

# Being a Scientist In Astrophysics and Planetary Sciences (Past, Prospects, and Opportunities)

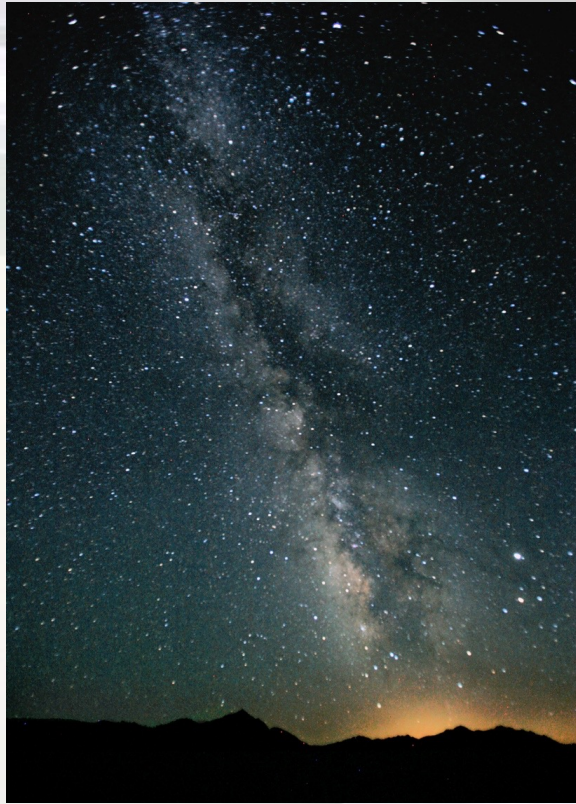
**Murthy Gudipati**  
Science Division, Jet Propulsion Laboratory,  
California Institute of Technology, Pasadena, CA, USA



© 2022 California Institute of Technology. Government sponsorship acknowledged.

University of Miami, Chemistry, April 12, 2022

# Looking Up Into the Nighty Skies: Where did we come from?



Our Galaxy “Milky Way”



Spectacular Show by “Comets”



## **Astronomy**

**Humans have been asking question:  
How and Why the Sky is full of Stars!**

**Later they found Galaxies**

**Some Stars they thought turned out to be Planets!**

**Today Astronomy is an exciting area of Research!**

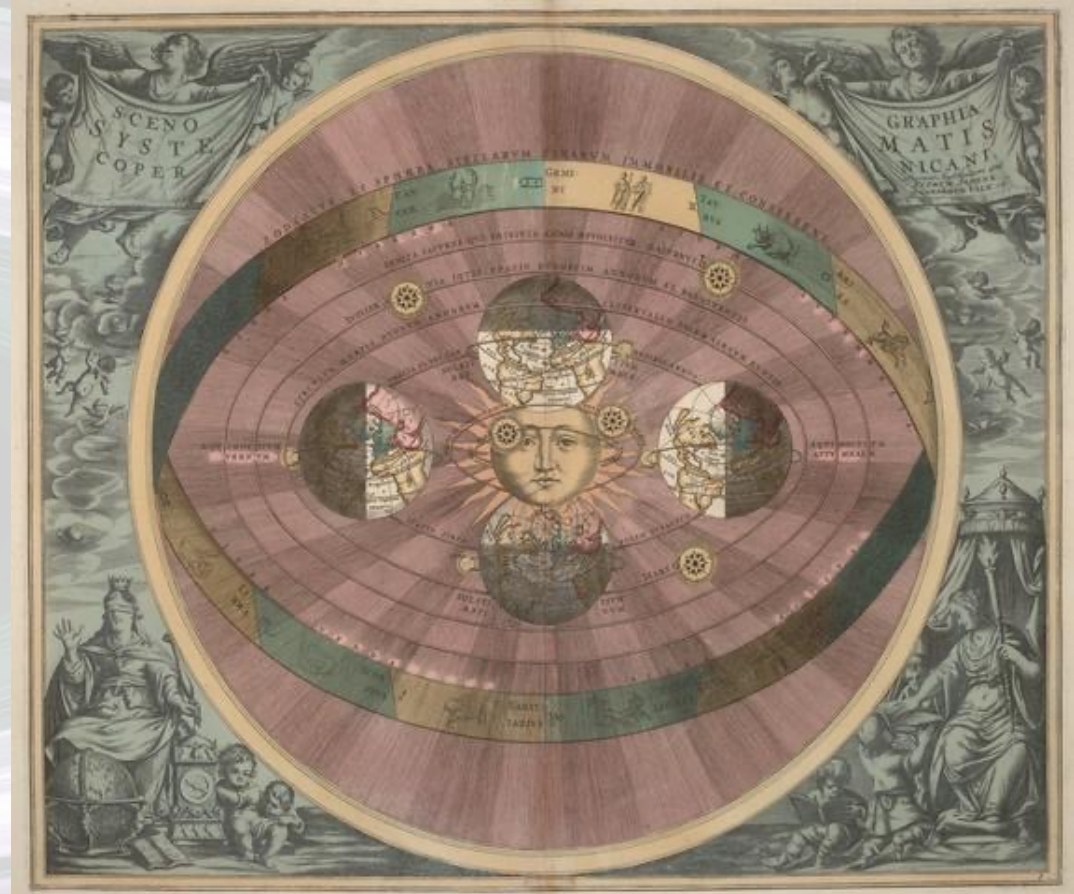




# Heliocentric Model: Planets rotate around the Sun

<https://en.wikipedia.org/wiki/Heliocentrism>

It was not until the sixteenth century (1543) that a mathematical model of a heliocentric system was presented by the Renaissance mathematician, astronomer, and Catholic cleric, Nicolaus Copernicus, leading to the Copernican Revolution. In the following century, Johannes Kepler introduced elliptical orbits, and Galileo Galilei presented supporting observations made using a telescope.



# It was not Easy to be an Astronomer 500 years ago

People and Religions conveniently believed on “Earth-Centric” Model, that makes Earth very special and hence humans on Earth!

However, Heliocentric model has been proposed and discussed all along for 1500 years. But, Galileo Galilei, who discovered Jupiter’s Moons, went public to promote Heliocentric Model. Galileo Galilei was imprisoned (house-arrest) until his death in 1642.

[https://en.wikipedia.org/wiki/Galileo\\_affair](https://en.wikipedia.org/wiki/Galileo_affair):

