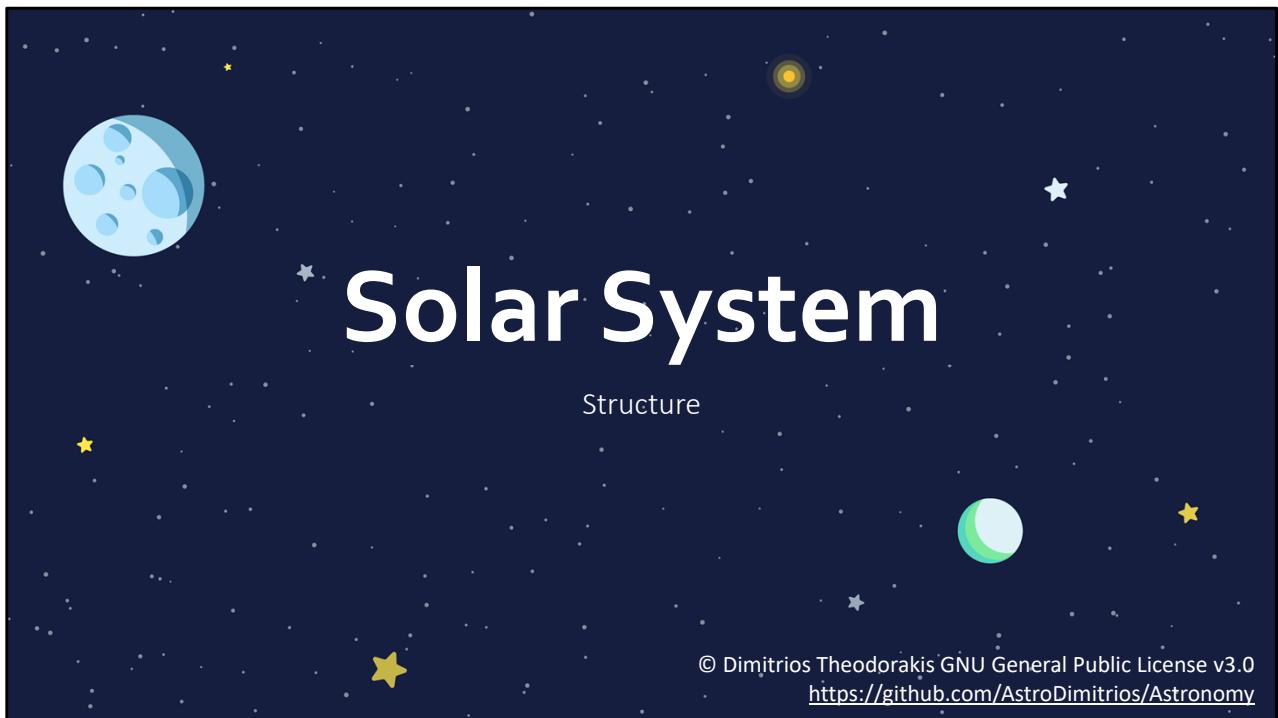


## Summary:

- Objects in the solar system
- Formation of the solar system

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<https://github.com/AstroDimitrios/Astronomy>

Great Kurzgesagt video on the Solar System:  
[https://www.youtube.com/watch?v=KsF\\_hdjWjo](https://www.youtube.com/watch?v=KsF_hdjWjo)



