A Taste of ASTR 122 (a.k.a. Fishers Favorite Astronomy Topics)

S. Fisher, UO Physics

June 2025

The Story of our Lecture

- Introduction to a few of my favorite topics:
  - A cosmic perspective check
  - Planets and Exoplanets
  - Pine Mountain and our research programs

Connecting to the Cosmos

- Science is cool, as kids we all know it, we just often get it "scared" out of us.
- We are all astronomers – because astronomy is present in all of our lives.
  - When we sleep/are active
  - How we tell time
  - Your Birthday
- A little astro knowledge goes a long way!

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- Product of s
  - Lake Sumter
  - Exchange stu
  - University of
- Gemini Staff
- Astronomer
  - Hilo, Hawaii
  - Outreach S
  - Hybrid resea position
  - Science/publ

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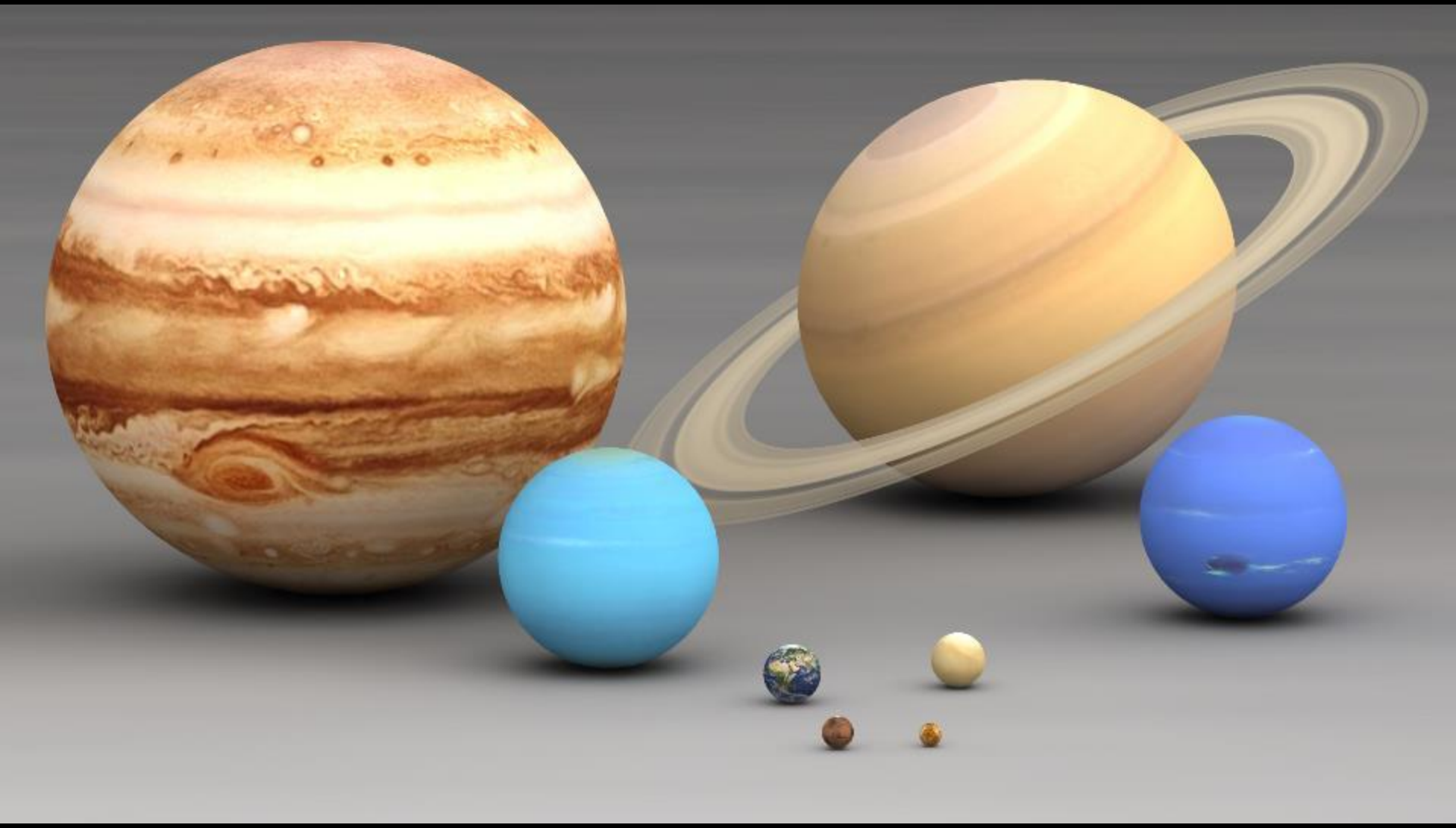
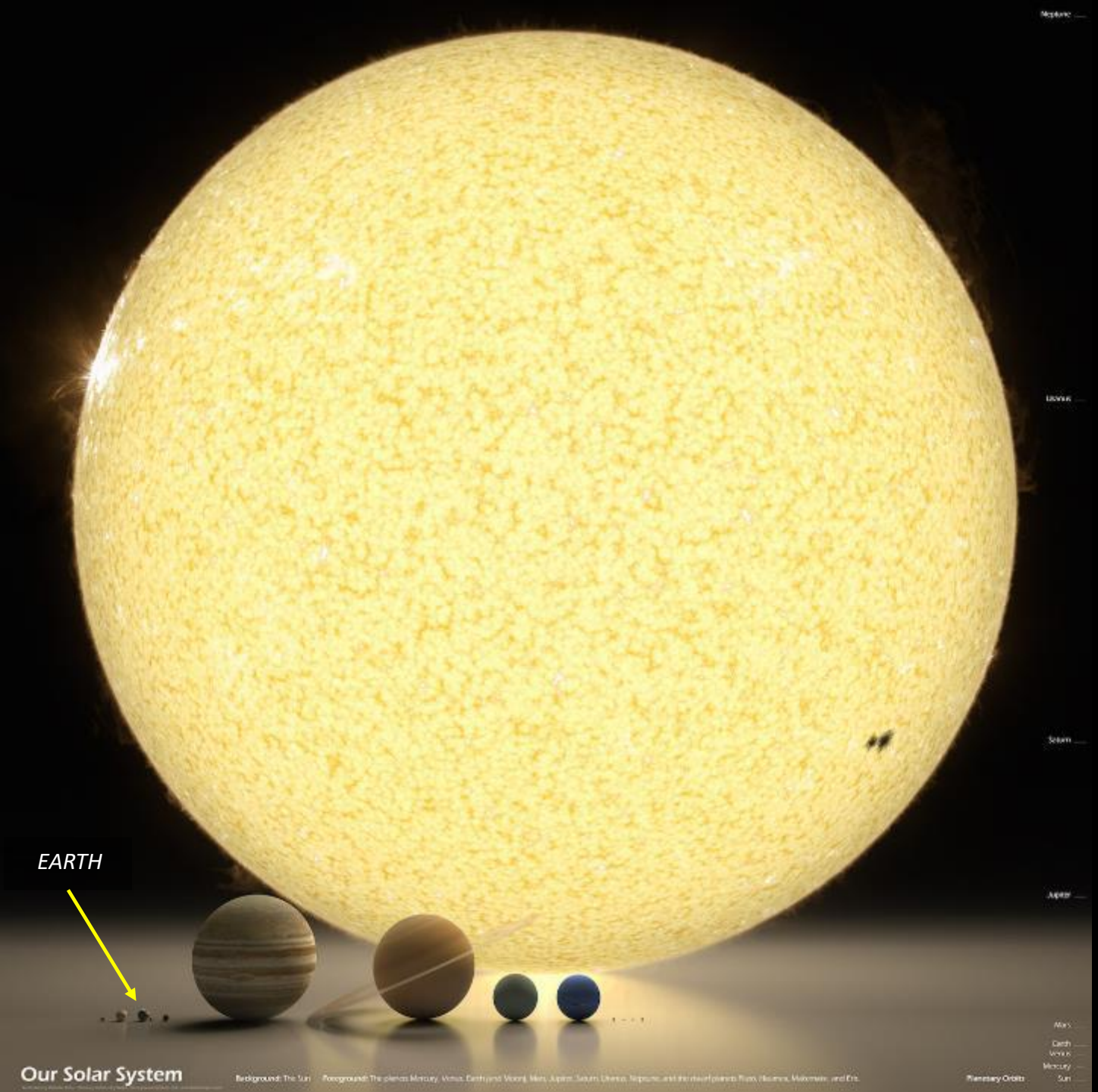
Credentials and Background

- Product of state schools
  - Lake Sumter CC
  - **University of Florida** (BS, PhD)
  - **University of Oregon** (faculty)
- Gemini Staff Astronomer
- NSF Program Director

- 15+ years observing at the 1st, 2nd, and 4th largest optical telescopes on Earth
- Awarded $40 million in federal grants in 3 years at NSF
- Professional Astronomer, Researcher, and Outreach Specialist turned Professor
- Appointed as the *Director of Pine Mountain Observatory*

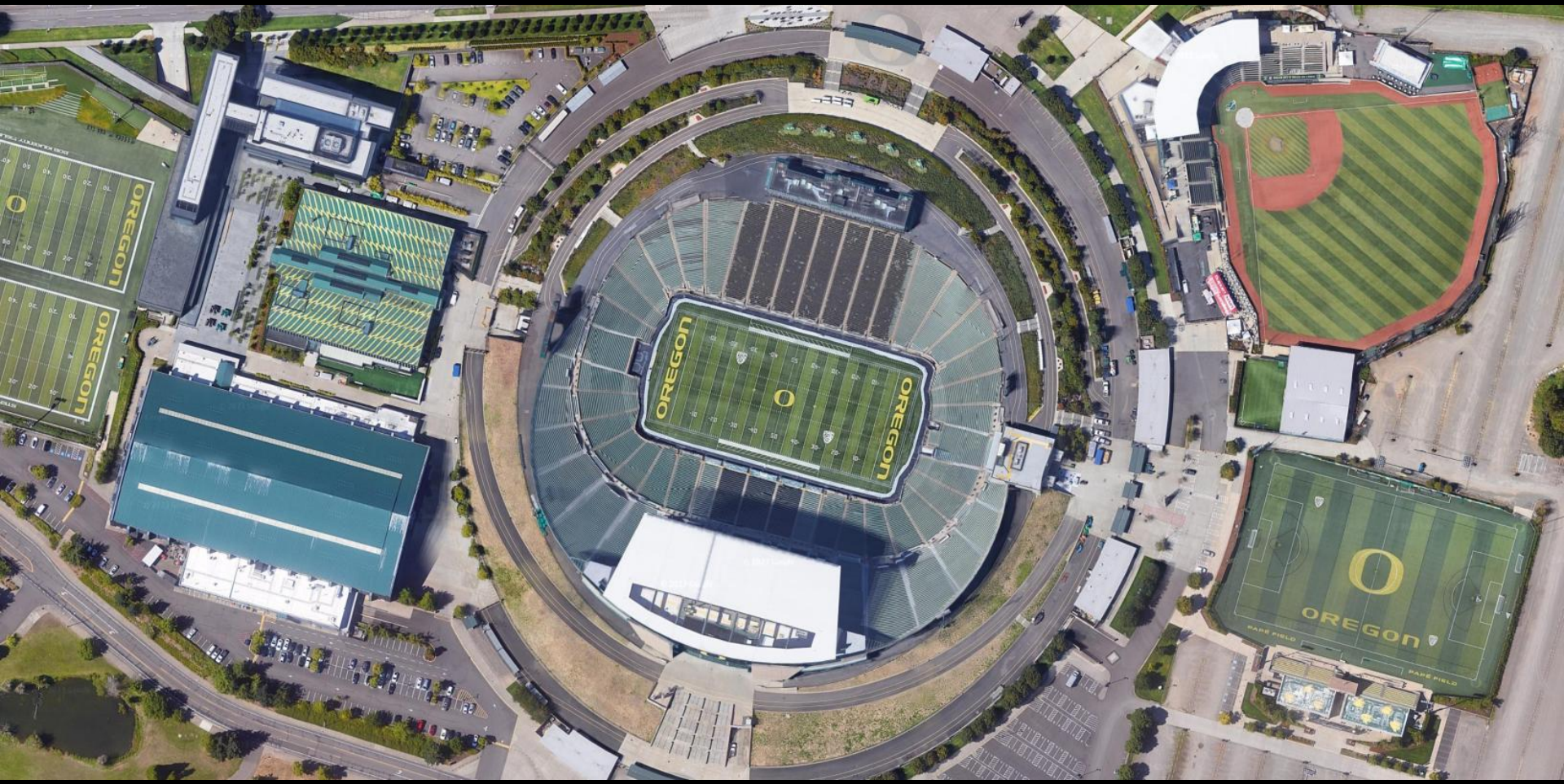




Our first cosmic perspective (check) of the term.