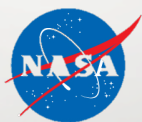
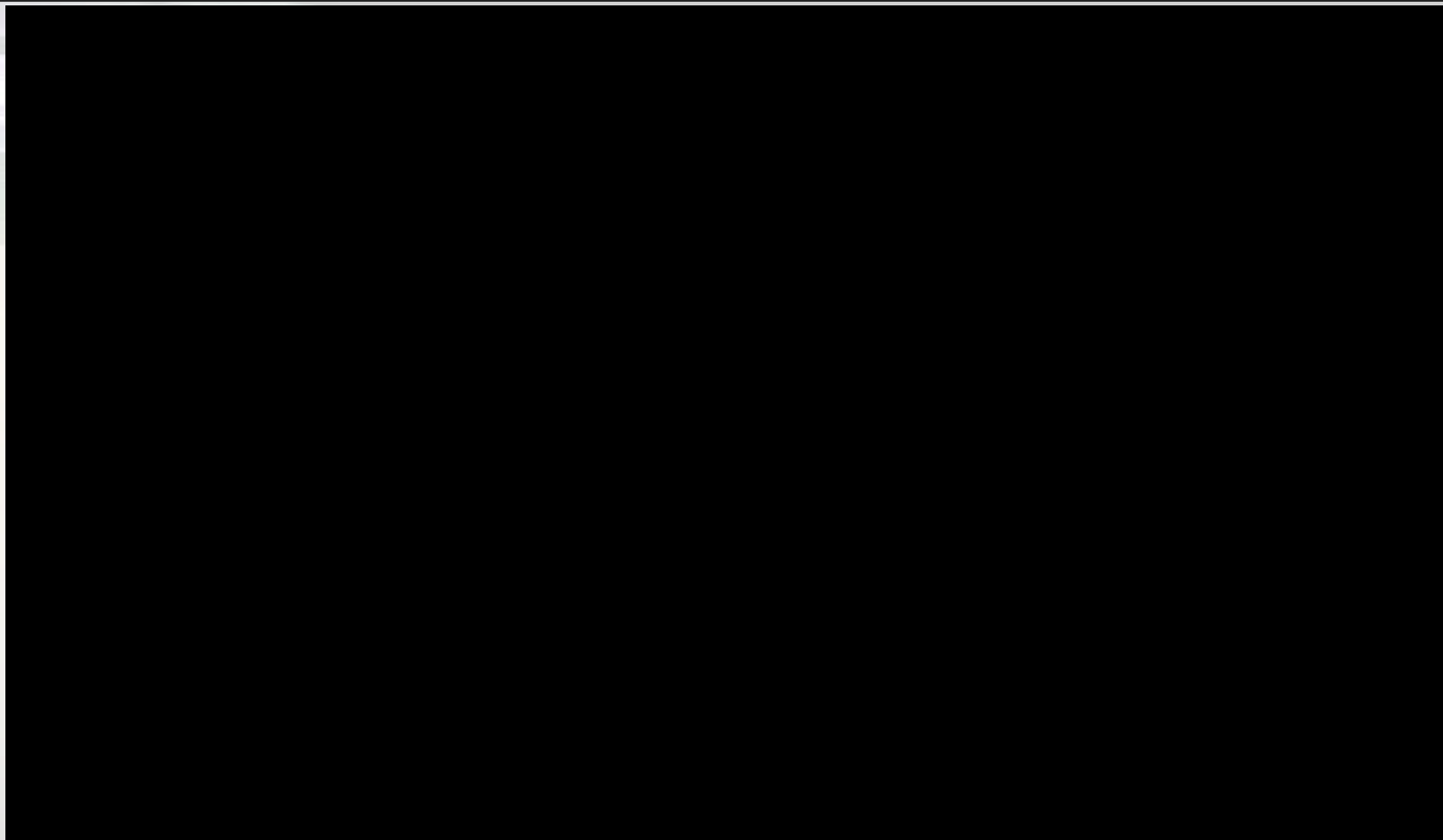
The **Galileo affair** (Italian: *il processo a Galileo Galilei*) began around 1610<sup>[1]</sup> and culminated with the trial and condemnation of Galileo Galilei by the Roman Catholic Inquisition in 1633. Galileo was prosecuted for his support of heliocentrism, the astronomical model in which the Earth and planets revolve around the Sun at the centre of the universe.

Science is not a Belief  
It is the accumulation of Knowledge, even against Beliefs at that time!



# Fast Forward to 2022 – In Just 480 Years

NASA JUNO Mission to Jupiter - Ongoing

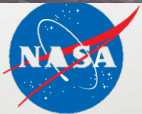
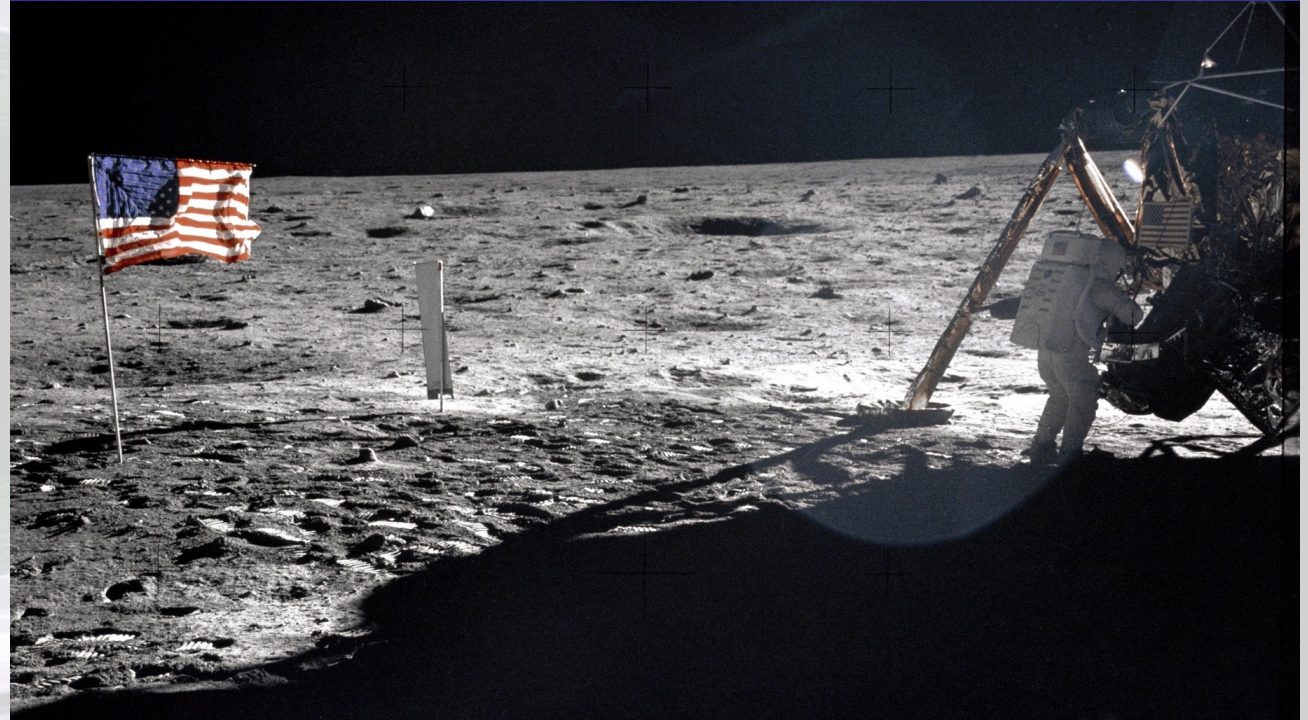


# We Landed on the Moon in 1969

Earthrise by astronaut William Anders - the Apollo 8 December 24, 1968.

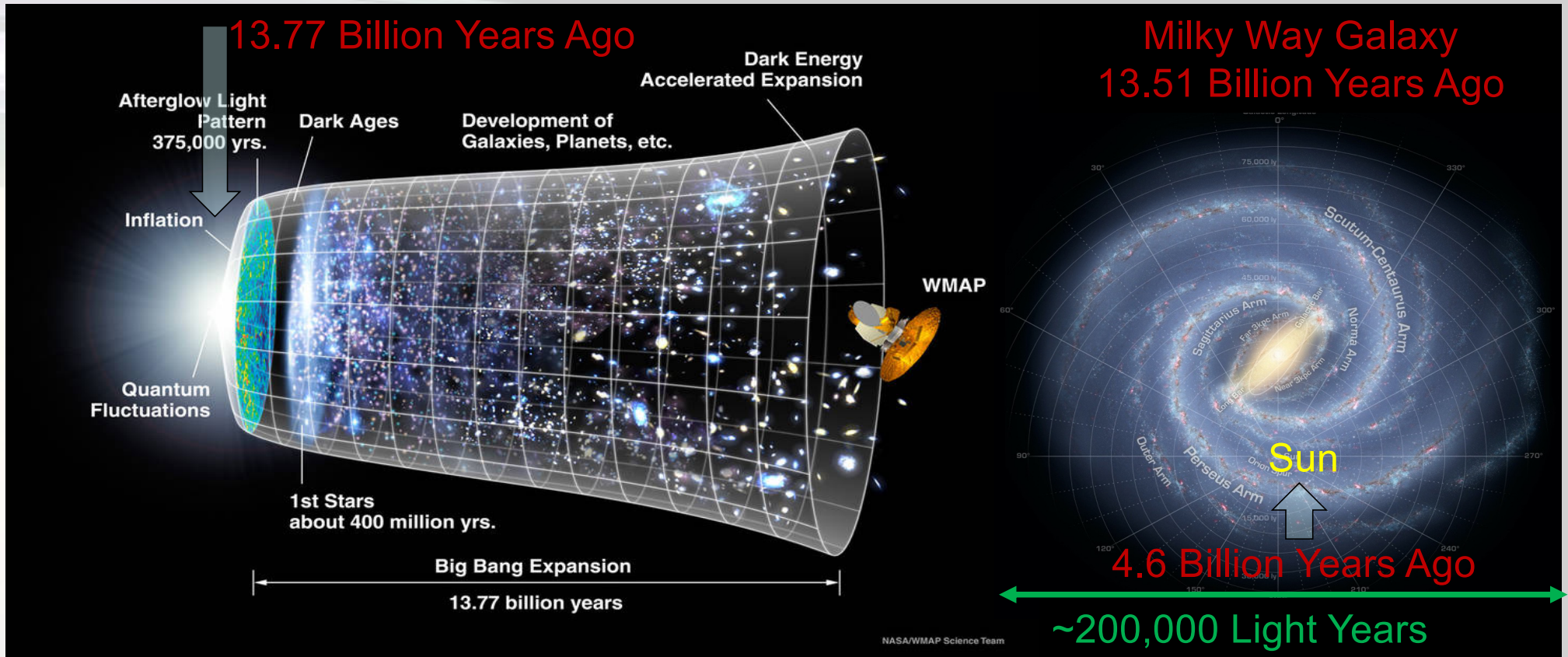


July 16, 1969, 10:56 pm EDT – Apollo 11 – Armstrong, Aldrin, and Collins: That's one small step for a man, one giant leap for mankind."