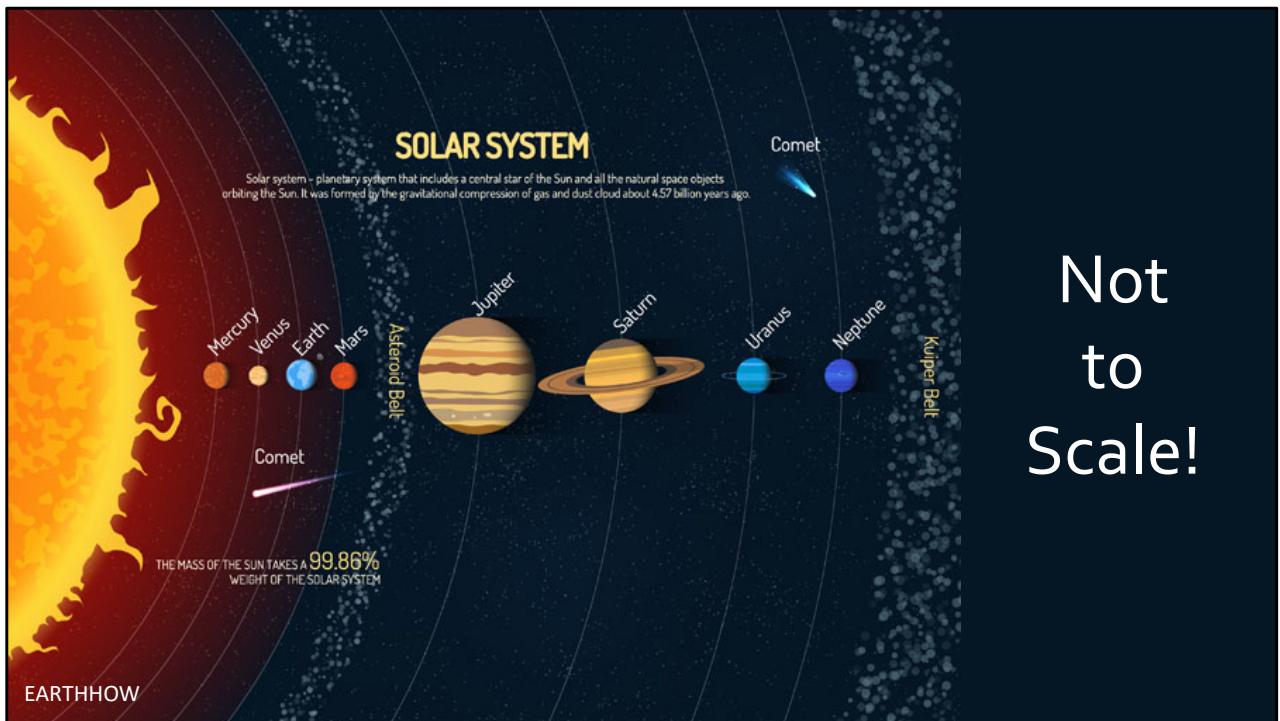
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<https://github.com/AstroDimitrios/Astronomy>

## Recap



1. Geocentric models of the Solar System were accepted based on what assumptions?
2. What evidence pointed towards Heliocentrism?
3. Give one example of how astronomy influenced ancient culture.





Not  
to  
Scale!

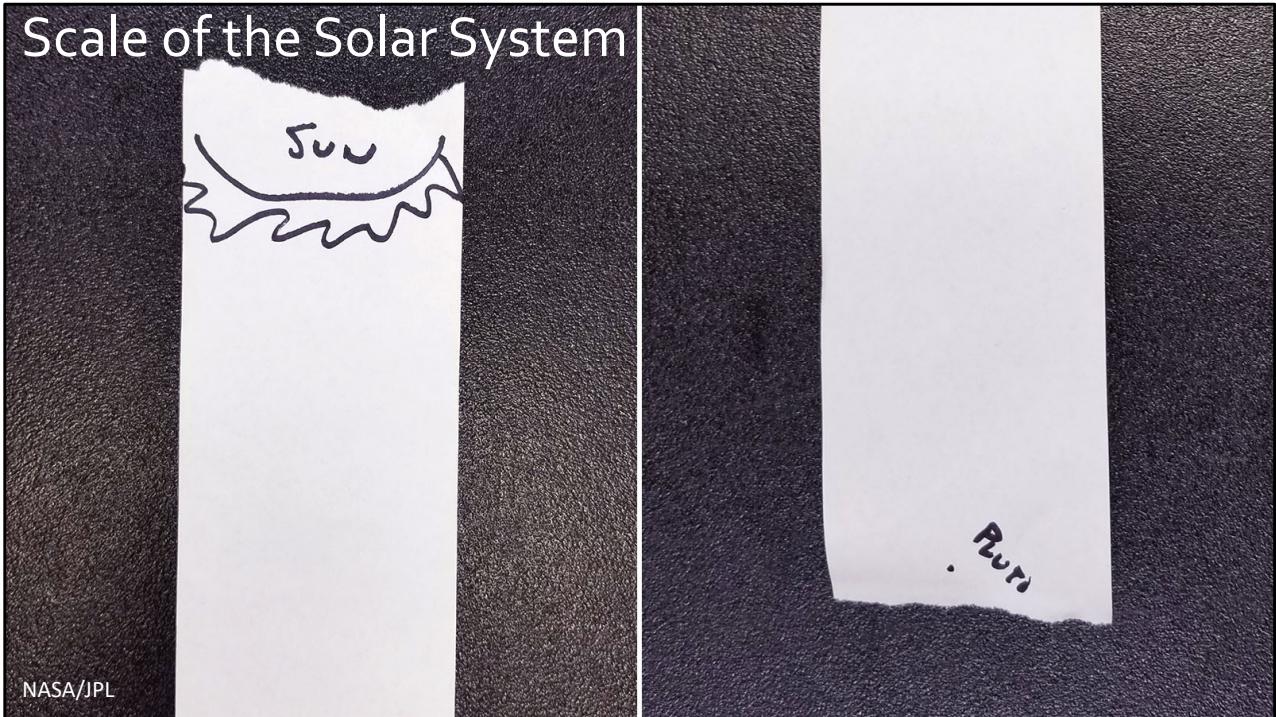
Diagram of the SS by EarthHow: <https://earthhow.com/solar-system-facts/>

