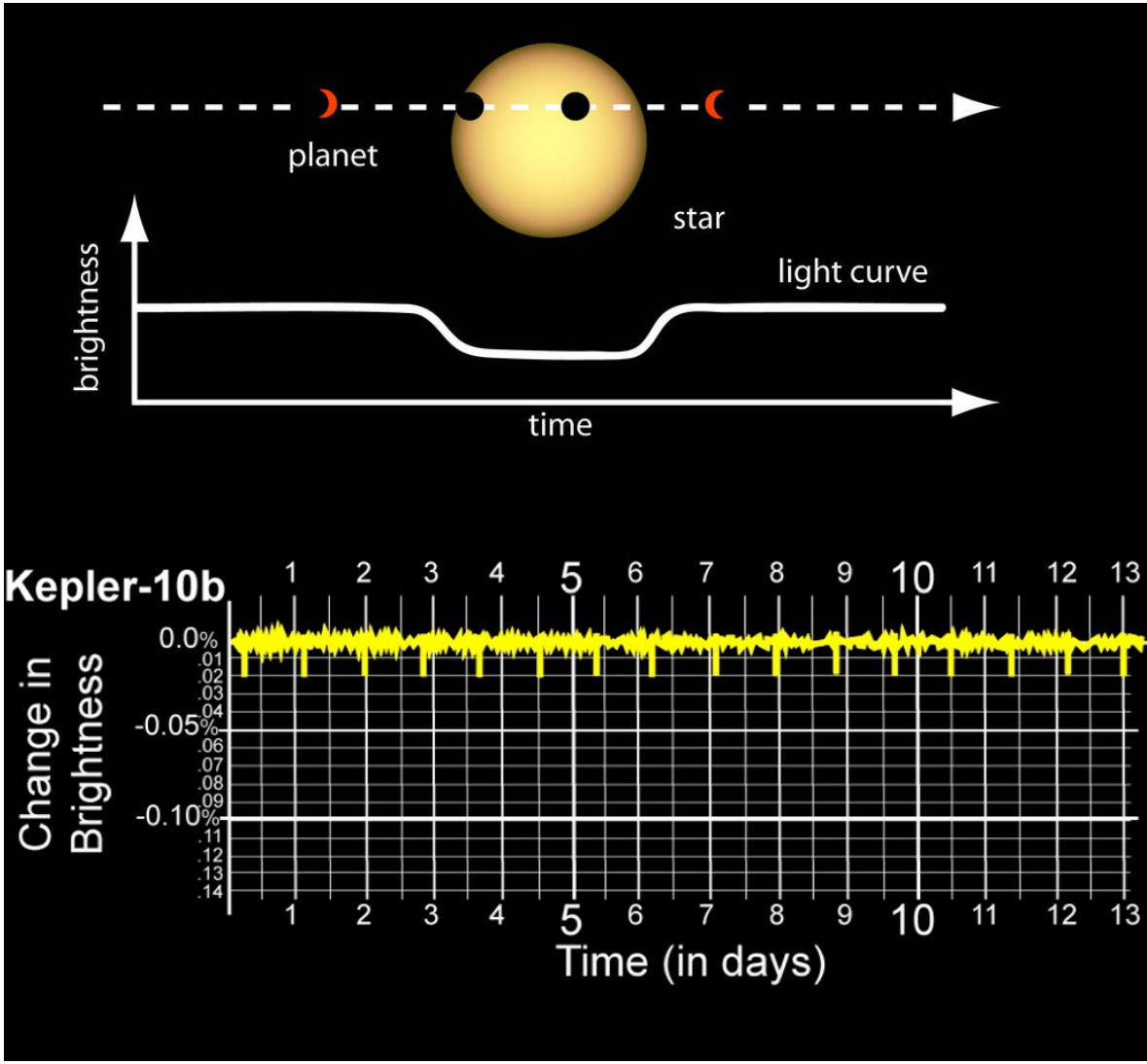
We have found planets orbiting other stars that are in the habitable zone