# Our Sun is at least a second generation & small Star!

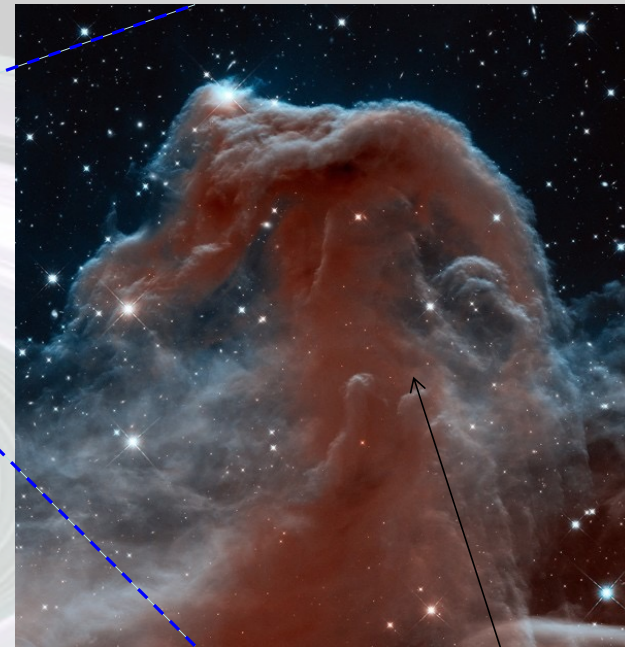


Billions of Galaxies

~400 Billion Stars

© 2022 California Institute of Technology. Government sponsorship acknowledged

# Space Telescopes: Closer Look at Birthplaces of New Stars

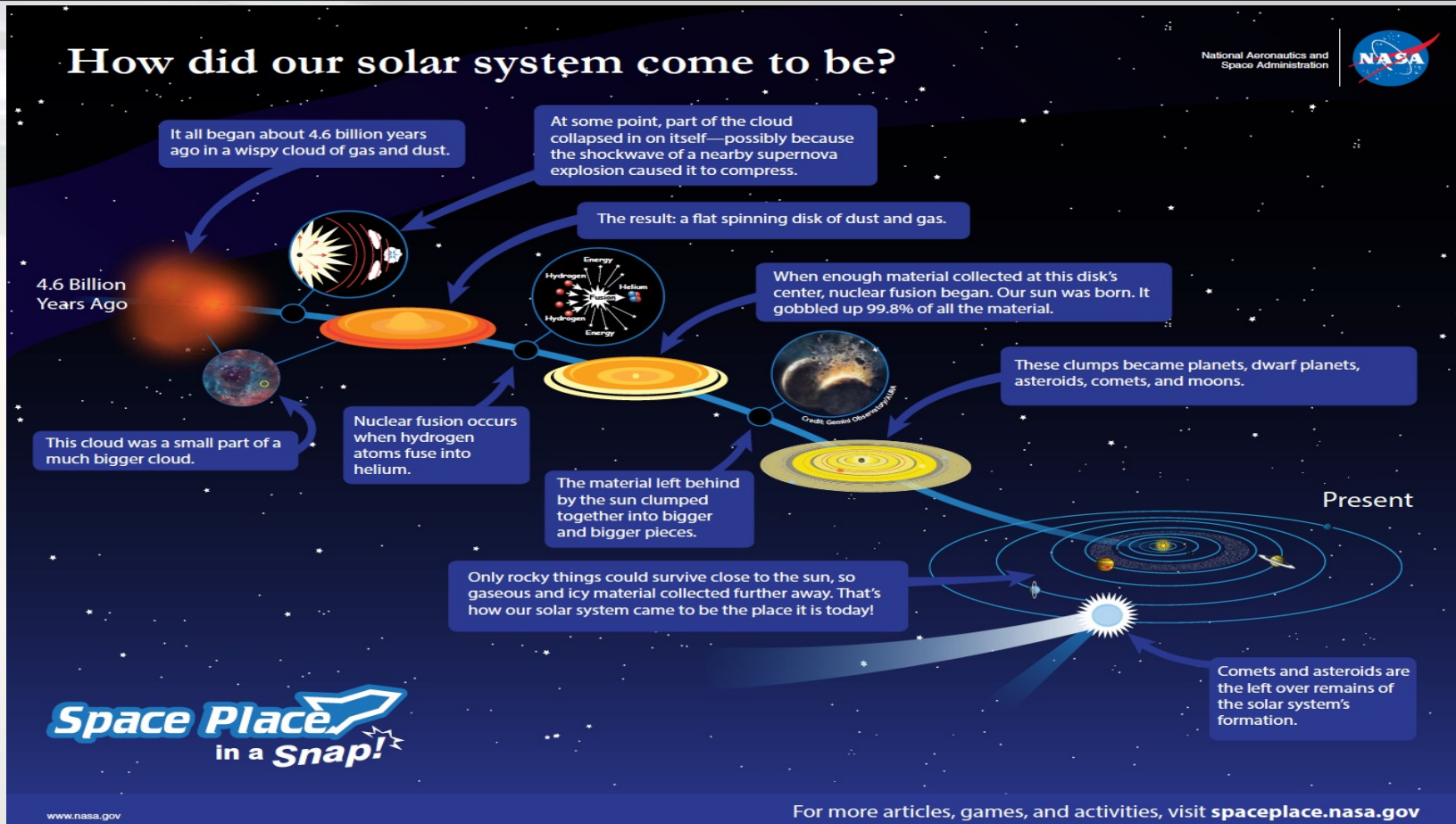


Orion Constellation  
Horsehead Nebula (very cold)  
NGC-2023 Reflection Nebula

NASA Hubble Space Telescope Images



# How Did Our Solar System Come Into Existence?



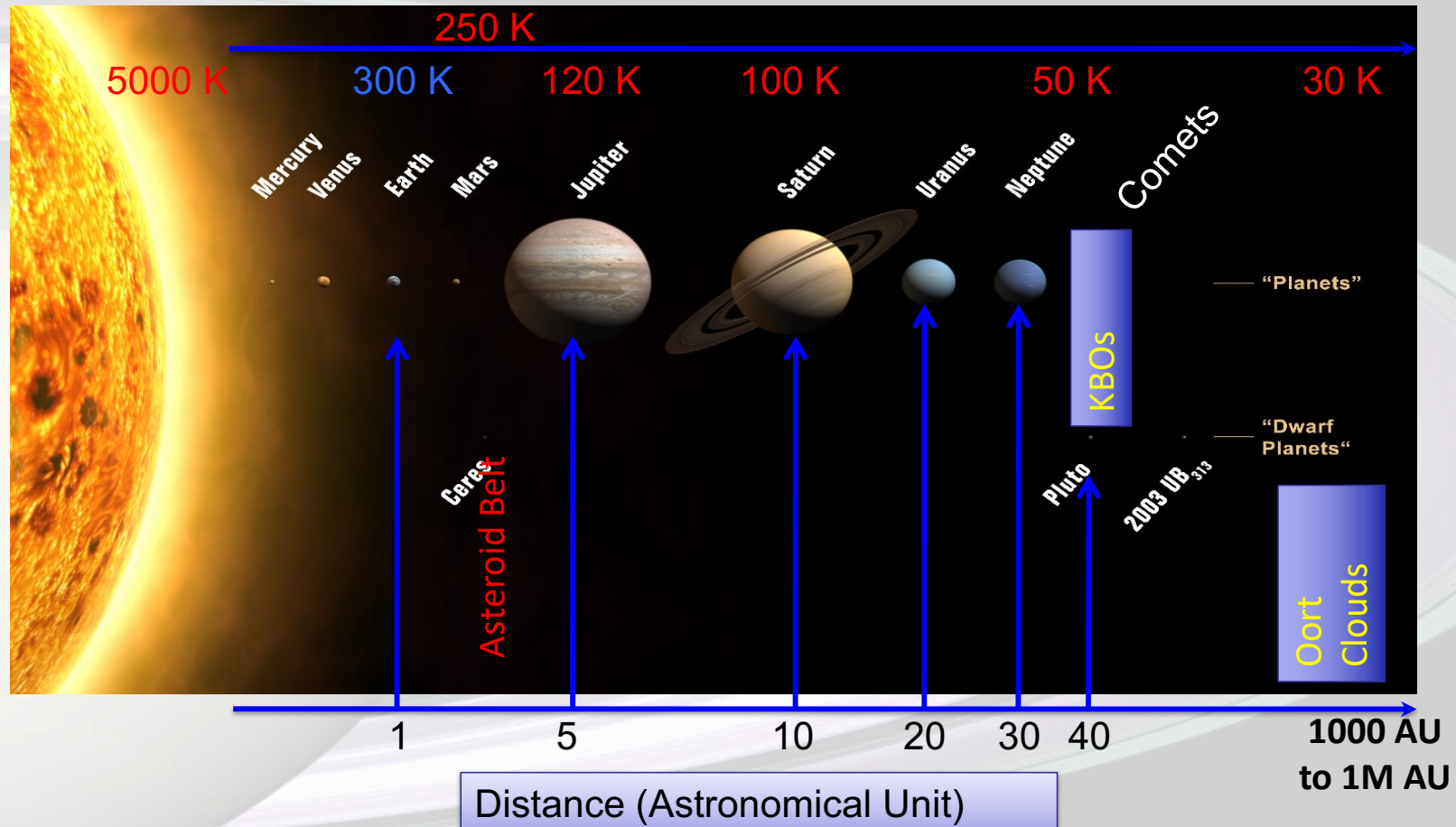
# Formation of Stars and Solar Systems: From Dust, Ice, and Gas in the Molecular Clouds