Oort cloud not shown!

Formed 4.571 billion years ago

Earth ~ 4.543 billion years

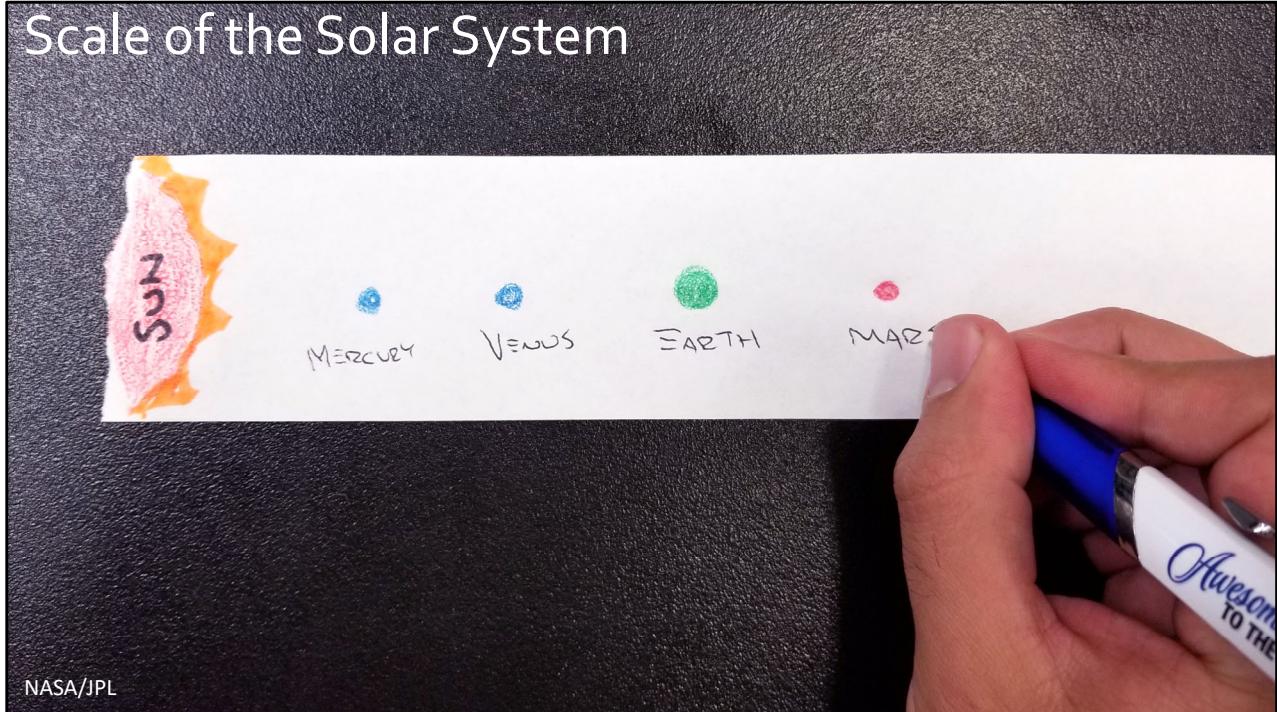
## Scale of the Solar System



Activity to get students to understand the scale of the SS (AA001 -  
<https://www.jpl.nasa.gov/edu/teach/activity/solar-system-scroll/>)

Get a long piece of paper and place the Sun and Pluto at opposite ends.