This is the Sun and the planets to scale

109 Earths will fit across the diameter of the Sun


OREGON
OREGON
OREGON
OREGON
OREGON
PAPE FIELD
PAPE FIELD

Solar Facts

- Diameter of the Sun = 109 Earths, Diameter of Autzen Stadium = (approx.) 109 of you

You:Stadium = Earth:Sun

- The "surface" of the Sun is called the photosphere.
  - The temperature of the "surface" is 10000 degrees F
- The distance to the Sun is 93,000,000 miles
  - This is equal to 8 light-minutes

A “Scaled” Solar System

The idea is…. Take the entire Solar System and shrink it by a HUGE factor. In this thought experiment, it is 10 Billion times smaller than in reality

Let’s reduce the size of the solar system by a factor of 10 billion; the Sun is now the size of a large grapefruit.

How big is Earth compared to our solar system?

Let's reduce the size of the solar system by a factor of 10 billion; the Sun is now the size of a large grapefruit.

How big is Earth on this scale?

1. an atom
2. a tip of a ballpoint pen
3. a marble
4. a golf ball

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Let's reduce the size of the solar system by a factor of 10 billion; the Sun is now the size of a large grapefruit.

How far is the Earth from the Sun on this scale?

1. 5 feet
2. 50 feet
3. 500 feet
4. 5 miles

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2. **50 feet**
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How far away are the stars?

On our 1-to-10 billion scale, it's about 50 feet from the Sun to the Earth.

How far would you have to walk to reach Alpha Centauri (the NEAREST star to the Sun)?

1. 1 mile
2. 10 miles
3. 100 miles
4. 2500 miles

How far away are the stars?

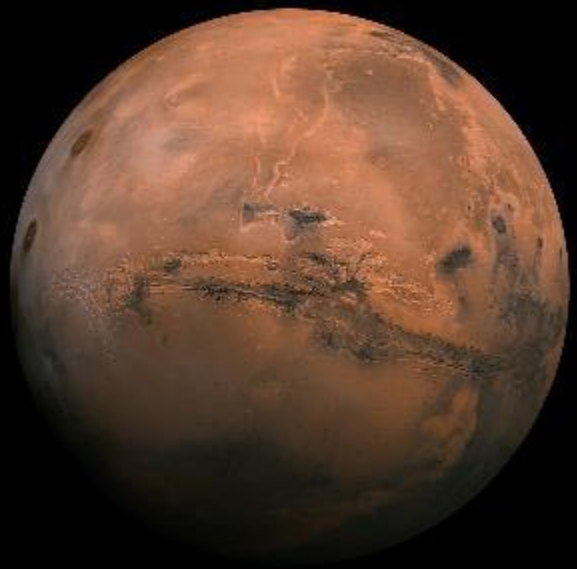
On our 1-to-10 billion scale, it's about 50 feet from the Sun to the Earth.

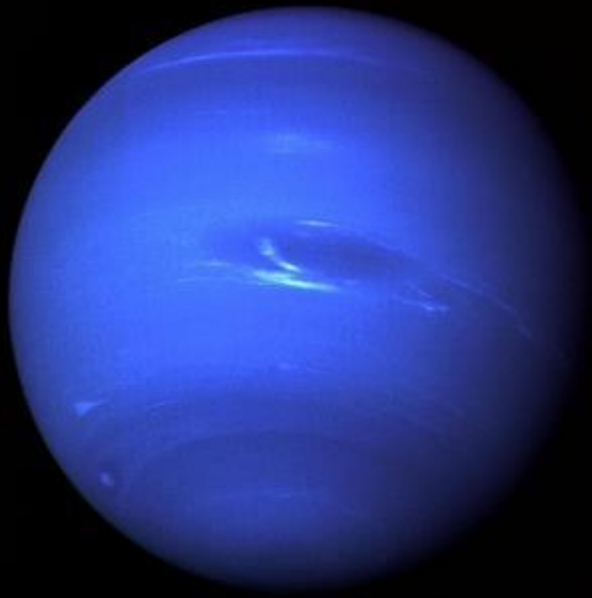
How far would you have to walk to reach Alpha Centauri (the NEAREST star to the Sun)?

1. 1 mile
2. 10 miles
3. 100 miles
4. ***the distance across the United States (2500 miles)***

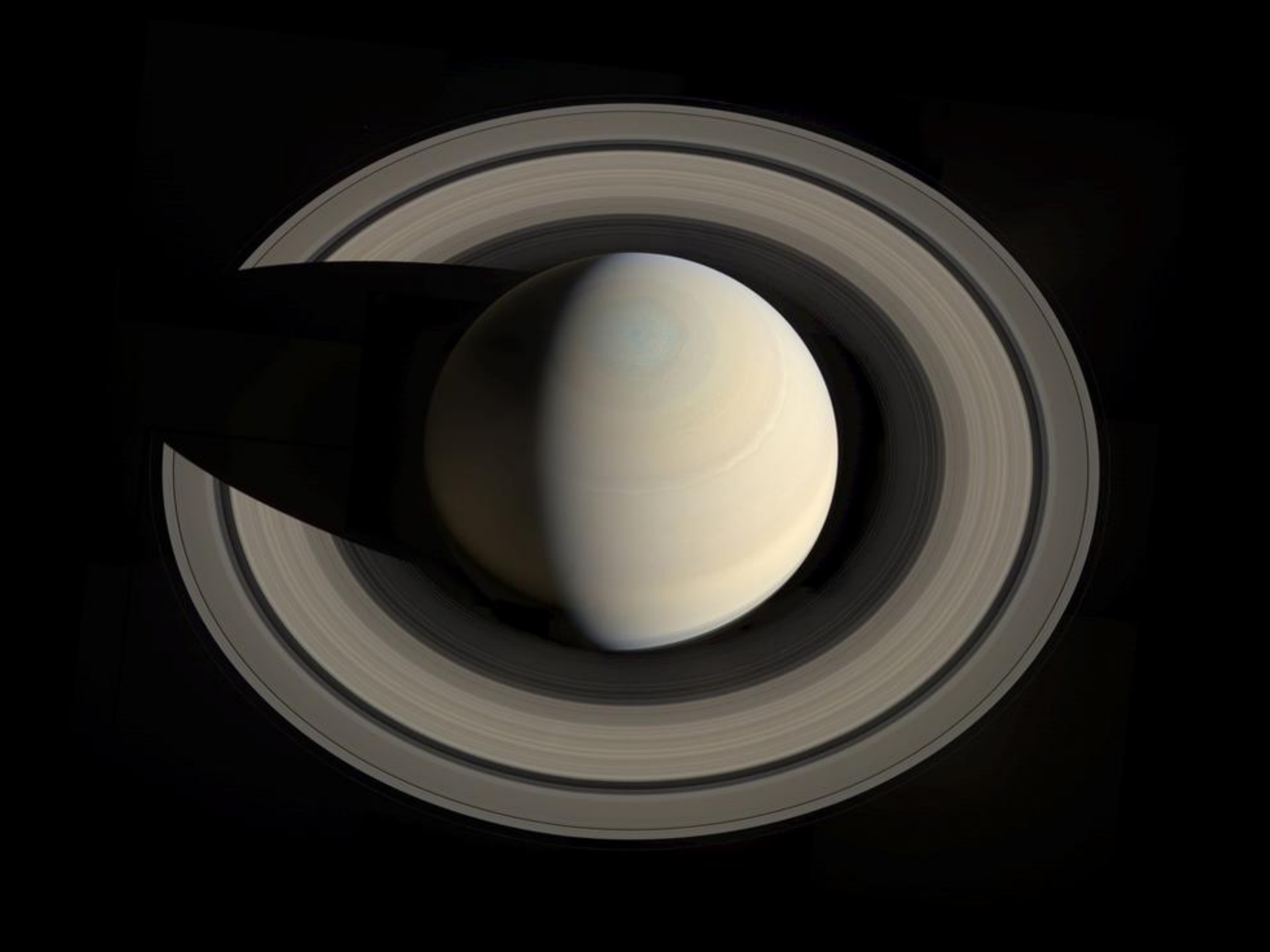
Planet

A moderately large object that orbits a star; it shines by reflected light. Planets may be rocky, icy, or gaseous in composition.