<https://www.youtube.com/watch?v=8Rg9v3J0liU>

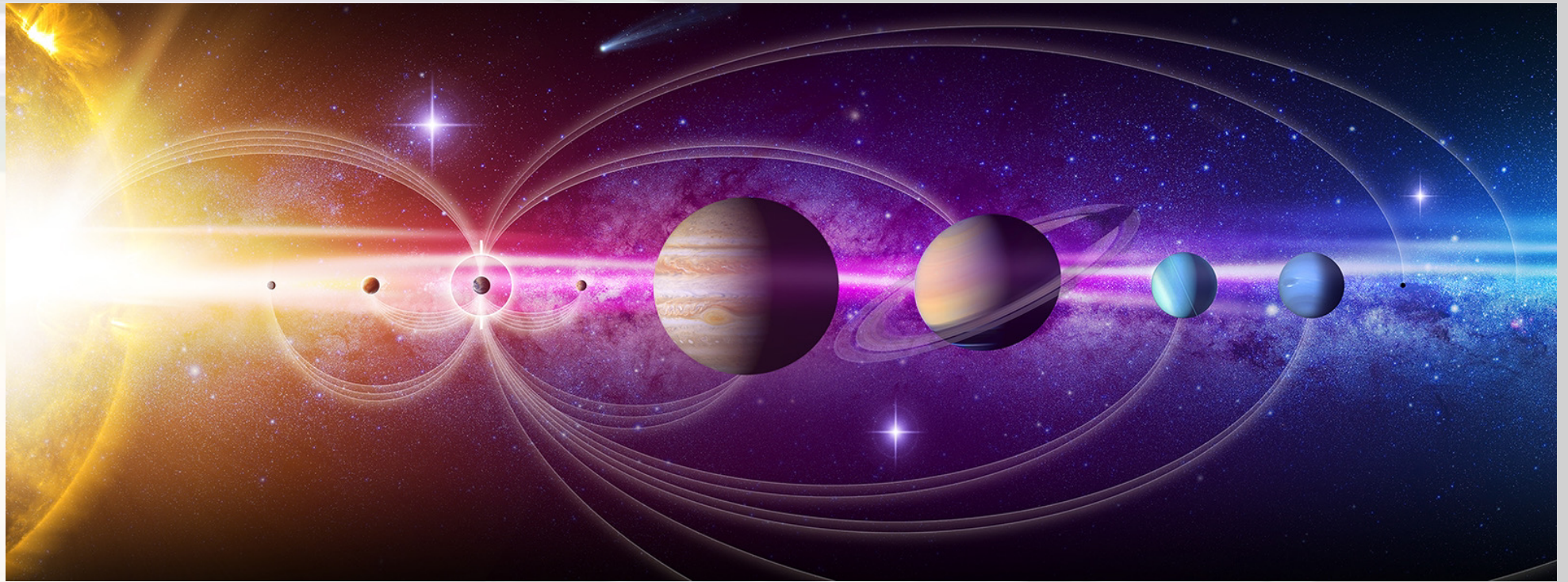


Excerpted from 2015 PNT (Position, Navigation and Time) Symposium talk, entitled: "Rosetta: To Escort and Land on a Comet" by Fred Jansen, Senior Rosetta Mission Manager  
© 2022 California Institute of Technology. Government sponsorship acknowledged

# Our Solar System



# NASA Spacecrafts visiting Our Solar System



# Other Stars, Solar Systems, and Exoplanets

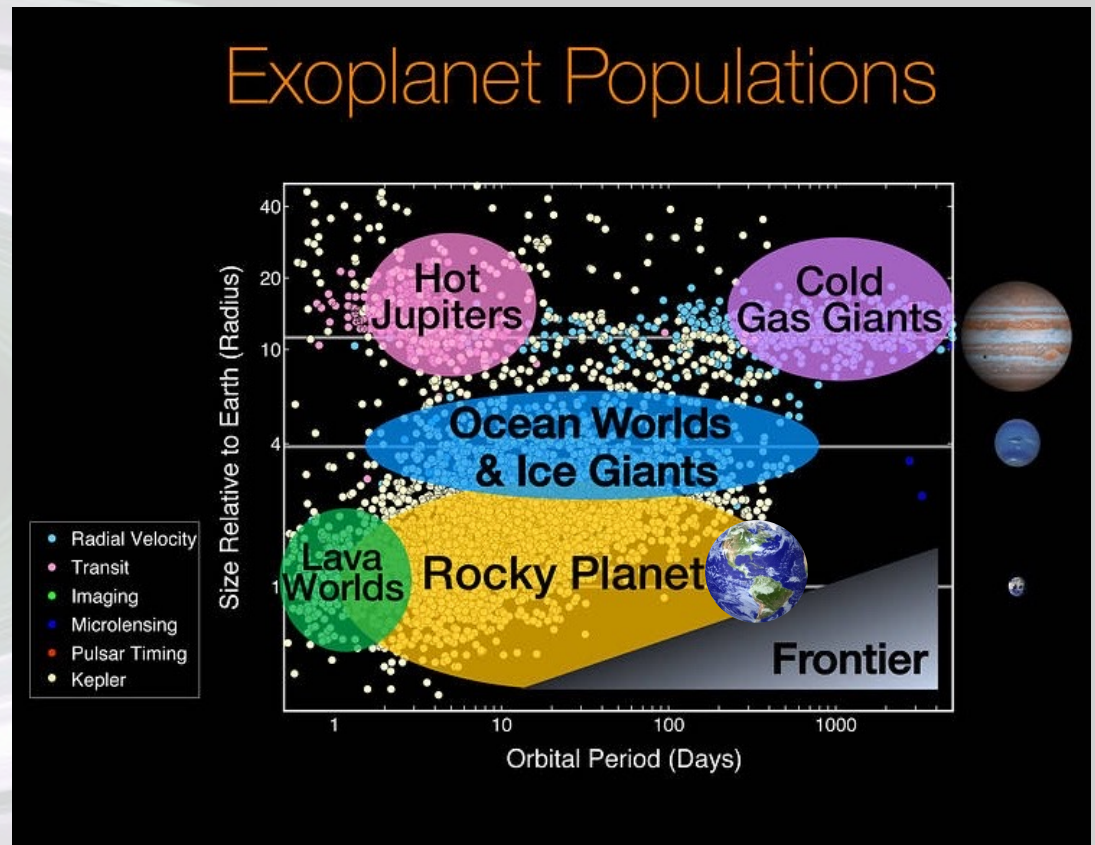
~5000 Exoplanets Discovered as of Today

[https://exoplanetarchive.ipac.caltech.edu/docs/counts\\_detail.html](https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html)

<https://exoplanets.nasa.gov/>

- Predominantly shorter orbital periods.
- Much closer to the star
- Higher UV flux
- Higher temperature

Understanding atmospheric chemistry of hot-Jupiters (simultaneous high-temperature and UV) demands new lab data and better models.