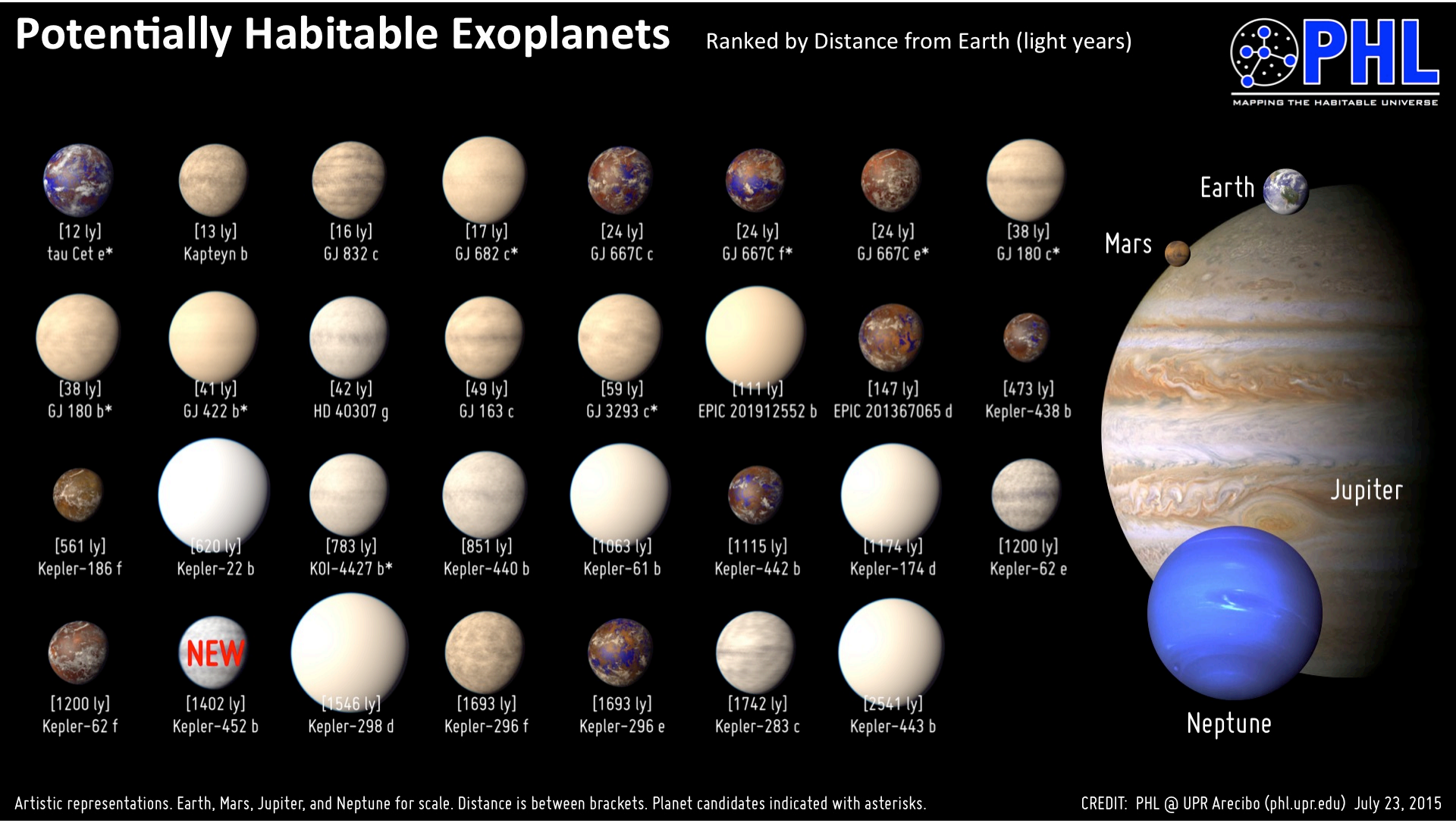
http://www.nasa.gov/mission_pages/kepler/multimedia/images/kepler-22b-diagram.html

The Kepler spacecraft has detected more than 1000 exoplanets by looking for a dip in brightness as they cross their host star