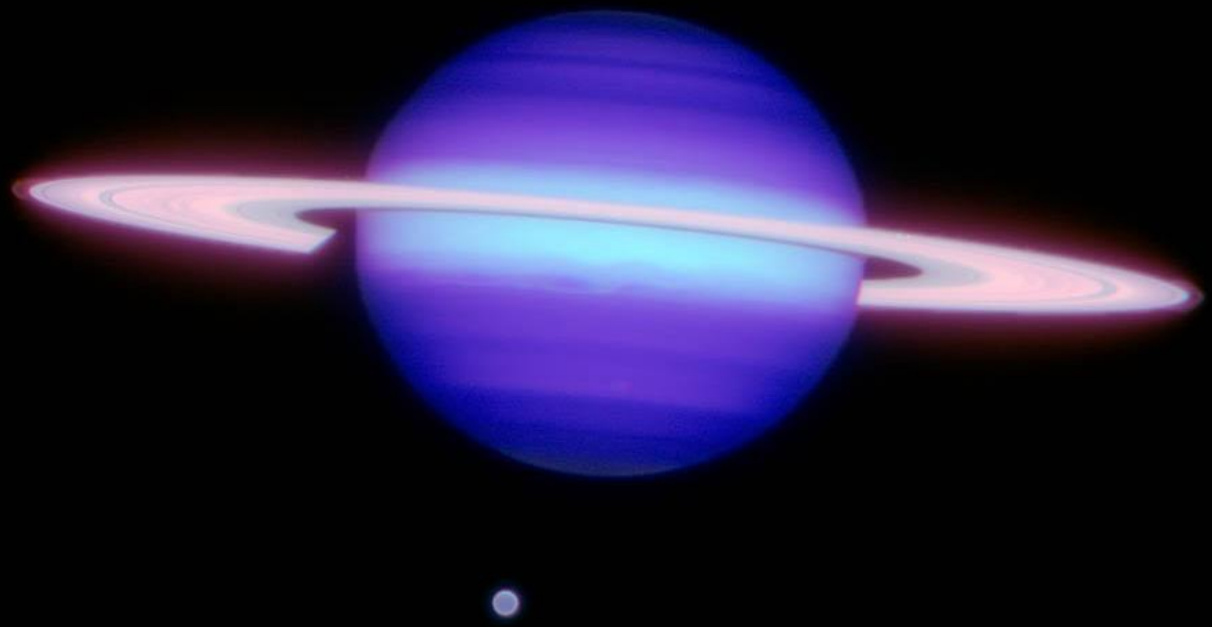




Neptune



Saturn and Titan (false color infrared image)



Gemini Observatory / AURA / H. Roe (Lowell Observatory), E. Schaller (IfA - University of Hawai'i)

Gemini Observatory Legacy Image

The Day the Earth Smiled

From Wikipedia, the free encyclopedia

The Day the Earth Smiled refers to July 19, 2013, the date on which the *Cassini* spacecraft turned to image Saturn, its entire ring system, and the Earth, during an eclipse of the Sun. The spacecraft had done this twice before (in 2006 and 2012) in its previous nine years in orbit. The name is also used to refer to the activities associated with the event, as well as to the mosaic photograph created from it.[1]

Conceived by the planetary scientist Carolyn Porco, who was the imaging team leader for *Cassini*, the concept called for the people of the world to reflect on their place in the cosmos, to marvel at life on Earth, and, at the time the pictures were taken, to look up and smile in celebration.[2][3]

The final mosaic from July 19, processed at the Cassini Imaging Central Laboratory for Operations (CICLOPS), was released to the public on November 12, 2013.[4][5] *The Day the Earth Smiled* photograph includes Earth, Mars, Venus, and many Saturnian moons.[6] A higher-resolution image, which depicts Earth and its moon as distinct points of light, was taken with the *Cassini* narrow-angle camera and was released shortly afterwards.

Full processed mosaic of images taken by the *Cassini* spacecraft on July 19, 2013

Earth can be seen as a blue dot underneath the rings of Saturn in this image taken by the *Cassini* spacecraft on July 19, 2013.

Photomosaic from NASA's "Wave at Saturn" campaign. The collage includes some 1,600 photos taken by members of the public on the Day the Earth Smiled.

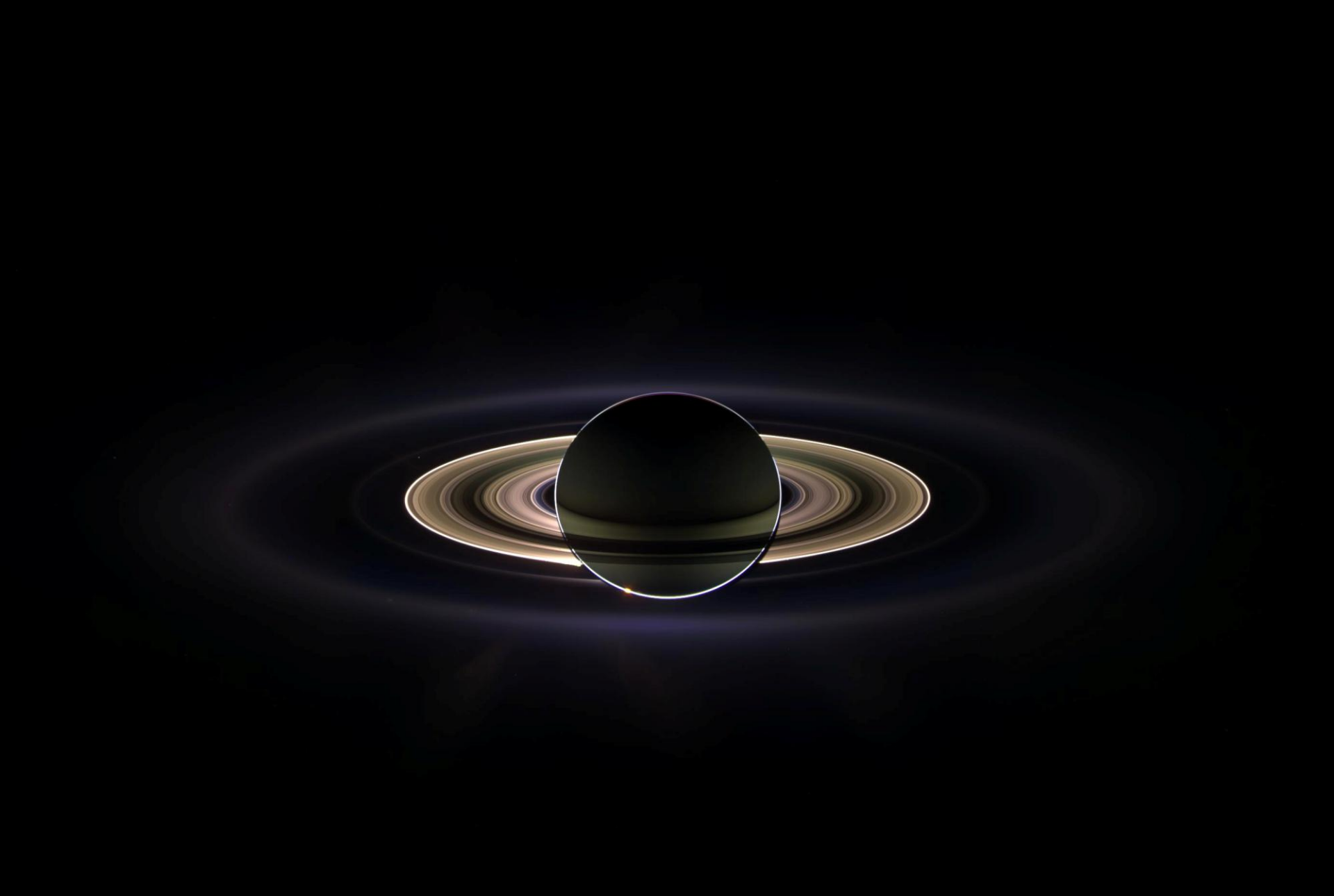
Contents [hide]

Events [edit]

The *Cassini* probe took images of Earth from close to a billion miles away at 21:27 UTC, July 19, 2013. A number of activities were planned to celebrate the occasion:

- A website was set up as a portal to activities associated with July 19.[7] On it, Porco encouraged the world to celebrate life on planet Earth and humanity's accomplishments in the exploration of the solar system.
- Astronomers Without Borders coordinated events internationally.[8]
- NASA spearheaded a related event called 'Wave at Saturn' "to help acknowledge the historic interplanetary portrait as it is being taken".[9]
- A "Message to the Milky Way" contest was held by Porco's company, Diamond Sky Productions. People could submit a digital photo taken on July 19 and/or a musical composition. The winning entries were beamed as a message to extraterrestrials, "into the Milky Way from the Arecibo Radio Telescope in Puerto Rico".[10] This follows the example set in 1974, when the first serious communication to alien civilizations, the Arecibo message, was broadcast from Arecibo.

Results [edit]



Saturn backlit by the Sun – from Cassini, in orbit around Saturn
In this image sunlight is coming through the rings

Exoplanet

A moderately large object that orbits a star THAT IS NOT THE SUN. Exoplanets may be rocky, icy, or gaseous in composition.

5819 – as of 2025 January

- Current theories suggest that approximately 100% of stars in our galaxy have planets (probably… we are still learning about this!)

Exoplanet

A moderately large object that orbits a star THAT IS NOT THE SUN. Exoplanets may be rocky, icy, or gaseous in composition.

- The first exoplanets were discovered in the 1990's
- We have discovered and CONFIRMED almost 6000 exoplanets
- Current theories suggest that approximately 100% of stars in our galaxy have planets (probably… we are still learning about this!)

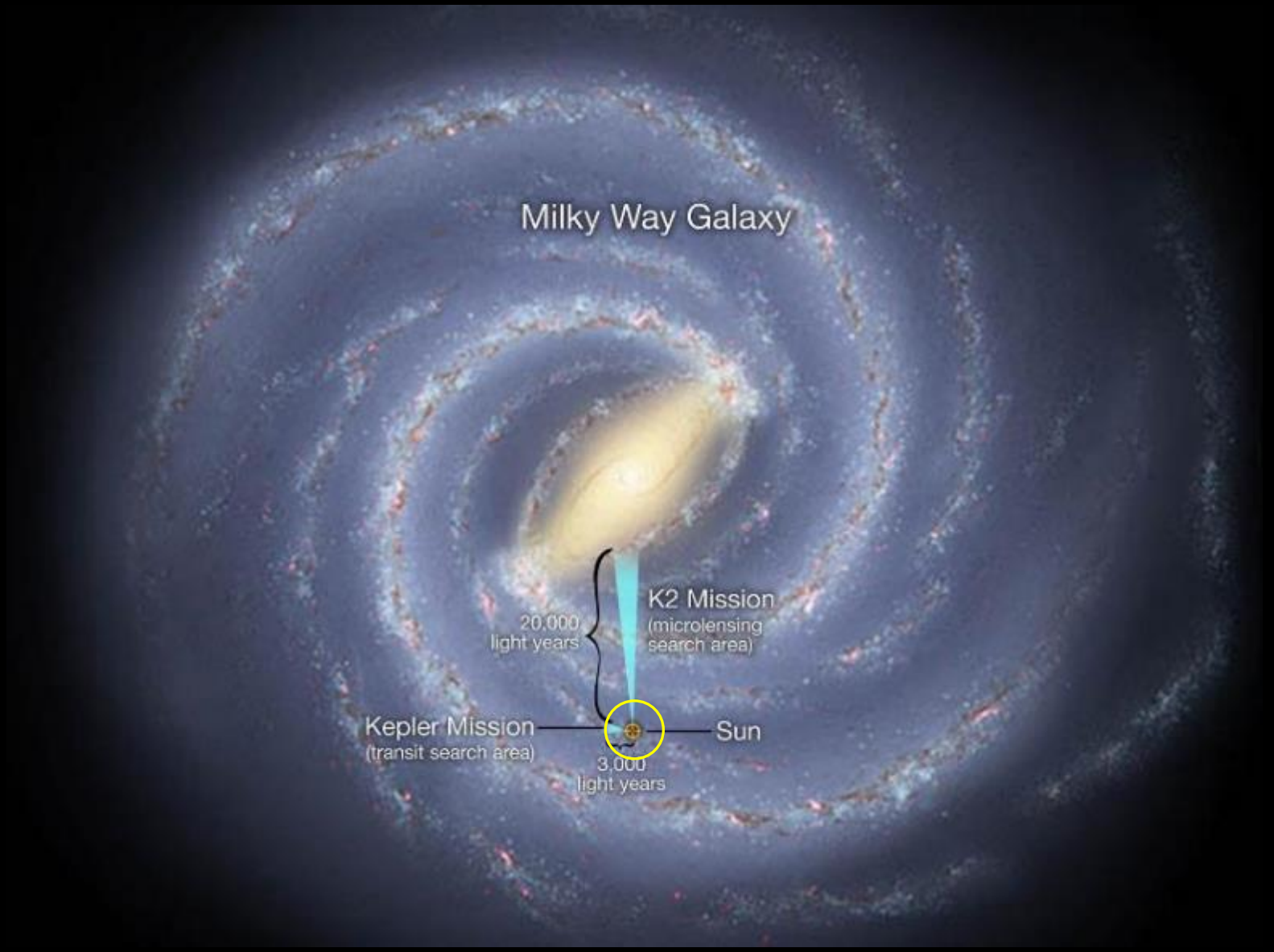
Exoplanet

A moderately large object that orbits a star THAT IS NOT THE SUN. Exoplanets may be rocky, icy, or gaseous in composition.