# NASA Missions Today

<https://www.nasa.gov/missions>

Human Space Habitats:  
International Space Station

Earth Sciences:  
Earth Orbiting or Geostationary Satellites

Astronomy:  
Space-based Telescopes (JWST, Hubble, TESS etc.)

Planetary Sciences:  
Orbiters and Landers (Mercury, Venus, Moon, Mars, Jupiter, Saturn, TNOs, beyond our Solar System – the Voyagers)





# Ices and Organics are all over the Universe

Earth Sciences

Planetary Sciences

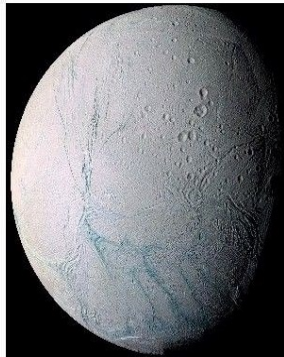
Astrophysics



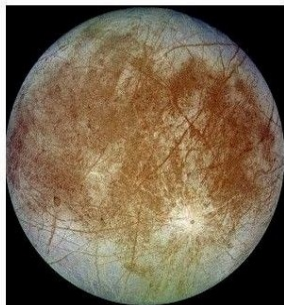
Atmospheric Aerosols



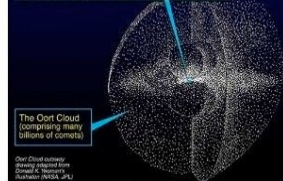
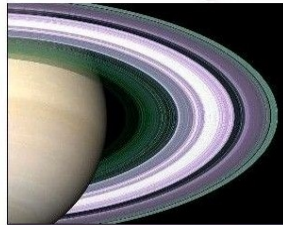
Polar (bear) ices



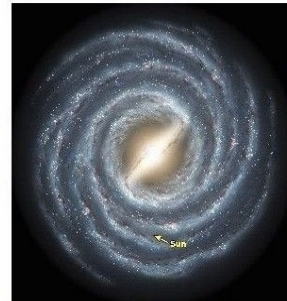
Enceladus



Europa



Comets (Hale-Bopp)



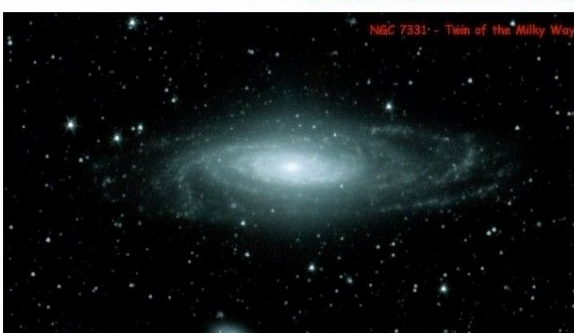
Galactic (Milky Way)



Horse-Head Nebula

Interstellar Medium

Dense Molecular Clouds



NGC-7331 Twin of the Milky Way

Under right conditions they form prebiotic molecules  
Under special conditions Life is triggered from these molecules

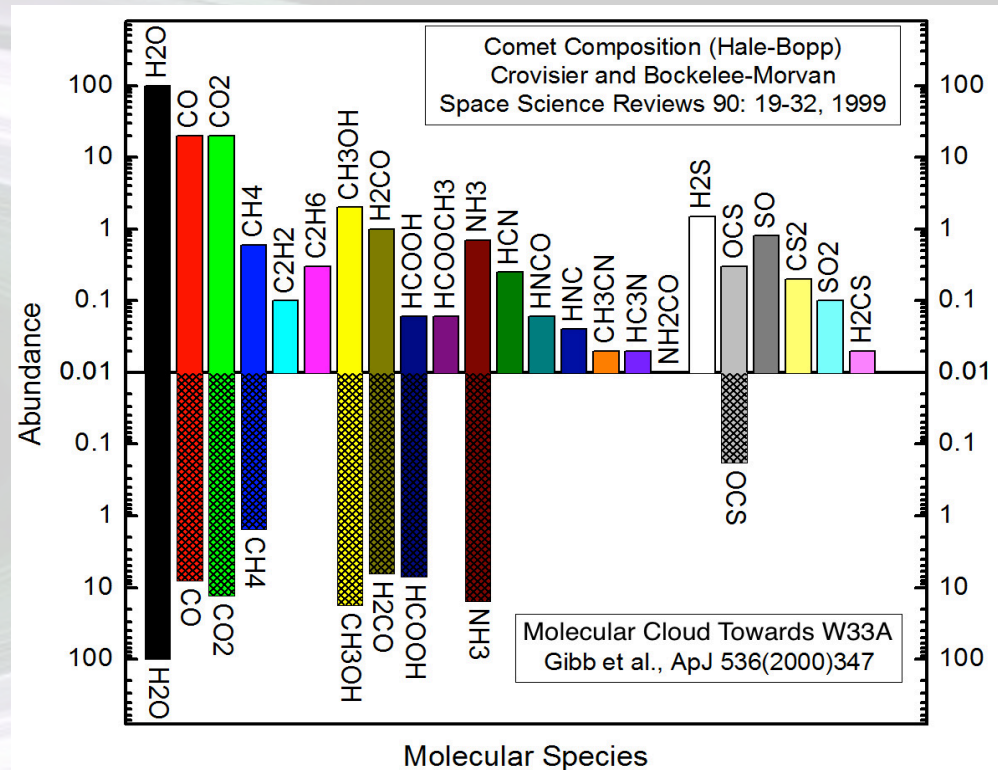


# Complex Chemistry from Simple Molecules Interstellar Ice Grains

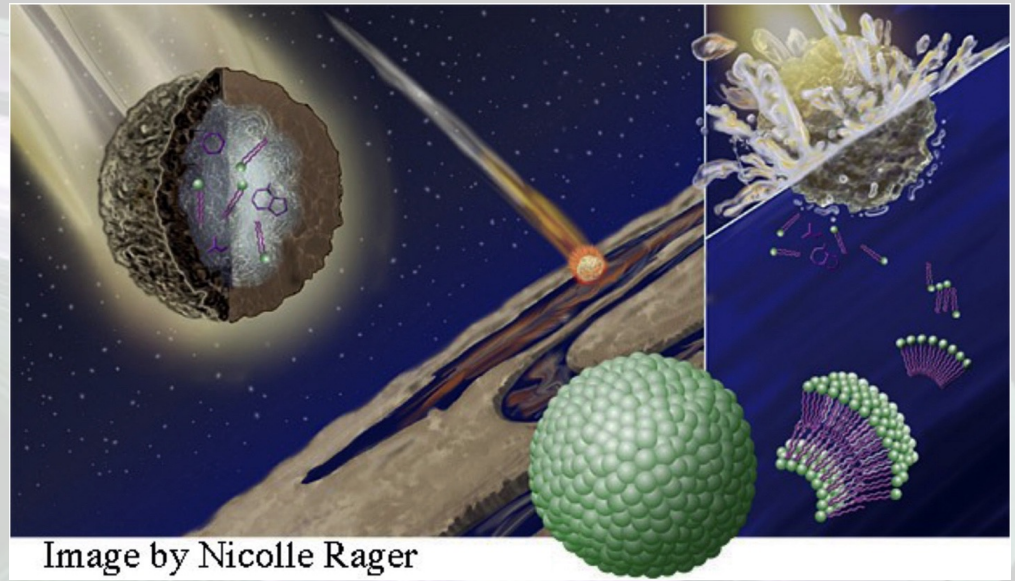
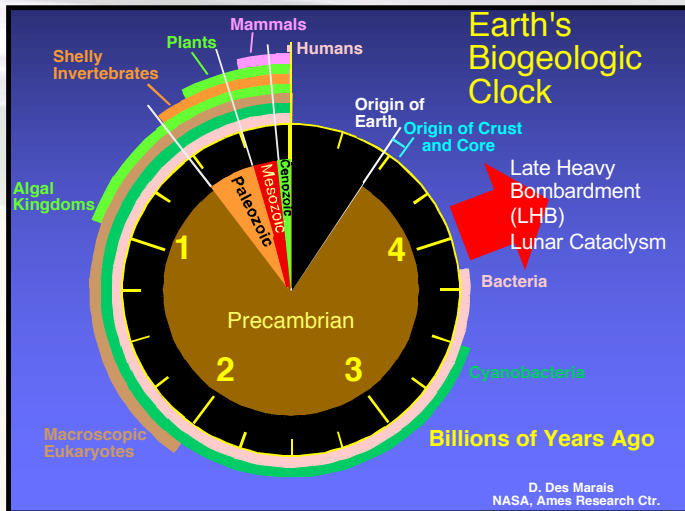
Is Cometary Nucleus a living Fossil of Interstellar Ice Grains?