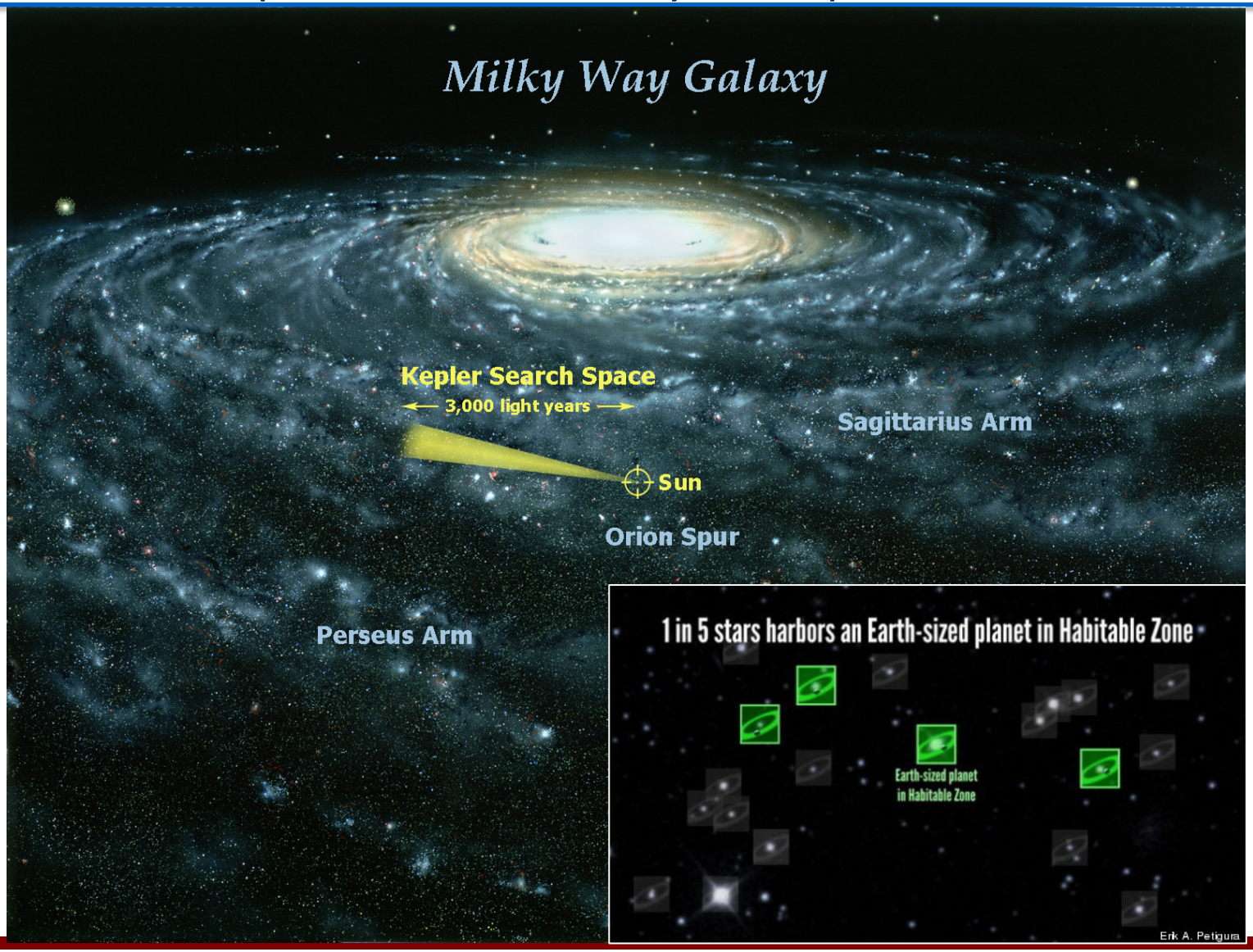




Many planets have been detected in the Goldilocks Zone



The Kepler spacecraft is looking at only a small part of the sky, so we can expect there are many more planets out there



http://www.extremetech.com/wp-content/uploads/2013/08/LombergA1024.jpg
https://groups.yahoo.com/neo/groups/PresidentBarakObama/conversations/messages/48334

We can estimate how many planets there are in the universe from the Kepler data and other astronomical information

200,000,000,000 galaxies in the known universe

x 100,000,000,000 planets per galaxy

= 20,000,000,000,000,000,000,000 planets in the universe

Since about 1 in 5 planets may be Earth-sized in habitable zones,

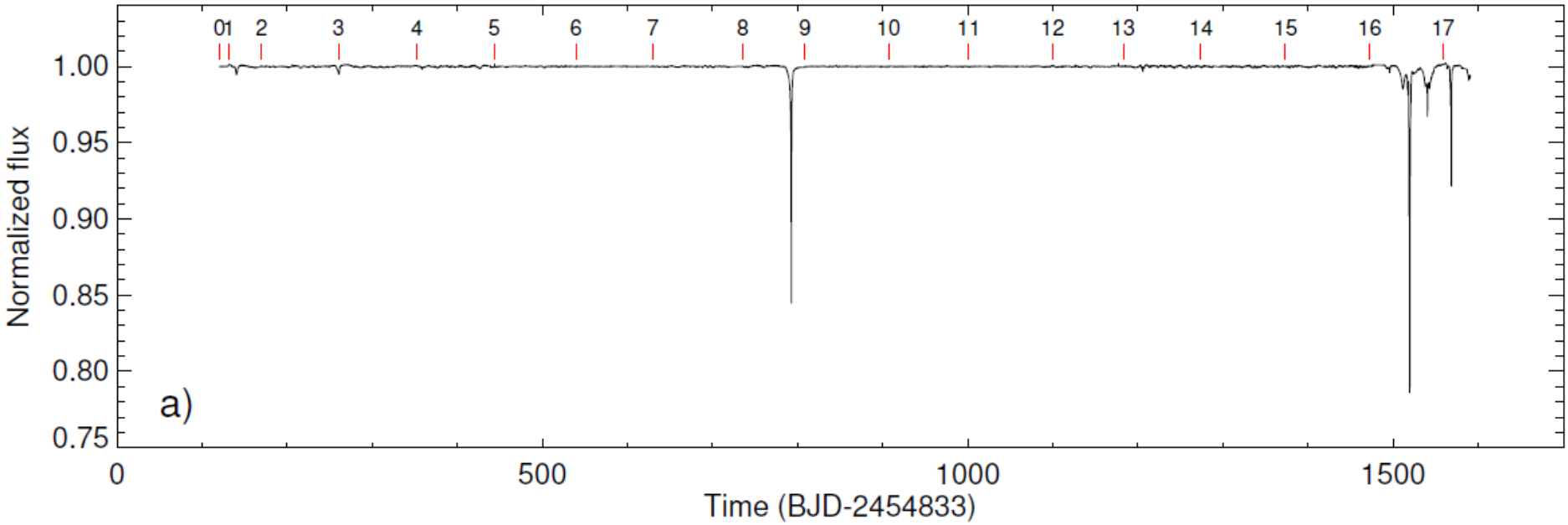
about 4,000,000,000,000,000,000,000 planets in the universe may be capable of supporting life.