- Animation of exoplanet discoveries:

  https://www.youtube.com/watch?v=yv4DbU1CWAY

Scientific Model of the Milky Way



The light blue triangles are regions that have been searched for exoplanets - we've only searched a tiny fraction of our galaxy (so far)!

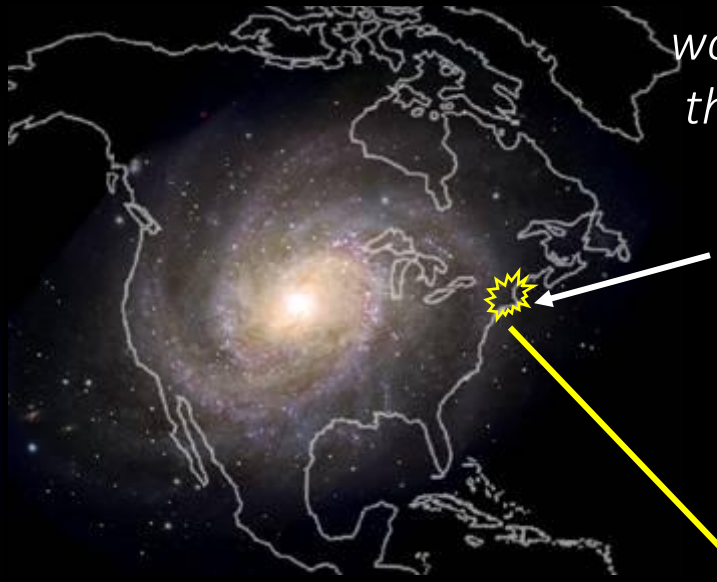
How big an area is that?

Imagine, if you shrunk our solar system to a little larger than a quarter:

Our whole Solar System

would be this big

Our Milky Way



would span North America.

Kepler Search Area

would be an area about the size of Connecticut. (or Lane County)

We have only searched a tiny fraction of the galaxy for exoplanets!

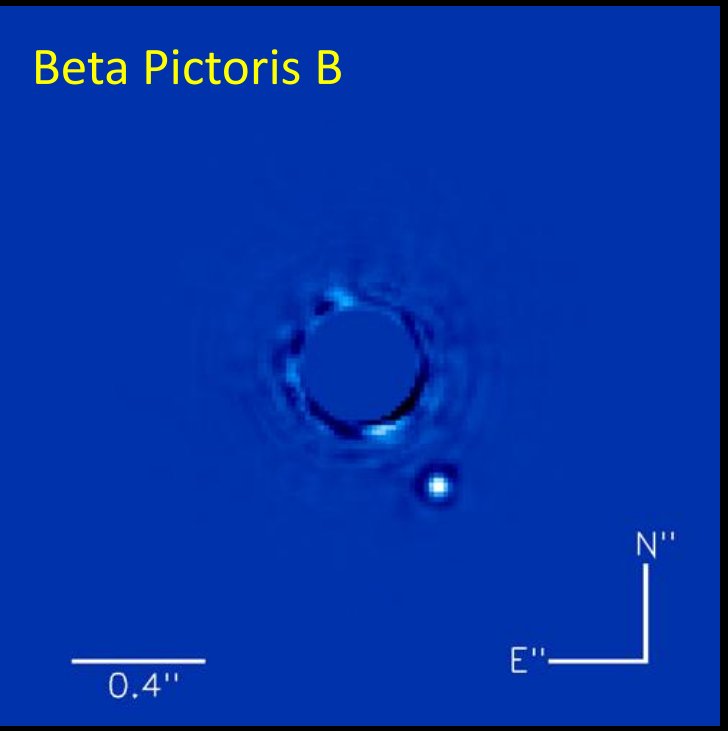
Exo-Planet (or exoplanet)

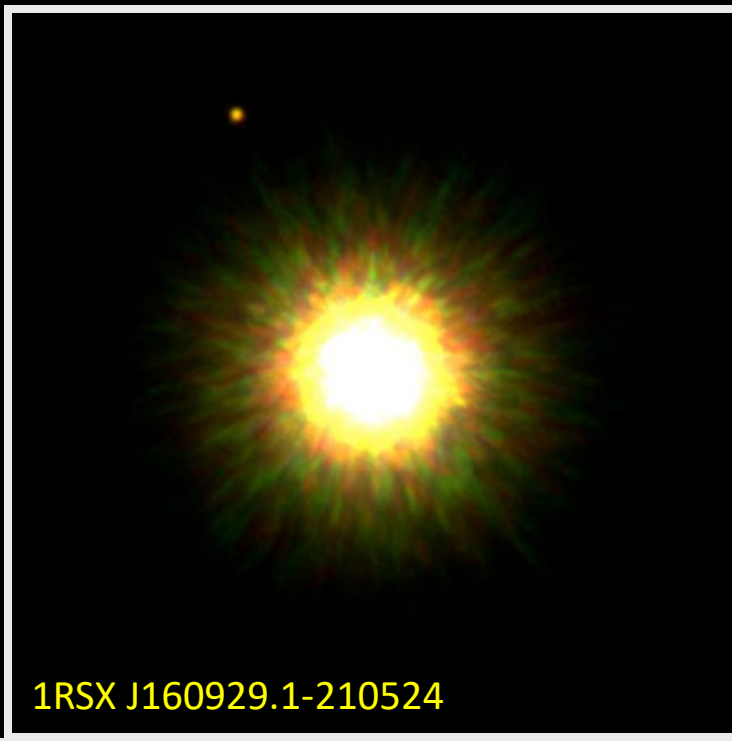
- All exoplanets are too far away to see any detail. Means – only "dots on images" for now.

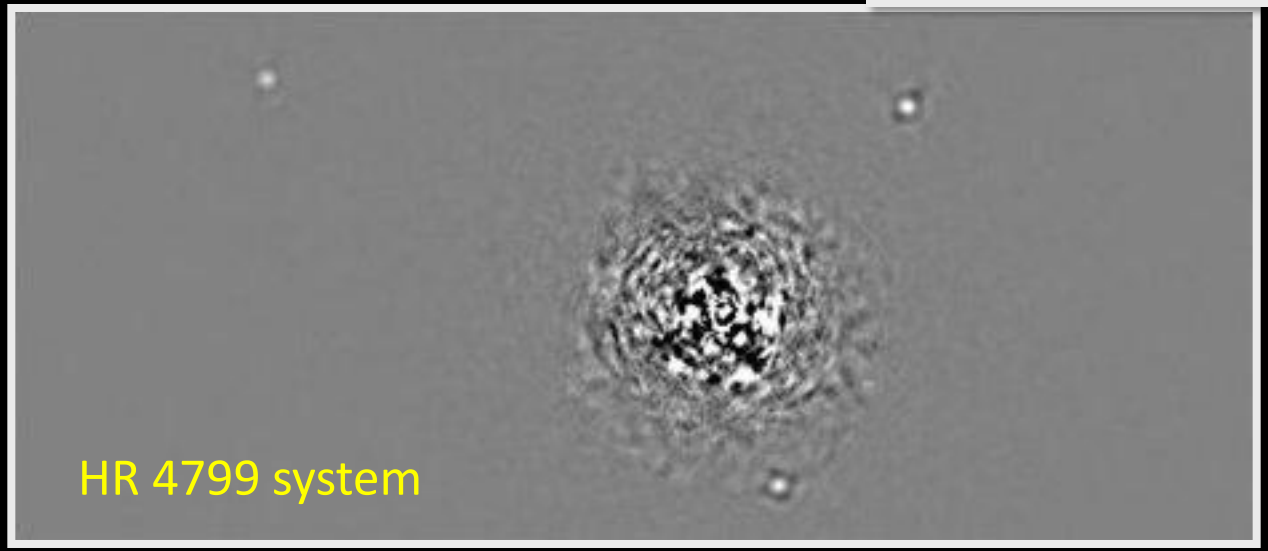
- The discovery of exoplanets completely changes our "place in the Universe" again. We now know that the Solar System is one of many, many planetary systems.

- This will be one of the defining discoveries of our time. It was our generations that did it. We should be proud. We are making the map that future humans will use to go to the stars.

Pictures of Exoplanets



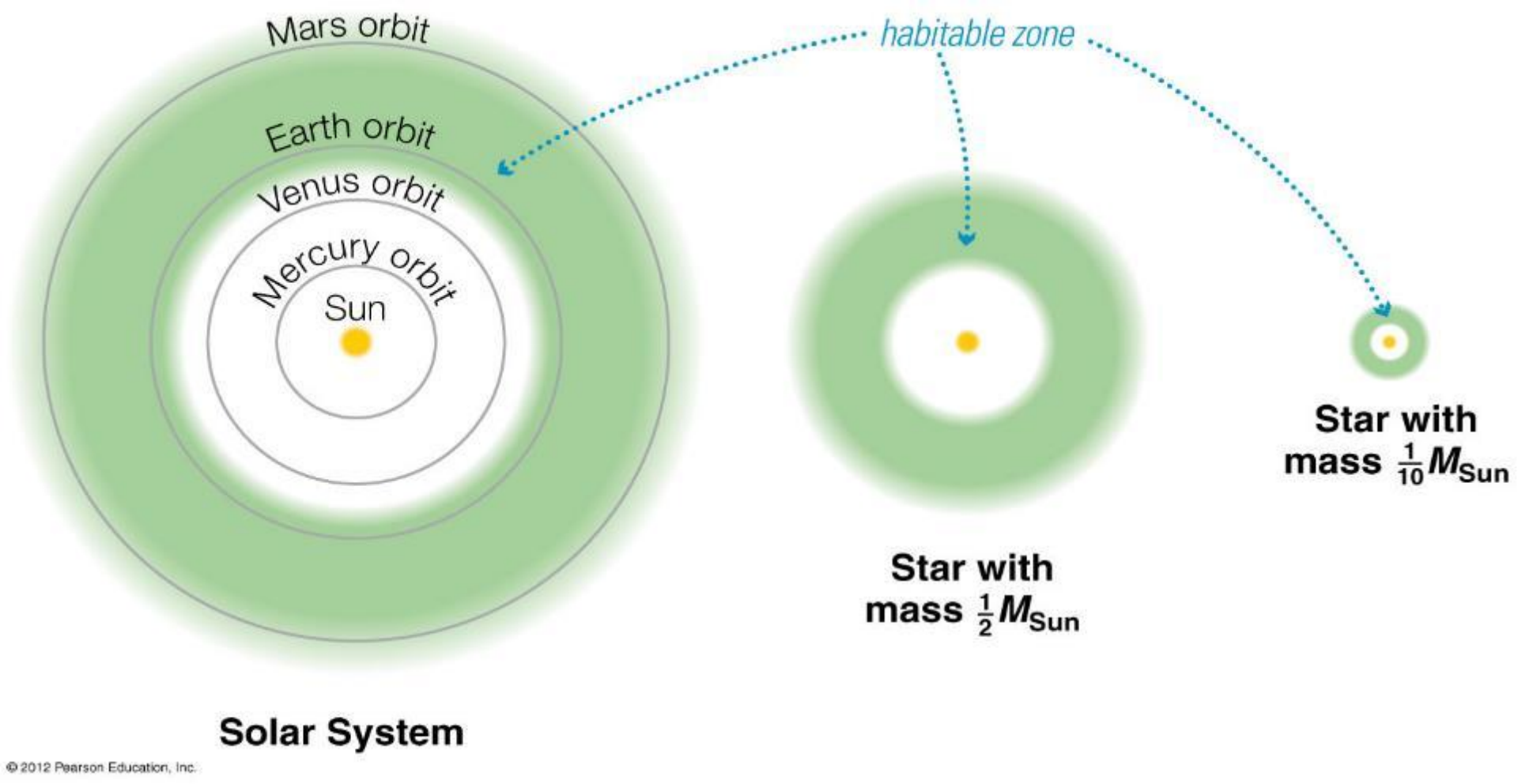




Are there Earth Like Planets out there?