Is Cometary Ice Amorphous or Crystalline?

We don't know



# Earth, Comets & Asteroids, and Origin of Life



**The Road is long and the Journey has just began to understand the Origin of Life on Earth!**

“Prebiotic Molecular Delivery” by Comets and Asteroid Precursors some 4 Billion Years ago to Earth, could have possibly triggered the “Origin of Life on Earth”



# Asteroid Impacts on Earth – Dinosaurs Extinction

<https://www.space.com/dinosaur-impactor-origin>

66 million years ago a big asteroid impacted on Earth at Yucatan Peninsula that led to dust storm and extinction of 75% life on Earth.



© 2022 California Institute of Technology. Government sponsorship acknowledged



# Study and Redirection of Near-Earth Objects

NASA is continuously surveying the space around Earth for any asteroid/comet in collisional path with Earth.

Small meteoroids (~1 m diameter) are not a threat to Life on Earth.

Large (100s of meters or a few km diameter) asteroids are extremely dangerous!

We have to develop technology to detect and mitigate these objects well before they collide with Earth.

Probability of such collisions is ~ 1 in 100 million years!



# Status of Our Knowledge in Astronomy and Planetary Sciences

We know now a lot about Space, Planets, Stars, Galaxies, and the Universe.  
But we still have a lot to gather Knowledge, Understand, and Explore!

- From Big Bang to Life on Earth
- Universe with billions of Galaxies
- Galaxies with billions of Stars
- How Stars are formed
- How Planets are formed
- Landed on the Moon
- Lived in Space Station (ISS)
- NOT YET - How Life happened on Earth
- NOT YET – Is there Life elsewhere in the Universe?
- NOT YET – Dark Matter and Dark Energy
- NOT YET – Human Travel to other Planets (Mars)
- NOT YET – How to avoid big asteroid/comet impacting Earth

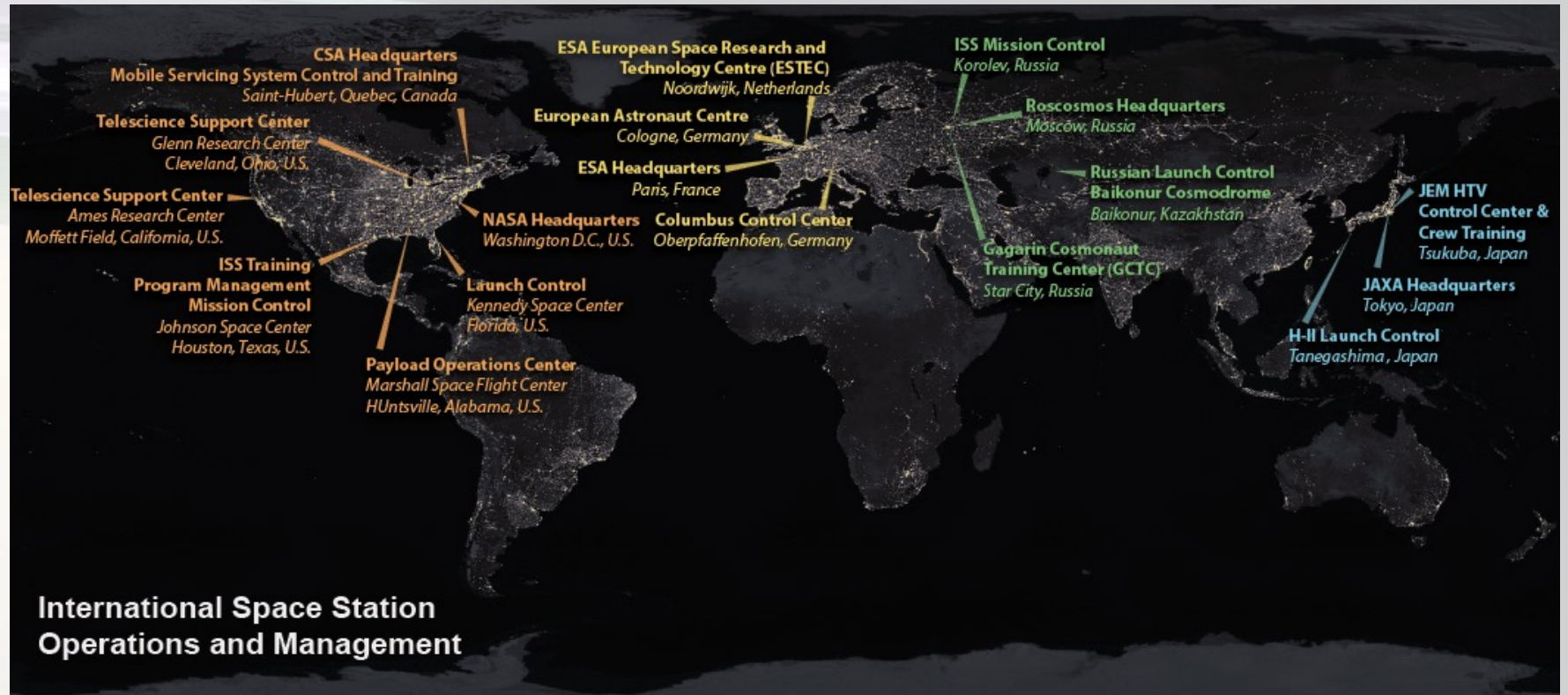


## Space Exploration is An International and a Multidisciplinary Pursuit.

Bringing Nations and Humanity Together!



# ISS – International Space Station







# United Nations Office for Outer Space Affairs (UNOOSA)

<https://www.unoosa.org/oosa/en/ourwork/space-agencies.html>





# Private Space Enterprises

[https://en.wikipedia.org/wiki/List\\_of\\_private\\_spaceflight\\_companies](https://en.wikipedia.org/wiki/List_of_private_spaceflight_companies)





# Career Opportunities in Space Sciences

It is a Multidisciplinary Endeavor! We need EVERY Discipline

Scientists:

Physics, Chemistry, Mathematics, Biology, Geology, Astronomy, Astrochemistry, Astrobiology, etc.

Engineers:

Civil, Electrical, Electronics, Mechanical, Thermal, Software, etc.

Medicine:

Human Space Physiology & Psychology

Agriculture:

Grow Food in Space (Terraforming).



We need Humans Diversity in order to bring Scientists and Engineers from various backgrounds to come together, think **OUT OF THE BOX** and find **NEW WAYS!**

Space Exploration is Extremely Complex – Diversity is the Solution!



YES

If you are passionate about exploring the Universe

If you are talented in any one subject  
(Science or Engineering or Medicine)

If you think out of the box

If you are a team player  
(better, but not required for basic research).