This is about as many grains of sand are on all the beaches on Earth.

Supercomputer model of clusters of galaxies in the universe

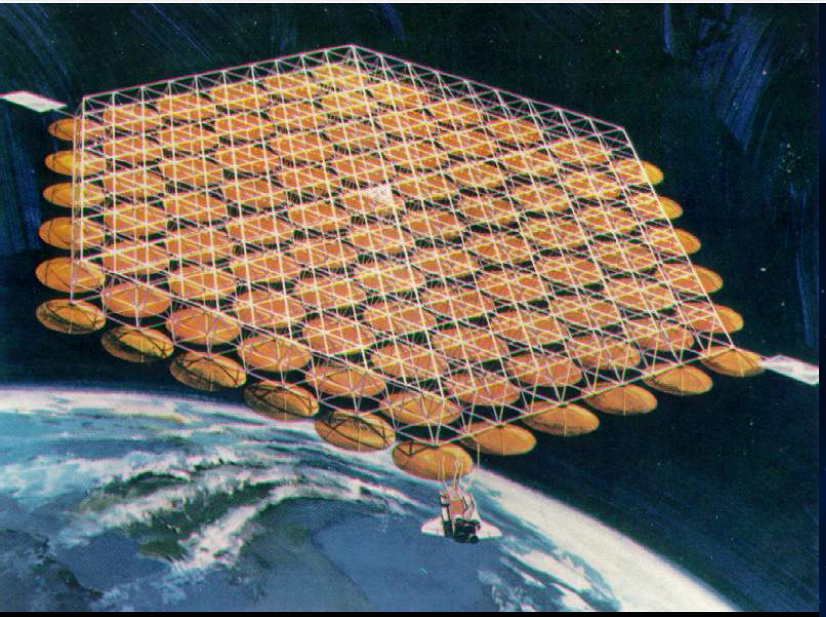
http://hipacc.ucsc.edu/Bolshoi/images/Images/BolshoiZ.jpg
http://www.cnet.com/news/the-milky-way-is-flush-with-habitable-planets-study-says/

Could other objects be orbiting distant stars?



- The star KIC 8462852 (1500 lightyears away) shows irregular, large dips in the light signal
- There could be many comets randomly passing in front of the star
- Could there be anything else shadowing the star?

Could the light variations in KIC 8462852 be caused by a large structure built by an advanced civilization?

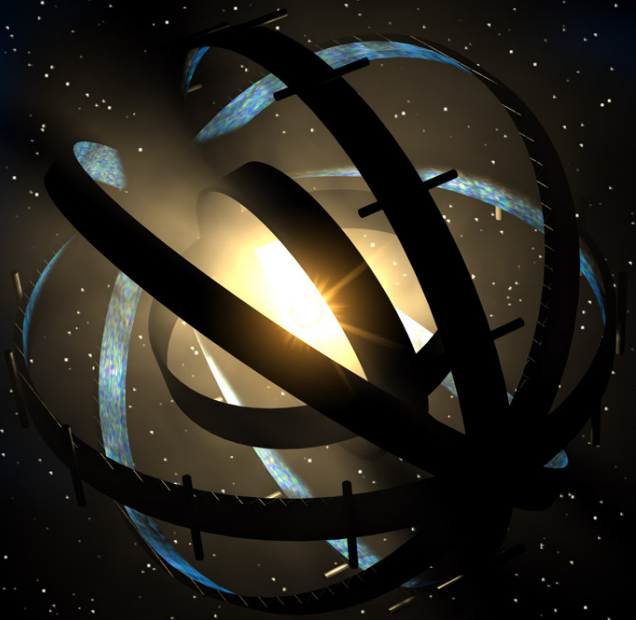


Space solar panel array

Is this science or science fiction?