Recall our scale model solar system:

- Finding them is very difficult!
- Looking for an Earth-like planet around a nearby star is like standing on the East Coast of the United States and looking for a pentip on the West Coast—with a VERY bright grapefruit nearby.
- But new technologies (like adaptive optics and 30-meter telescopes) should soon show the way.
- Current estimates say that maybe ~1% of exoplanets will be “Earth like” – not too shabby!!



Habitable Zone – the region around a star where the temperatures would allow liquid water to exist. The more massive the star, the larger the habitable zone—higher probability of a planet in this zone

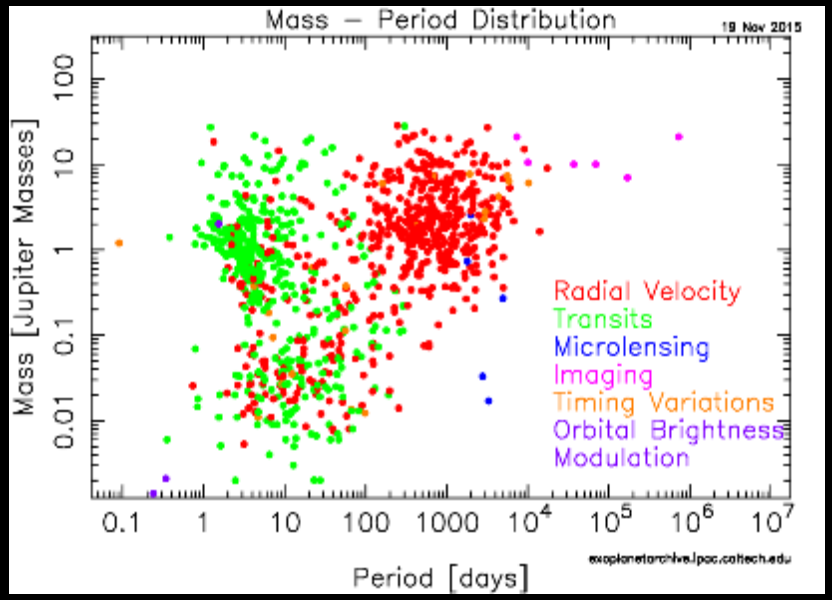
Habitable (Earth-like) Planets

Definition:

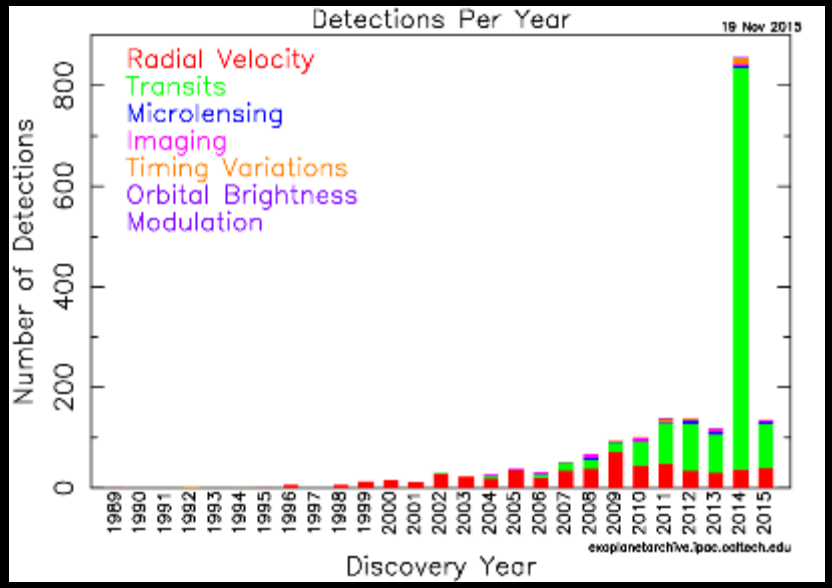
A habitable planet contains the basic necessities for life as we know it, including liquid water. Habitable planets are just far enough away from their host stars that liquid water could exist on their surface.

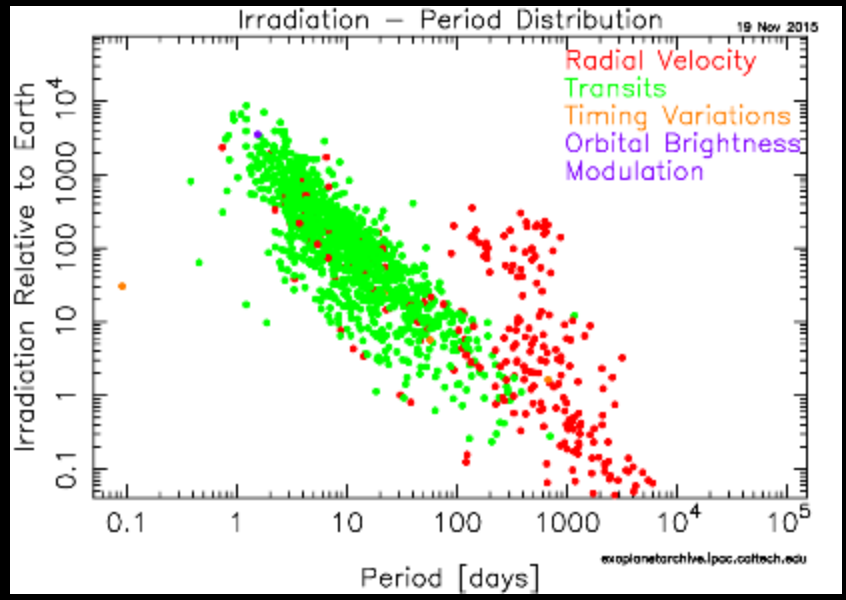
- It does *not* necessarily have life.
- Current models suggest that 25-50% of exoplanets *may be* habitable → perhaps 100 million in our galaxy

Exoplanets and exoplanet data is being studied to look for trends and relationships



Remember…. You don't have to understand the "math" or the "data" completely. But you should feel good that there are people like me (and other scientists) out here that DO understand it – and that is important for our culture and way of life!





Undergraduate research projects continue:

- *exoplanet transits*
- *asteroid light-curve analysis*

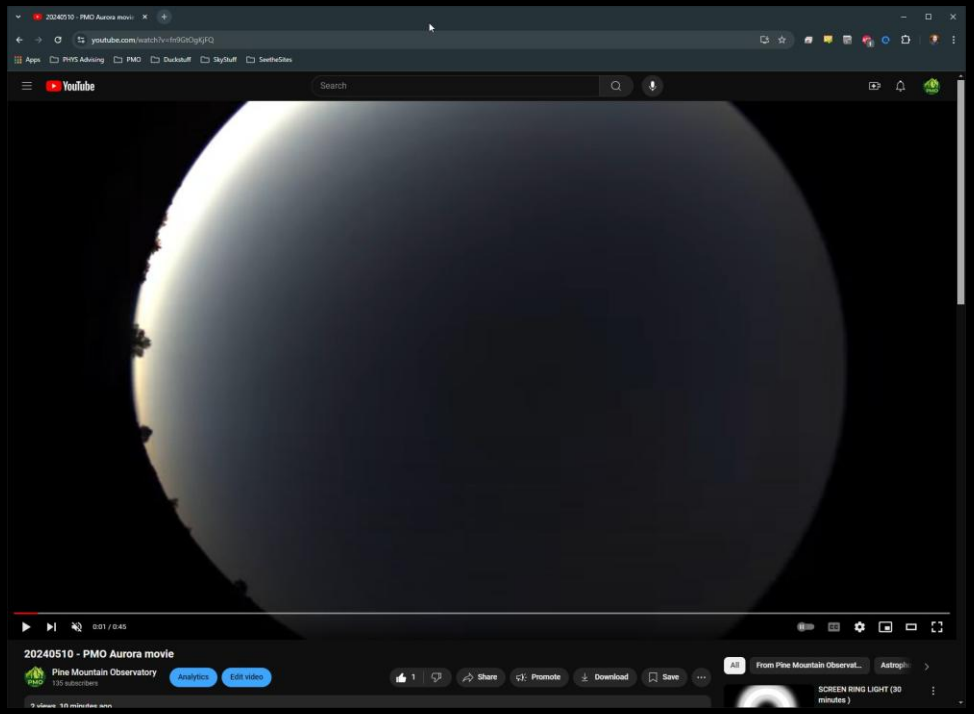
- *~800 visitors over the summer*

- *The ROCC – Remote Observatory Control Center is fully operational (KLA 103)!*

- *Collaborations near and far:*
  - *UO Alumni Association*
  - *Oregon NASA Space Grant*
  - *U. Conception, Chile*
  - *U. Kobe, Japan*