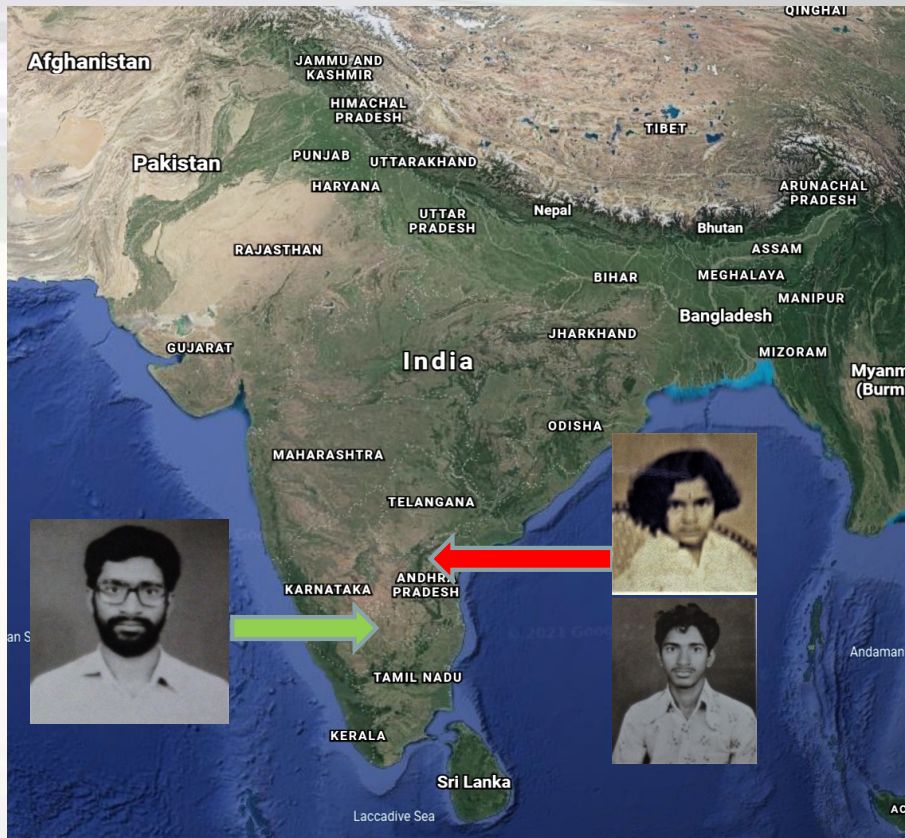


# My Own Career Journey

I Paved my own Career Path  
Focusing to do the best in what I took-up!



# I was born and grew up in small Villages in India



- My Childhood was not easy, but also filled with joy of living in the “Villages immersed the Nature”
- In my 7<sup>th</sup> Grade, I was walking 4.5 miles (7.2 km) one way to the school and then 4.5 miles back.
- When I was 11 years old, my father died.
- Our Mother took care of us with earnings on a small agricultural land, and sent us to Schools.
- I was determined to learn Science, so I continued to work hard.
- I studied only at Government Schools, Colleges, and Public Libraries in Andhra Pradesh.
- After passing B.Sc. I was told to take up a job.
- But I wanted to become a Scientist!
- So, I took a Bank Loan when I got admitted to the Central University of Hyderabad to study M.Sc.
- I sent my Merit Scholarship to my Mother.
- After M.Sc. I got admitted to Ph.D. at IISc
- I continued to support my Mother and Sisters with a part of my Ph.D. Scholarship.



# Indian Institute of Science (IISc) – Best Days of My Life!



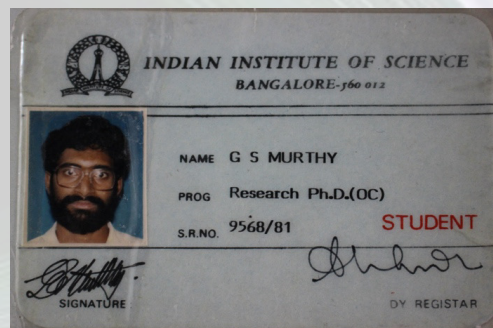
The Nobel Prize in Chemistry 1964  
Structures of Penicillin & Vitamin B12  
1985, IISc, Benaguru



Kailasam  
Venkatesan

Dorothy  
Hodgkin

Murthy  
Gudipati



Five Solid Years at IISc



Best Thesis Award Received by  
my Mother from CNR Rao in 1987

Worked at the Library to make extra  
money to support my mother & sisters





# From India to the USA to Germany and back to the USA

NASA Ames Research Center  
„Astrochemistry“;  
JPL/Caltech “Planetary  
Sciences”

3

Tenure-Track Faculty  
Habilitation in  
Physical Chemistry  
(Köln, Germany)

2

M.Sc., and Ph.D. in  
Chemistry

1

Postdoctoral Fellow  
Chemistry at the  
University of Texas  
at Austin

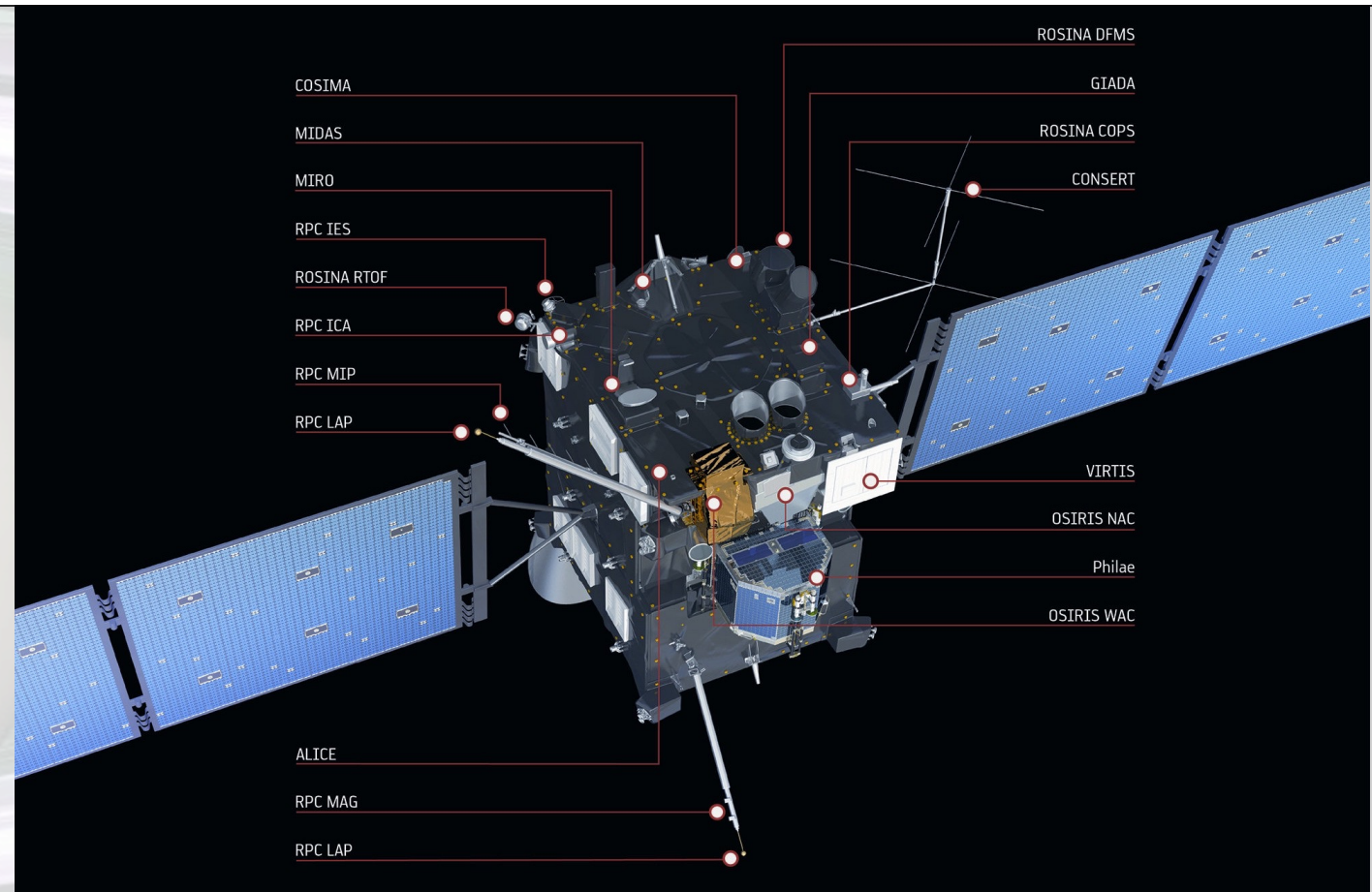
International/Interracial  
Family. Career  
Opportunities - USA



# Rosetta Mission (ESA/NASA) Chasing & Landing on a Comet

I was a part of the Rosetta Mission focused on surface spectroscopy and detection of ice.