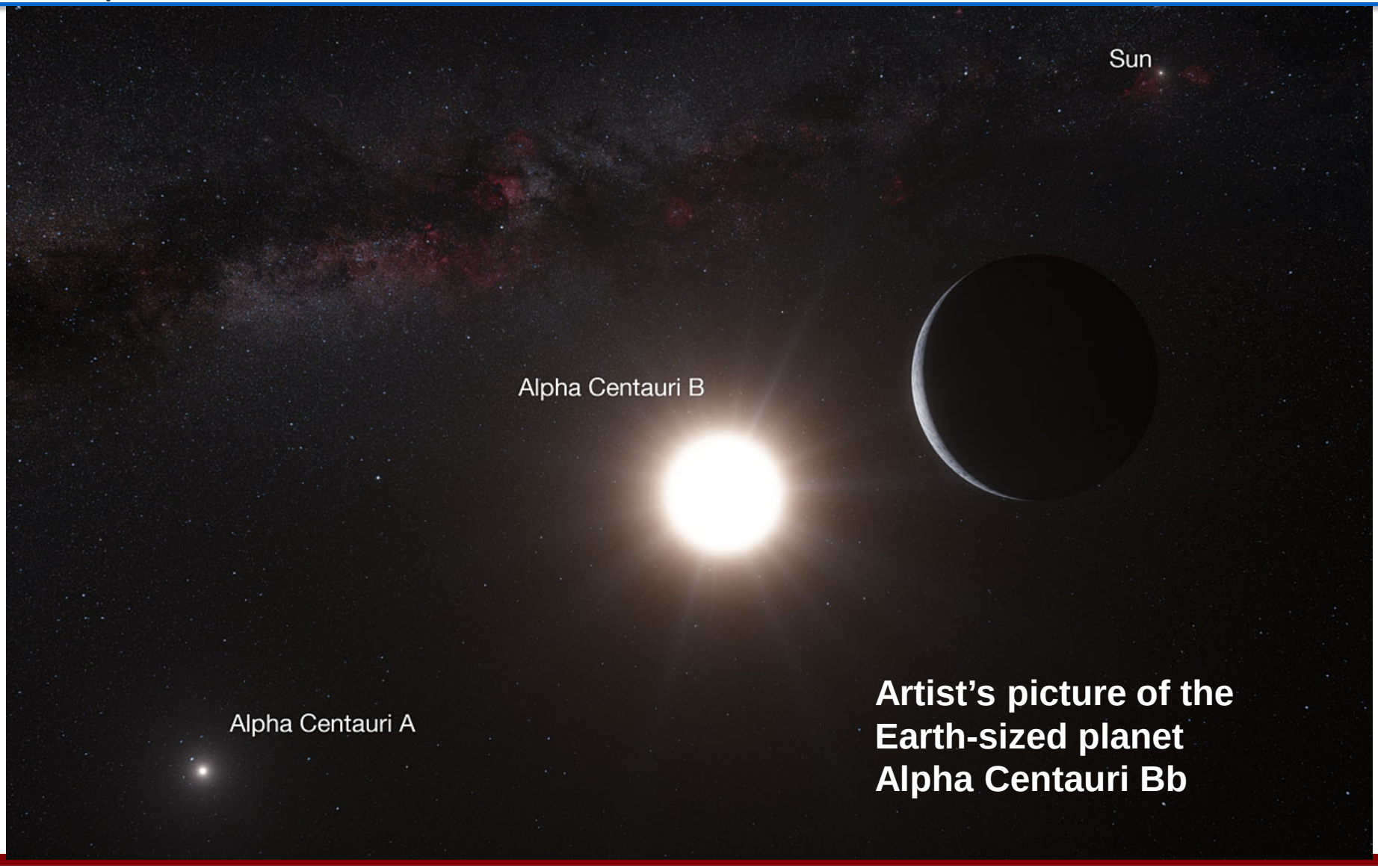
Is there life on other planets?

How could we know for sure?