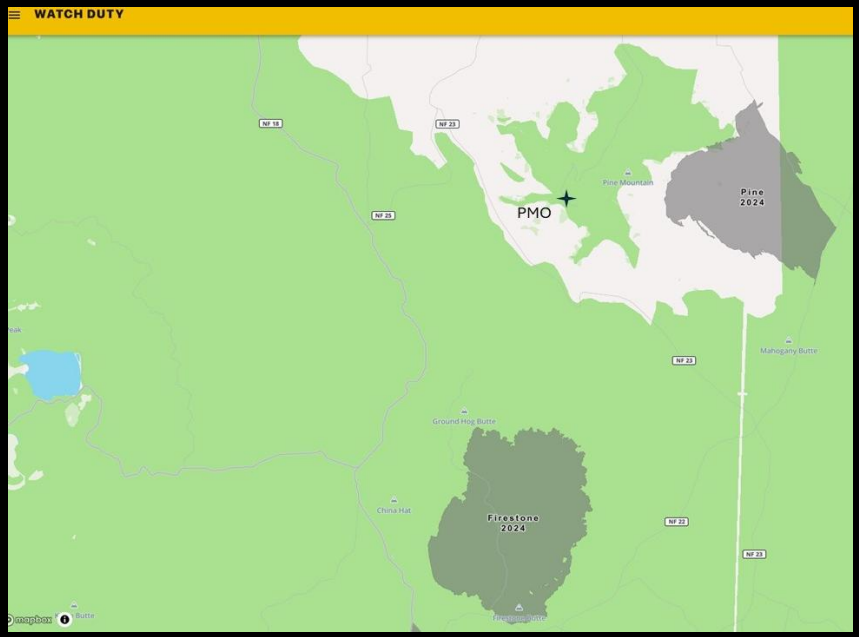
Credit: PMO Staff

Extracurriculars at PMO this Summer



Time-lapse, All-sky view (fisheye lens) of the aurora at PMO on May 10, 2024:

https://youtu.be/fn9GtOgKjFQ?si=b-Ie2J6IZSoTwAOx

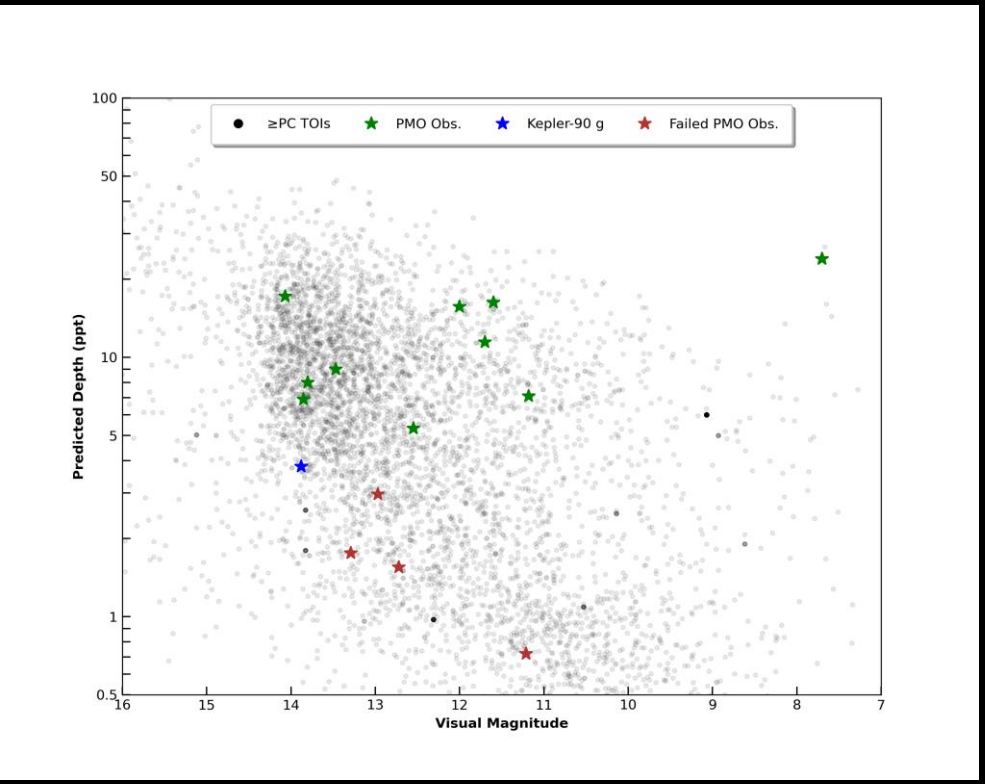


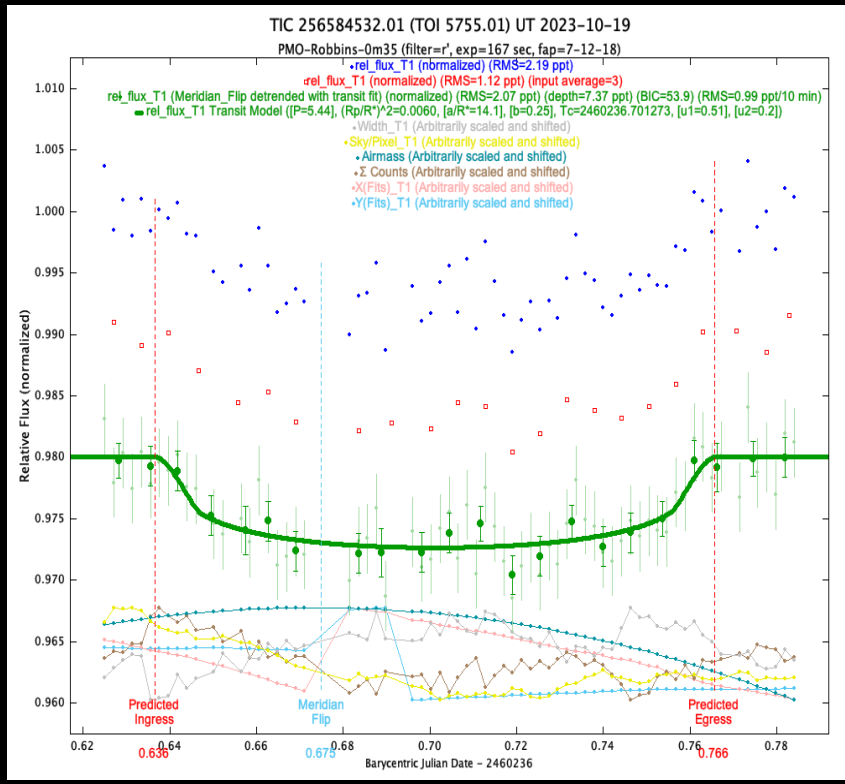
The 9,500-acre Firestone fire made it within ~4 miles of PMO (star symbol) in August/September. We were evacuated from the site for about 2 weeks. The Pine Fire got within 0.9 miles of PMO. Air quality was > 1500 multiple times during the event. There was no permanent damage to equipment or the facility.

Exoplanet transit graphic and animation:

https://svs.gsfc.nasa.gov/13022

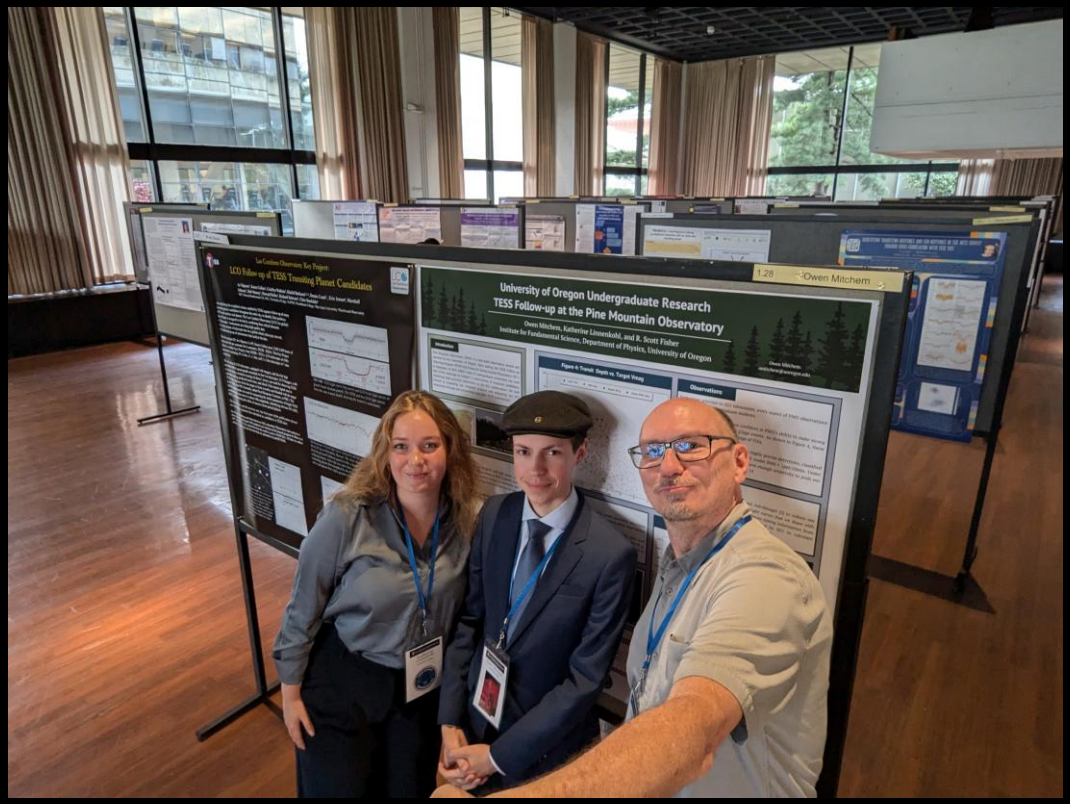
TESS (Transiting Exoplanet Survey Satellite) Mission - Follow-up Observations at PMO





Grey points are TESS targets-of-interest, Colored points are PMO observations (green = good, red = bad, blue = paper for 2 UO undergraduates (Owen and Katie)!

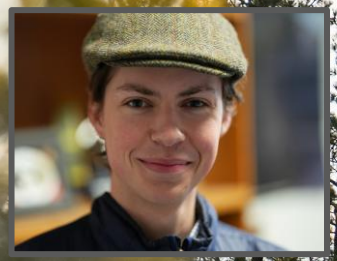
Exoplanet transit detection at PMO. Transit depth is 0.7% on 14th mag(v) host star. Duration ~3 hours.



Katie L., Owen M., and SF with our 2nd place poster at the TESS Science conference at MIT in August 2024,

Fisher awarded $260k over 3-years from HSF for support of PMO and its programs. We also have received >$500k over 10 years from Roundhouse (based in Sisters)