Rosetta and Philae are now both on the comet 67P/CG (Churyumov–Gerasimenko)



# Europa Clipper – Assessing Habitability of Europa’s Oceans



**EUROPA**  
CLIPPER



© 2022 California Institute of Technology. Government sponsorship acknowledged



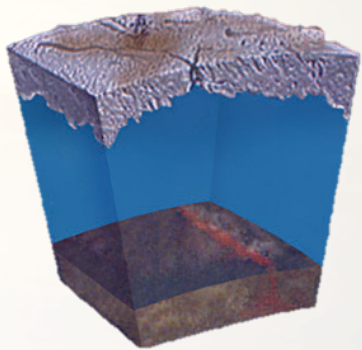
**Europa**  
**Project Science Group Meeting #1**  
**August 4, 2015**

Initiated in 2015, Launch Date 2024

# Europa Clipper Mission Science

## Exploring to Investigate Europa's Habitability

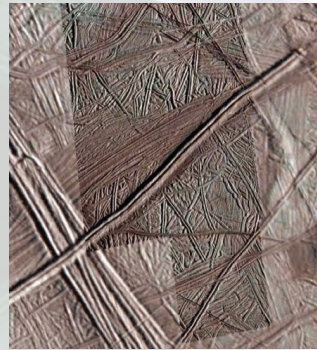
Ice Shell and Ocean



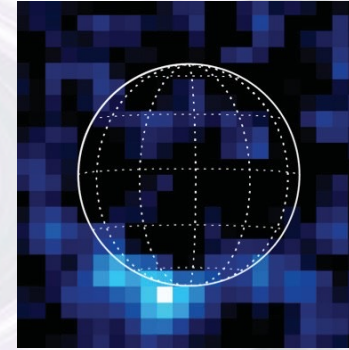
Composition



Geology



Activity



Reconnaissance



# Europa Clipper Instruments and Investigations

## MASPEX

*Mass Spectrometer*  
**PI: Hunter Waite, SWRI**  
sniffing atmospheric composition

## SUDA

*Dust Analyzer*  
**PI: Sascha Kempf, U. Colorado**  
surface & plume composition

## ECM

*Magnetometer*  
**TL: Margaret Kivelson, U. Michigan**  
sensing ocean properties

## PIMS

*Faraday Cups*  
**PI: Joe Westlake, APL**  
plasma environment

## Europa-UVS

*UV Spectrograph*  
**PI: Kurt Retherford, SWRI**  
seeking plumes

## EIS

*Narrow-angle Camera +  
Wide-angle Camera*  
**PI: Zibi Turtle, APL**  
mapping alien landscape

## MISE

*IR Spectrometer*  
**PI: Diana Blaney, JPL**  
surface chemical fingerprints

## E-THEMIS

*Thermal Imager*  
**PI: Phil Christensen, ASU**  
searching for hot spots

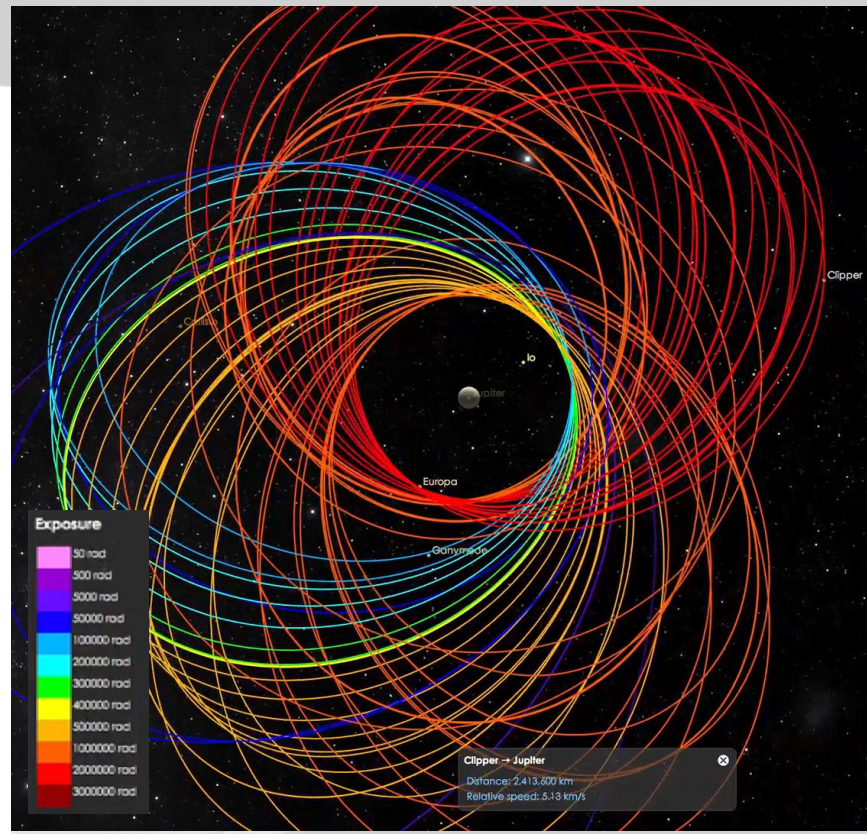
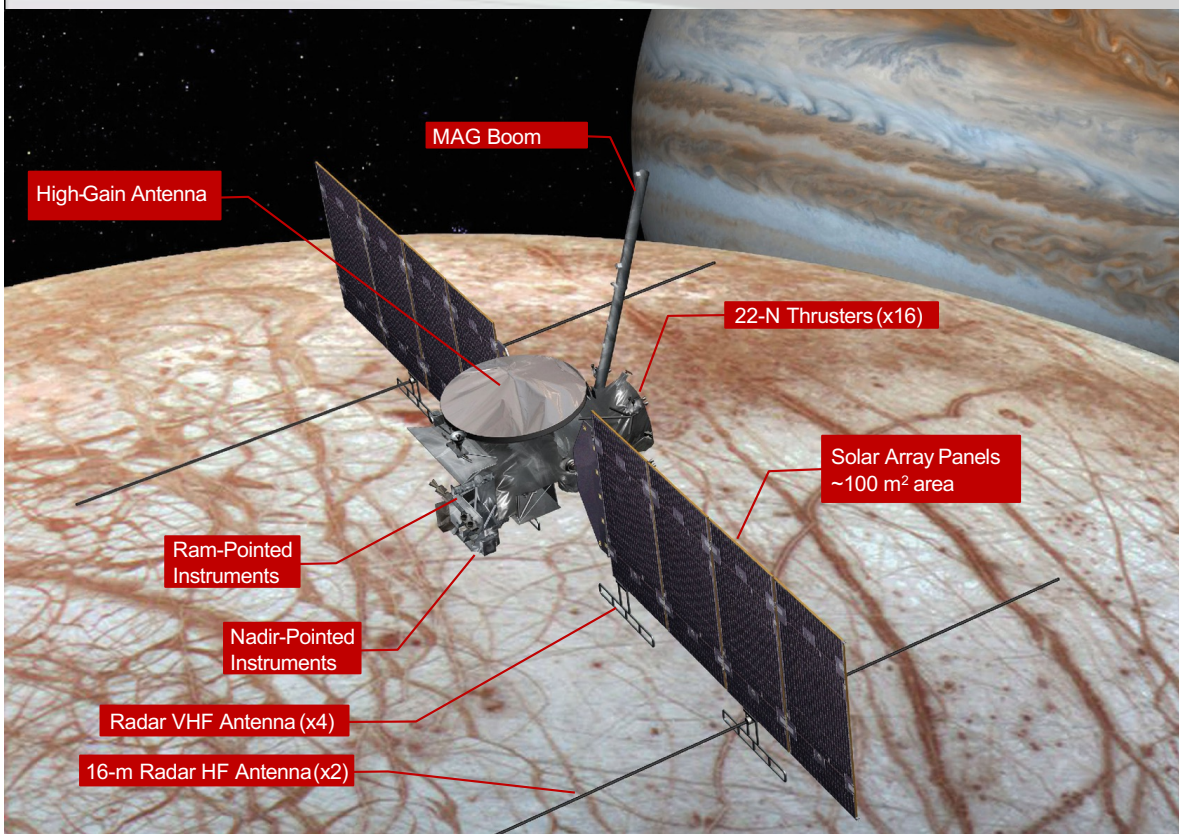
## REASON

*Ice-Penetrating Radar*  
**PI: Don Blankenship, UTIG**  
probing the ice shell

Gravity &  
Radio Science



# Europa Clipper Flight System and Flybys



We are living in  
“The Peak of Human Civilization”  
“The Peak of Space Explorations”

There are still unanswered Science Questions  
How Did Life Start on Earth? Is There Life Elsewhere? What is Dark Matter & Dark Energy?

There is an opportunity for New Space Technologies  
Human Space Missions, Sample Return Missions, Space-based Hubs, Energy  
Space Medicine and Space Human Psychology  
To Enable Long-term Space Explorations by Humans!

You can have a career in Astrophysics, Planetary Sciences, Space  
Engineering, Space Medicine, International Space Cooperation,  
Leadership in Space Explorations, etc.

You need passion, dedication, talent, and out-of-the-box thinking!