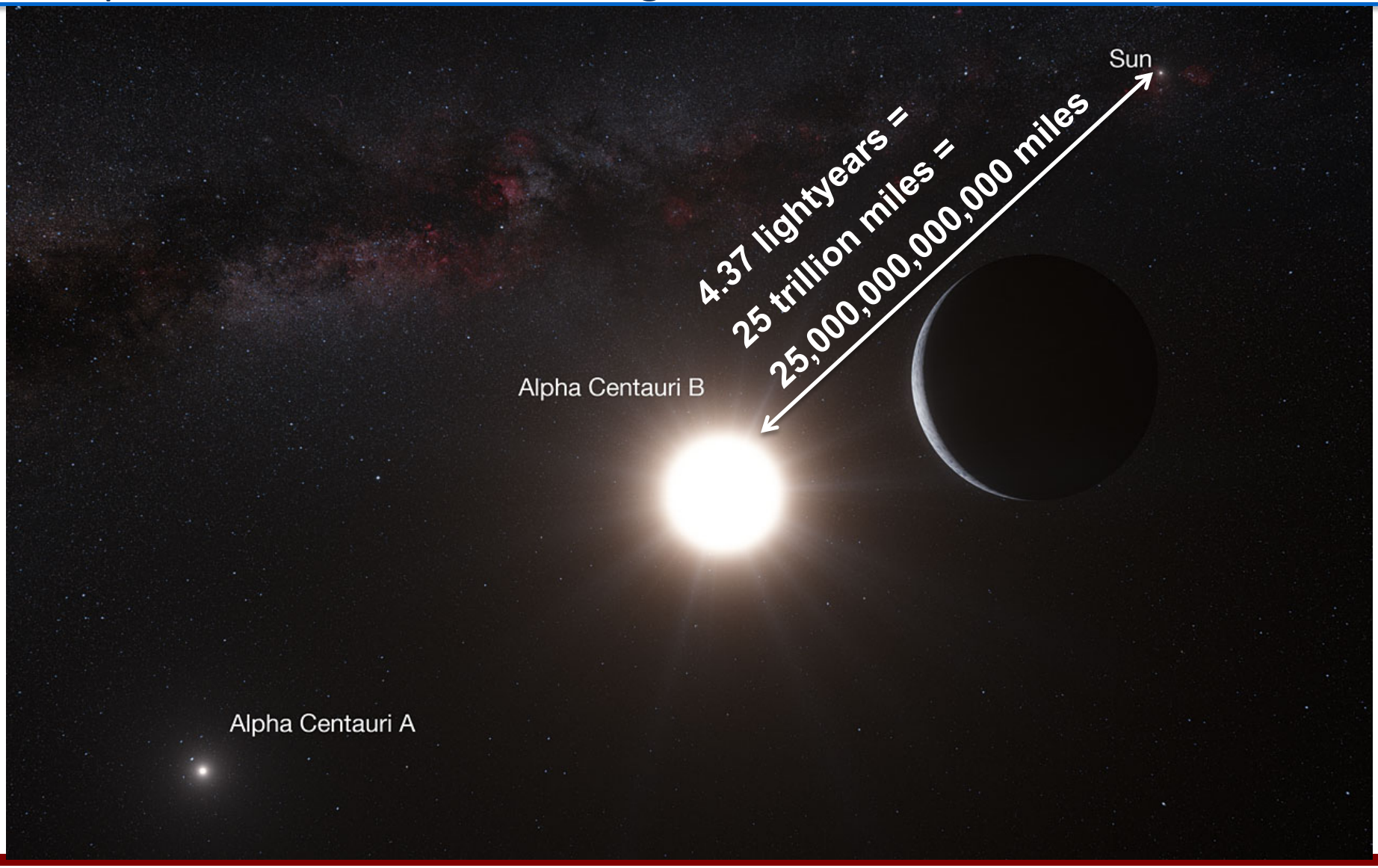
Dyson sphere

Our closest star neighbors, the Alpha Centauri system, have planets…



https://www.eso.org/public/usa/images/eso1241b/

Our closest star neighbors, the Alpha Centauri system, have planets…but could we ever get there?



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How fast can we go?

Your car driving on the freeway	70 mph

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Land speed record	Thrust SSC	763 mph

Thrust Supersonic Car is basically a race car with two jet engines attached

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Manned air-breathing airplane	SR-71A Blackbird	2,190 mph

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

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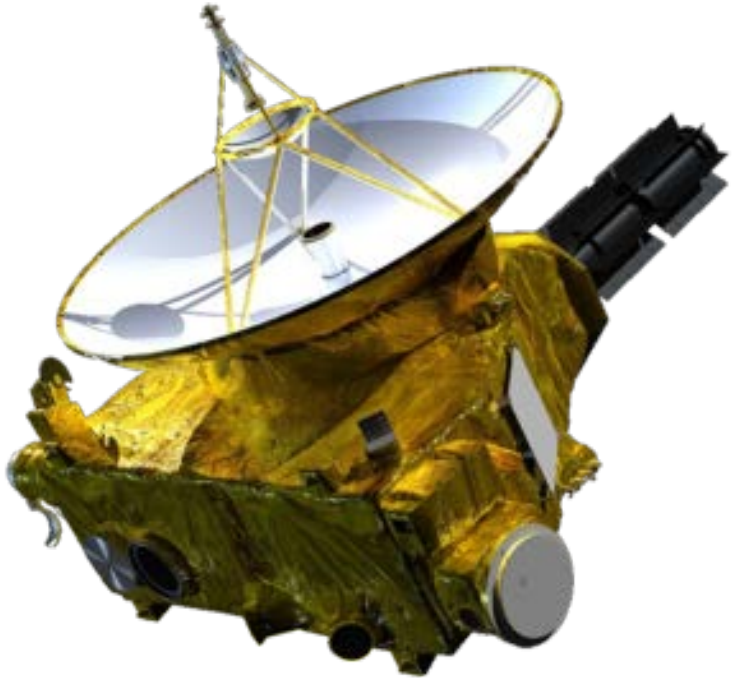