Our Group



Owen Mitchem

Katie Linnenkohl

Abby Lewis

Erin Morrison

Calvin Ajizian

Caisa McCraw

Ian Sherman

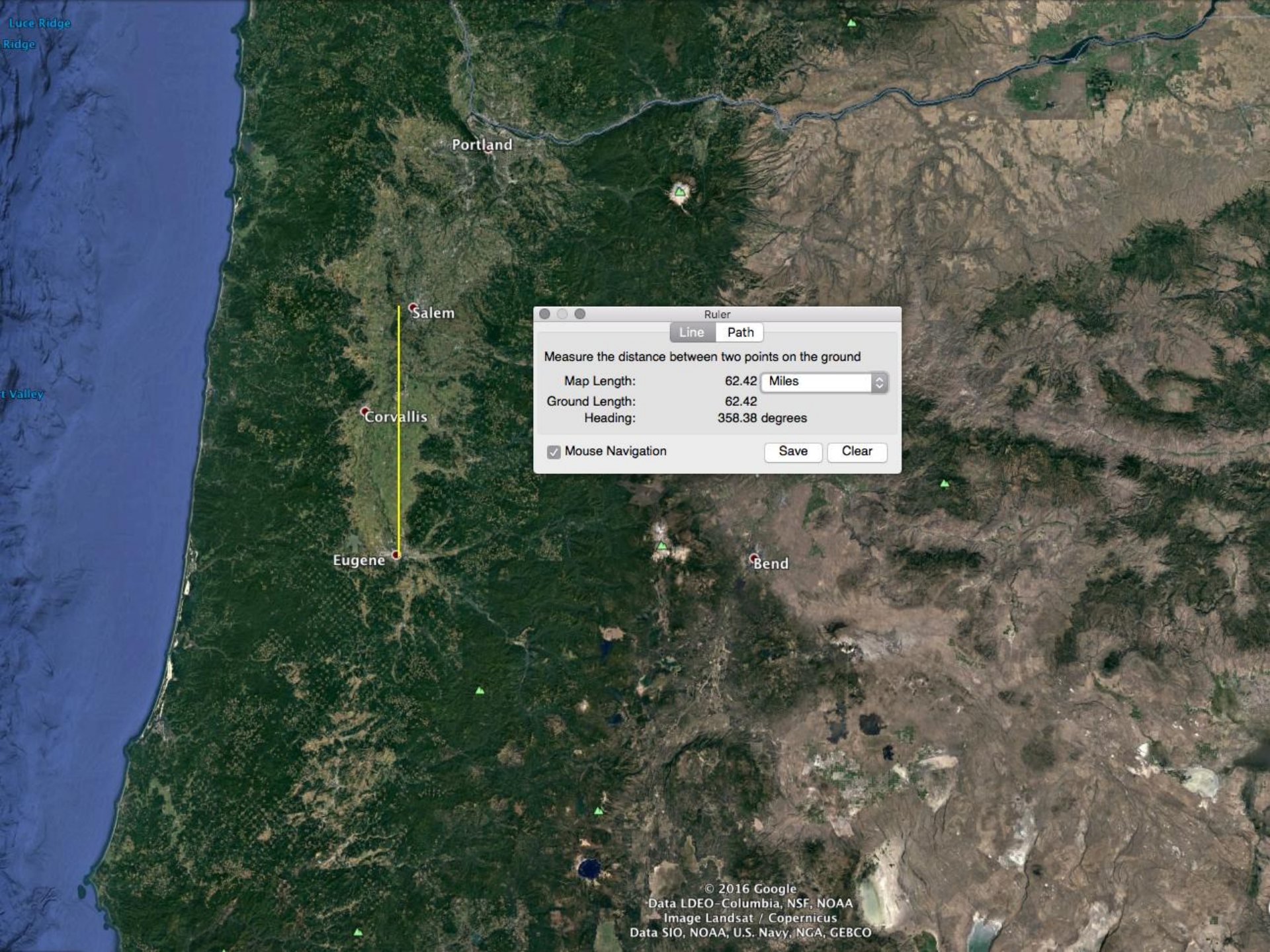
Scott Fisher

Alton Luken

WeeBee

Pop Quiz

How far away is outer space?


Luce Ridge
Ridge
Portland
Salem
Corvallis
Eugene
Bend
t Valley
Ruler
Line
Path
Measure the distance between two points on the ground
Map Length:
62.42
Miles
Ground Length:
62.42
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Data LDEO-Columbia, NSF, NOAA
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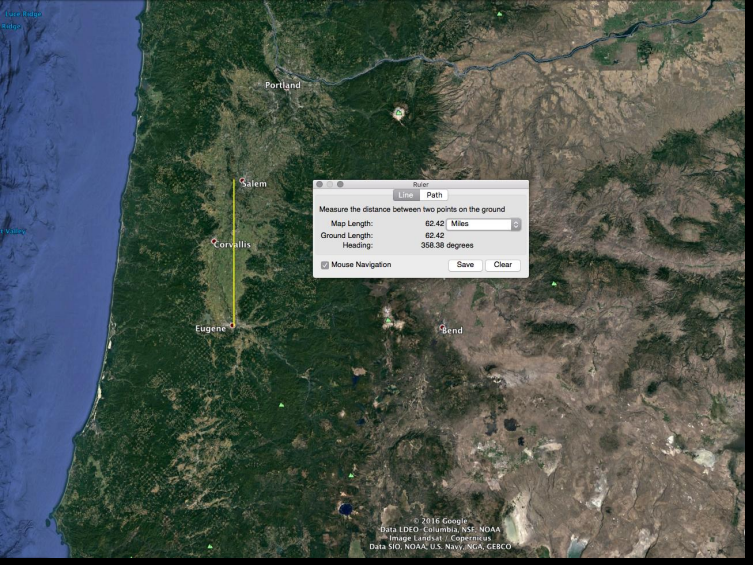


Outer space is 62 miles away

(The distance from Eugene to Salem.)

- 62 miles = 100 kilometers
- The “boundary” of space is defined as this since:

  At this altitude (62 miles up) the energy Earth receives from the Sun is balanced by the energy that Earth loses to space.

Aurora from the ISS and the scale of the atmosphere

62 miles!

This is the entire “sky”.

This is the only thing protecting us from the vacuum of space.

62 miles!

The entire sky is the very thin bright blue “line” tightly wrapped around Earth.

Please make sure that your friends and family know this. The sky is not infinite. It does not “go on forever”.

How does SETI (the Search for Extraterrestrial Intelligence) work?

SETI experiments look for deliberate signals from an E.T.

We've even sent a few deliberate signals ourselves…

Earth to globular cluster M13: Hoping we'll hear back in about 42,000 years!

This was the actual message sent by Arecibo in 1974

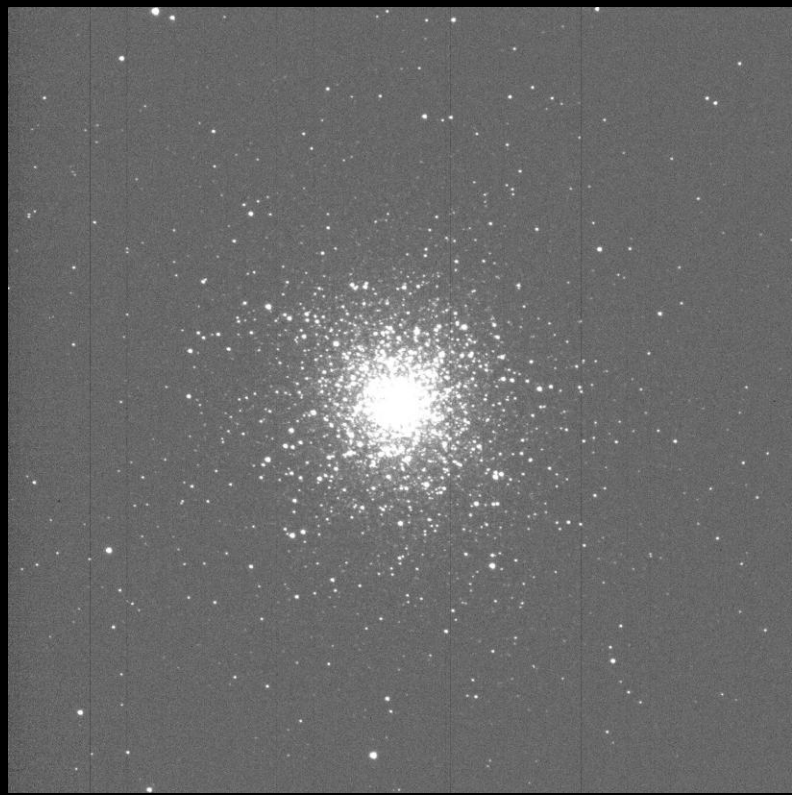
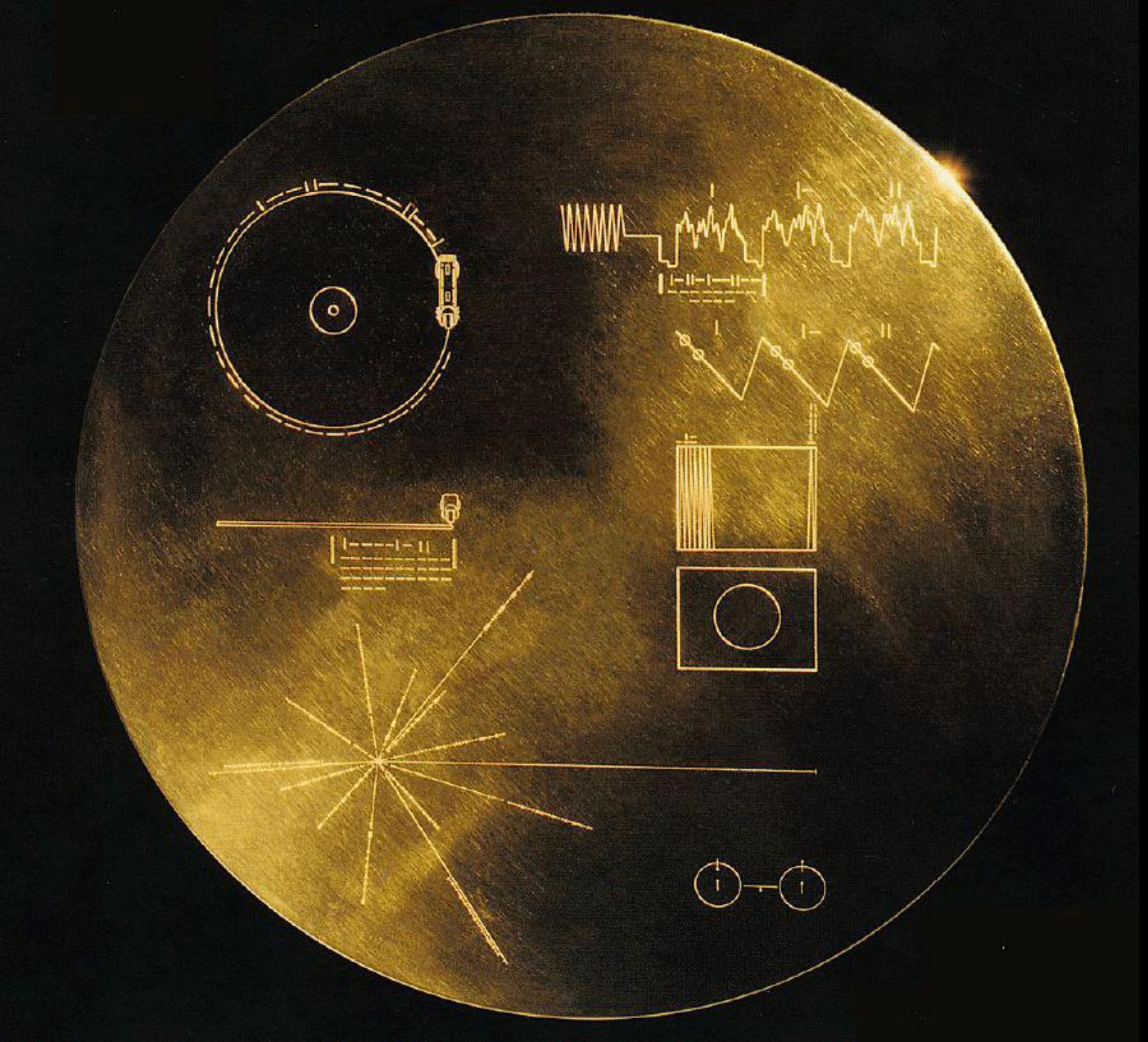


Image of M13 taken at Pine Mountain!