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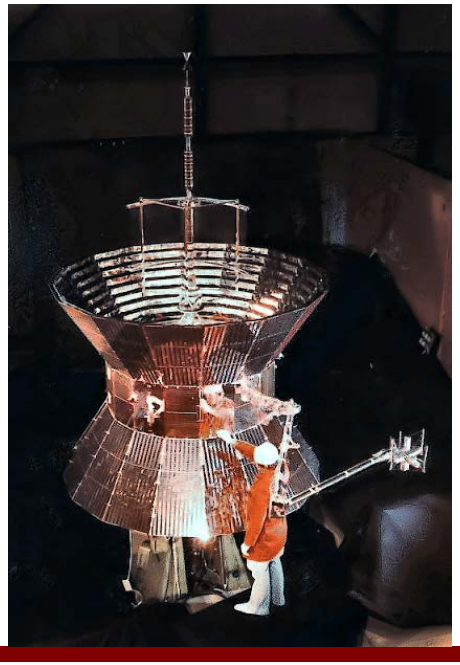
Spacecraft relative to Sun	Helios 2	157,000 mph

Helios 2 flew toward the Sun, and sped up due to the Sun's gravity pulling it inward



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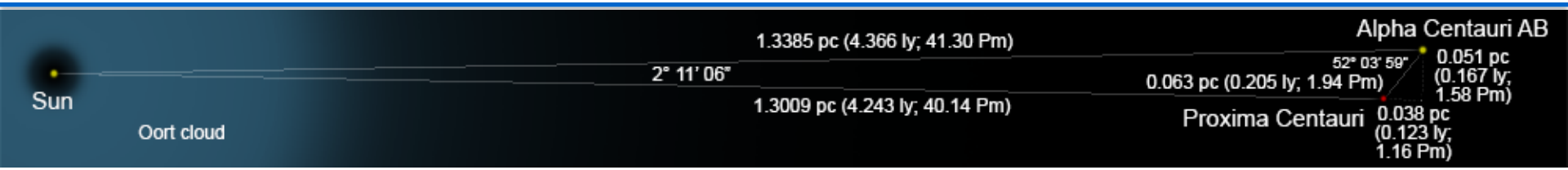
Manned air-breathing airplane	SR-71A Blackbird	2,190 mph
Spacecraft relative to Earth	New Horizons	36,000 mph
Spacecraft relative to Sun	Helios 2	157,000 mph
Spacecraft leaving the solar system	Voyager I	38,000 mph

38,000 miles per hour is more than

300,000,000 miles per year

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

Let’s calculate how long it might take to get to Alpha Centauri



Let’s round the distance to 30 trillion miles

Let’s assume the speed is 300 million miles per year

Then, the time to travel this distance would be

30,000,000,000,000 miles divided by

300,000,000 miles per year

https://en.wikipedia.org/wiki/Alpha_Centauri#/media/File:Relative_positions_of_Sun,_Alpha_Centauri_AB_and_Proxima_Centauri.png

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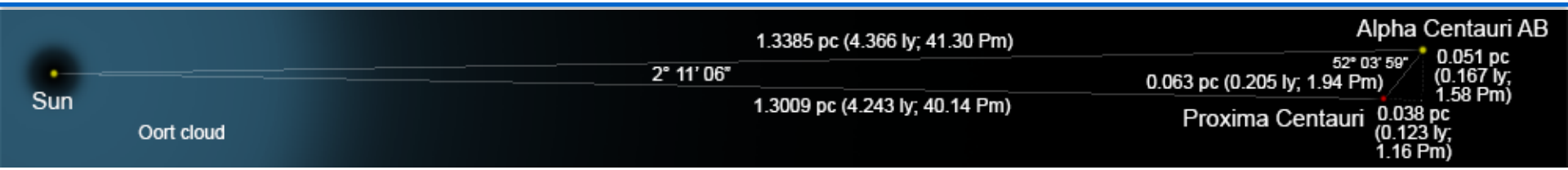


Let’s round the distance to 30 trillion miles

Let’s assume the speed is 300 million miles per year

Then, the time to travel this distance would be

30,000,000,000,000 miles divided by

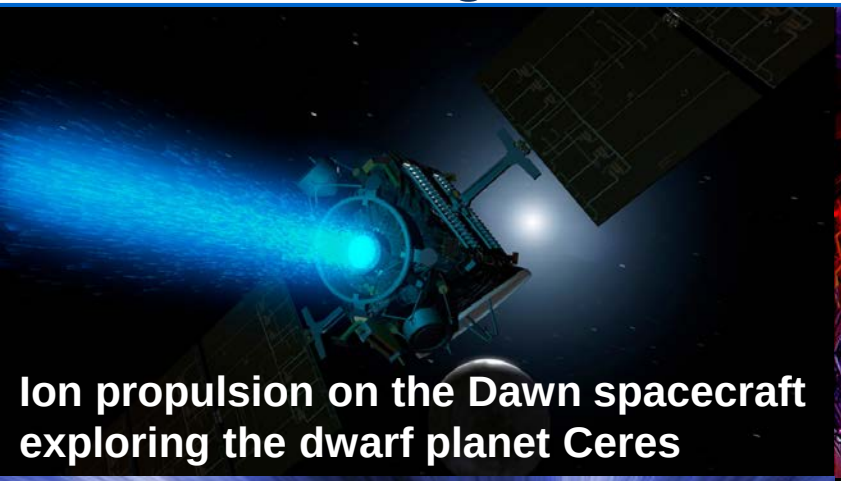
300,000,000 miles per year

= 100,000 years

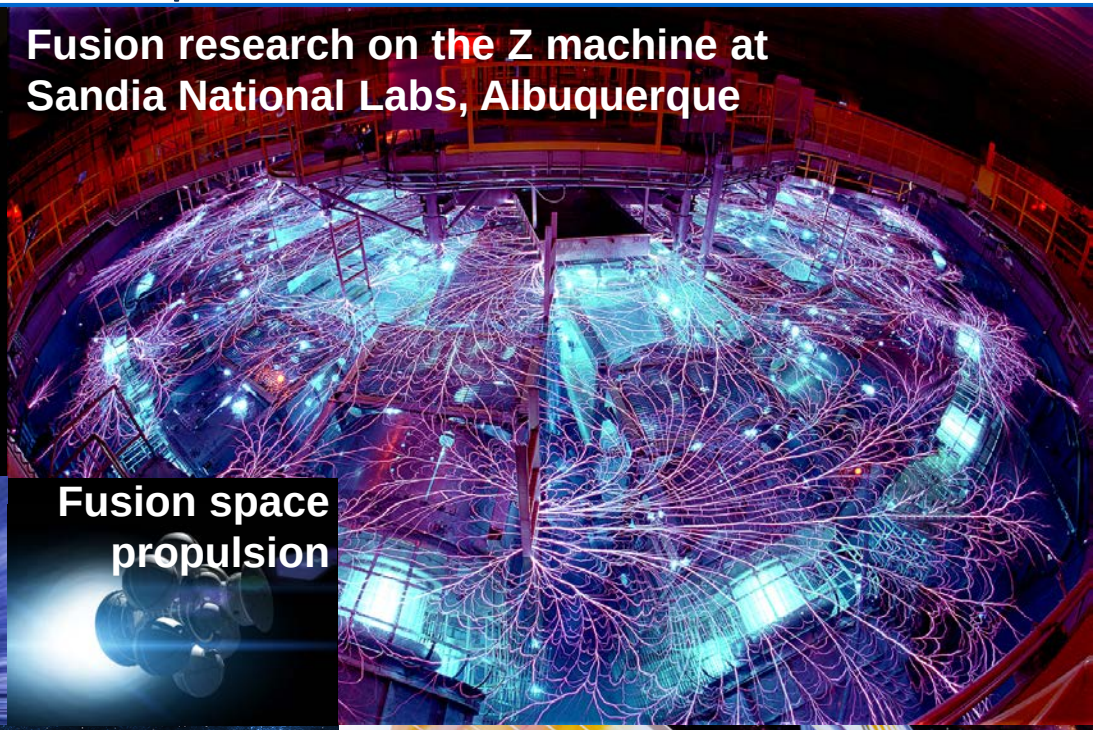
That is a long time!

https://en.wikipedia.org/wiki/Alpha_Centauri#/media/File:Relative_positions_of_Sun,_Alpha_Centauri_AB_and_Proxima_Centauri.png

How could we get to another star system faster? Who will figure out if these are possible?



Ion propulsion on the Dawn spacecraft exploring the dwarf planet Ceres



Fusion research on the Z machine at Sandia National Labs, Albuquerque

Warp drive or hyperspace

Fusion space propulsion

Wormholes

Generation ships

http://www.space.com/28732-nasa-dawn-spacecraft-ion-propulsion.html
http://www.space.com/21337-advanced-spacecraft-propulsion-concepts-images.html; https://modulouniverse.files.wordpress.com/2015/03/hyperspace_falcon.jpg
http://www.space.com/20881-wormholes.html; http://i.kinja-img.com/gawker-media/image/upload/s--Ww4zs6HN--/c_scale,fl_progressive,q_80,w_800/opl98ia1thlol3zkdyb3.jpg