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Contents of the Voyager Golden Record

From Wikipedia, the free encyclopedia

The Voyager Golden Record contains 115 images plus a calibration image and a variety of natural sounds, such as those made by surf, wind, and thunder, and animal sounds, including the songs of birds and whales. The record additionally features musical selections from different cultures and eras, spoken greetings in fifty-nine languages,[1][2] and printed messages from President Jimmy Carter and U.N. Secretary-General Kurt Waldheim. The items were selected for NASA by a committee chaired by Carl Sagan of Cornell University.

After NASA had received criticism over the nudity on the Pioneer plaque (line drawings of a naked man and woman), the agency chose not to allow Sagan and his colleagues to include a photograph of a nude man and woman on the record. Instead, only a silhouette of the couple was included.[3]

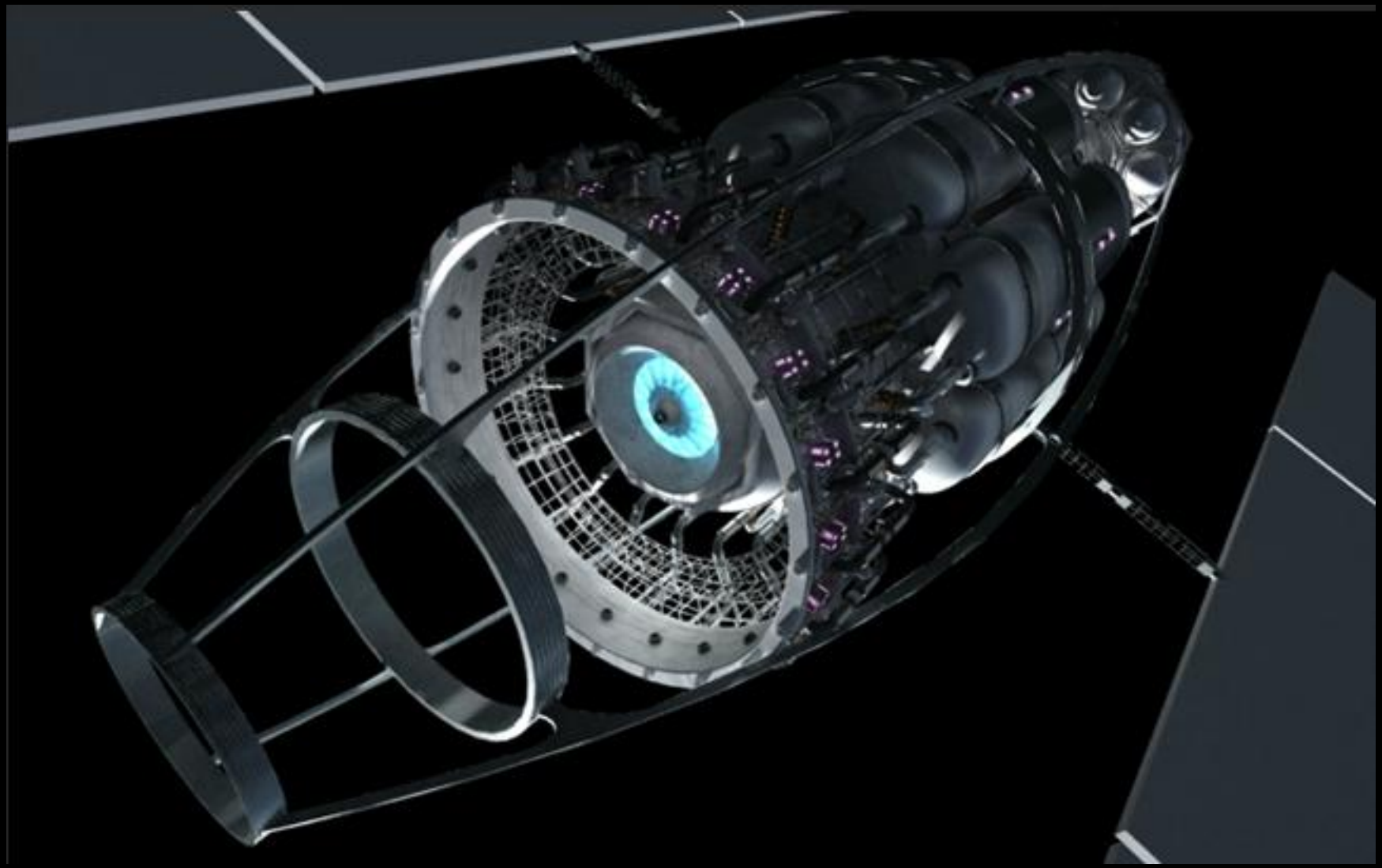
Here is an excerpt of President Carter's official statement placed on the Voyager spacecraft for its trip outside our solar system, June 16, 1977:

> We cast this message into the cosmos ... Of the 200 billion stars in the Milky Way galaxy, some – perhaps many – may have inhabited planets and space faring civilizations. If one such civilization intercepts Voyager and can understand these recorded contents, here is our message: This is a present from a small distant world, a token of our sounds, our science, our images, our music, our thoughts, and our feelings. We are attempting to survive our time so we may live into yours. We hope some day, having solved the problems we face, to join a community of galactic civilizations. This record represents our hope and our determination and our goodwill in a vast and awesome universe.[4]

A copy of the record on display at the Udvar-Hazy Center in Washington Dulles International Airport

Contents [hide]

How difficult is interstellar travel?



Current Spacecraft are WAY too slow to travel between stars

- Pioneer 1 & 2 were launched in the 1970s, and they are just BARELY outside our solar system now.

- Recall Grapefruit scale, from Willamette Hall:
  just outside the Solar System = at the Duck Store on 13th street
  and the nearest star is in Washington, DC!

- Current spacecraft travel at much less than 1/10,000 of the speed of light → more than 100,000 years to the nearest stars

- By far – the biggest obstacle for space travel and aliens is DISTANCE between stars (and planets).

Practical Difficulties of Interstellar Travel

- Far more efficient engines are needed.
- Energy requirements to power an interstellar ship are enormous.
- Ordinary interstellar particles become like cosmic rays.
- There are social complications of time dilation.

Where are the aliens?

The Fermi Paradox

- Plausible arguments suggest that civilizations should be common. For example, even if only 1 in 1 million stars gets a civilization at some time this implies that there are around 100,000 civilizations out there in the Milky Way!

- So why haven't we detected them?

Possible solutions to the paradox

1. We are alone: life/civilizations much rarer than we might have guessed
   - Our own planet/civilization looks all the more precious…

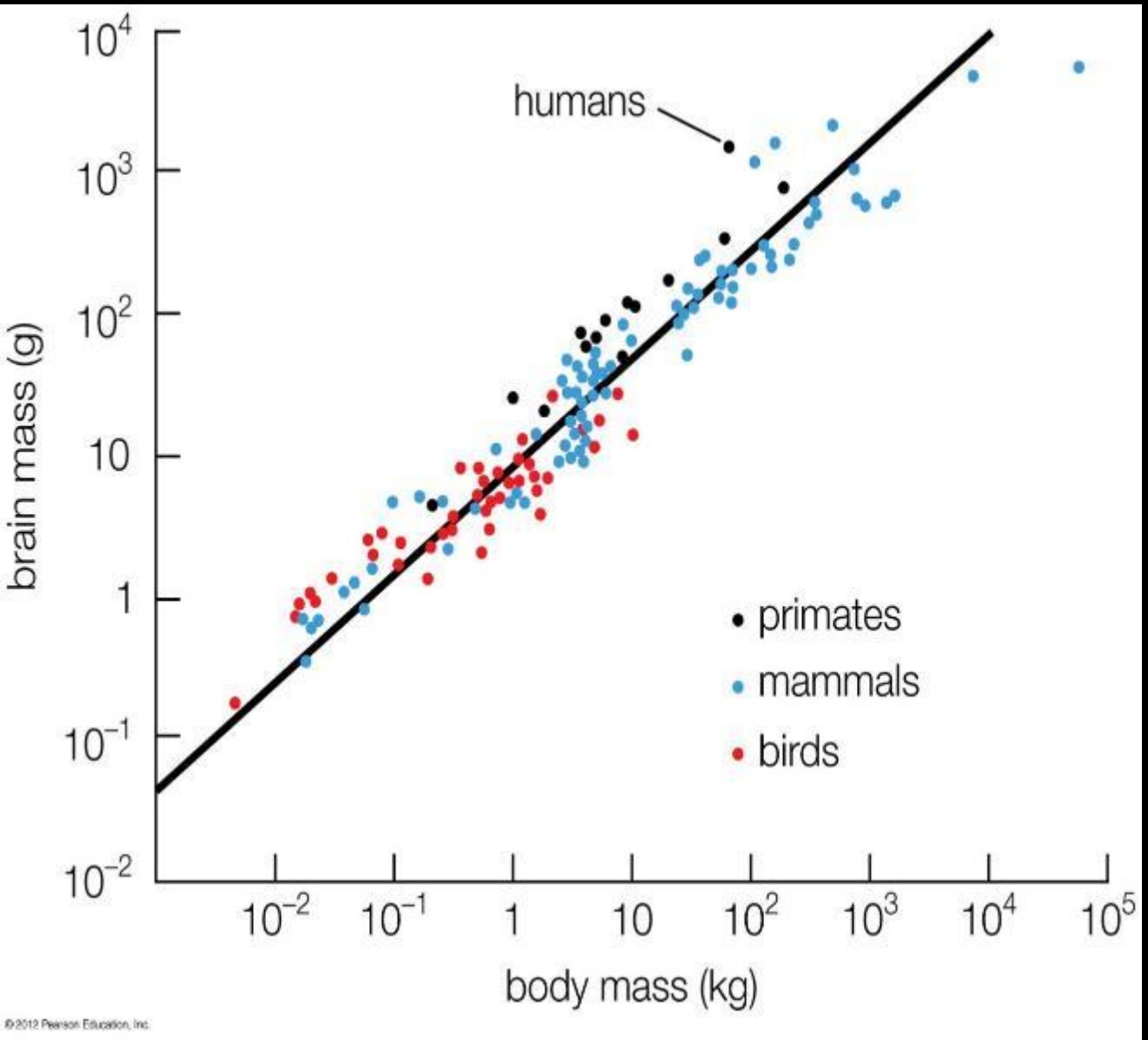
2. Civilizations are common, but interstellar travel is not, perhaps because:
   - interstellar travel is more difficult than we think.
   - the desire to explore is rare.
   - civilizations destroy themselves before achieving interstellar travel.

Possible solutions to the paradox

3. There IS a galactic civilization…

   … and someday we will meet them.

Are we "off-the-chart" smart?



- *Humans have comparatively large brains.*
- *Does that mean our level of intelligence is improbably high?*

Fishers Thoughts on Aliens

- I suspect that life is everywhere throughout the Universe. But mostly SIMPLE life – like plants, algae, bacteria, single cell organisms.
- I suspect that there are also some “dinosaur worlds” or worlds that have animals roaming the surface (and oceans!).
- I suspect that the “hard thing” is to make the jump to intelligent, self-aware species (like us). My gut feeling is that species that have curiosity and the ability to build complex machines are VERY rare.
- I do NOT think that Earth has ever been visited by aliens… the size and scale of the Universe is just too big... and the technical challenge is at this point – unsurmountable.
- I hope for a Star Trek (Next Generation) future... And I think we can reach it!


Thank you!
Worthy Garden Club, Grant Tandy
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