# Scale of the Solar System



Now get students to guess the locations of the planets on the roll.



Jet Propulsion Laboratory  
California Institute of Technology

SOLAR SYSTEM SCROLL  
[JPL.NASA.GOV/EDU](http://JPL.NASA.GOV/EDU)

1/32

0 1/16 1/8

1/4

1/2

3/4

1

SUN

JUPITER

SATURN

URANUS

NEPTUNE

PLUTO  
(START OF KUIPER BELT)

ASTEROID BELT

MARS

MERCURY, VENUS, EARTH

NASA/JPL

Actual positions!

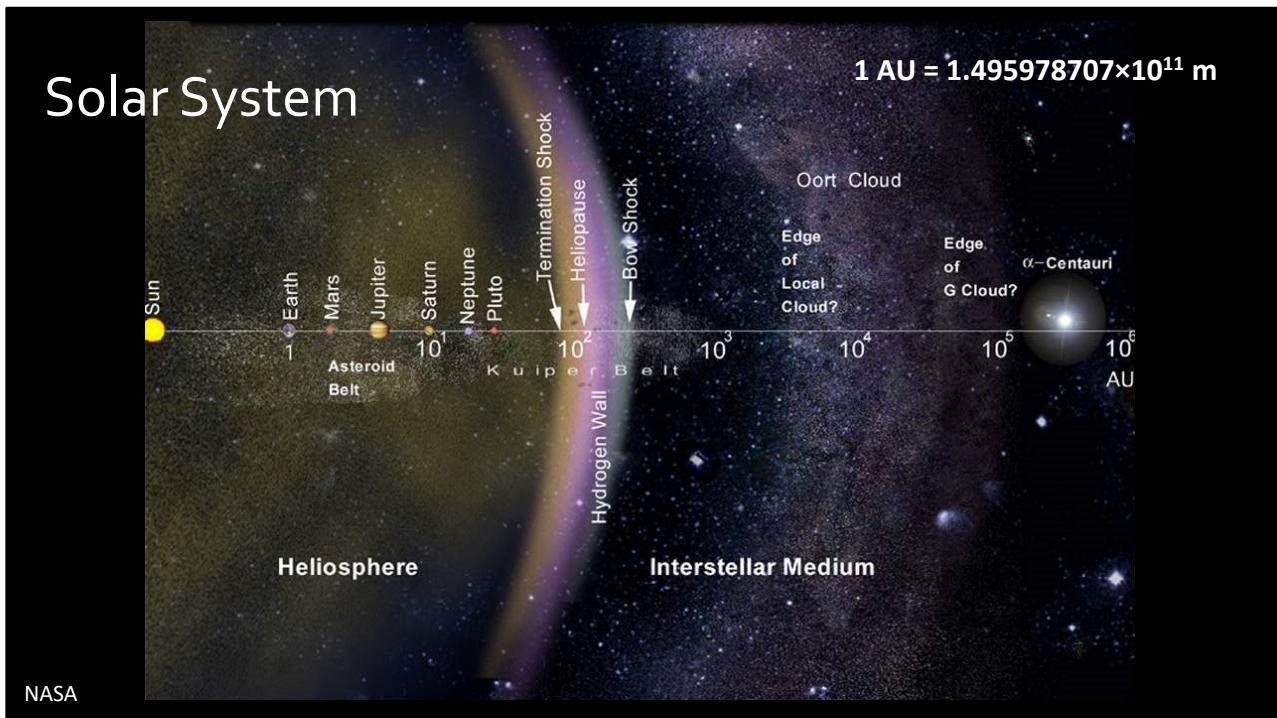


Image from an article about Voyager: <https://voyager.jpl.nasa.gov/mission/did-you-know/>

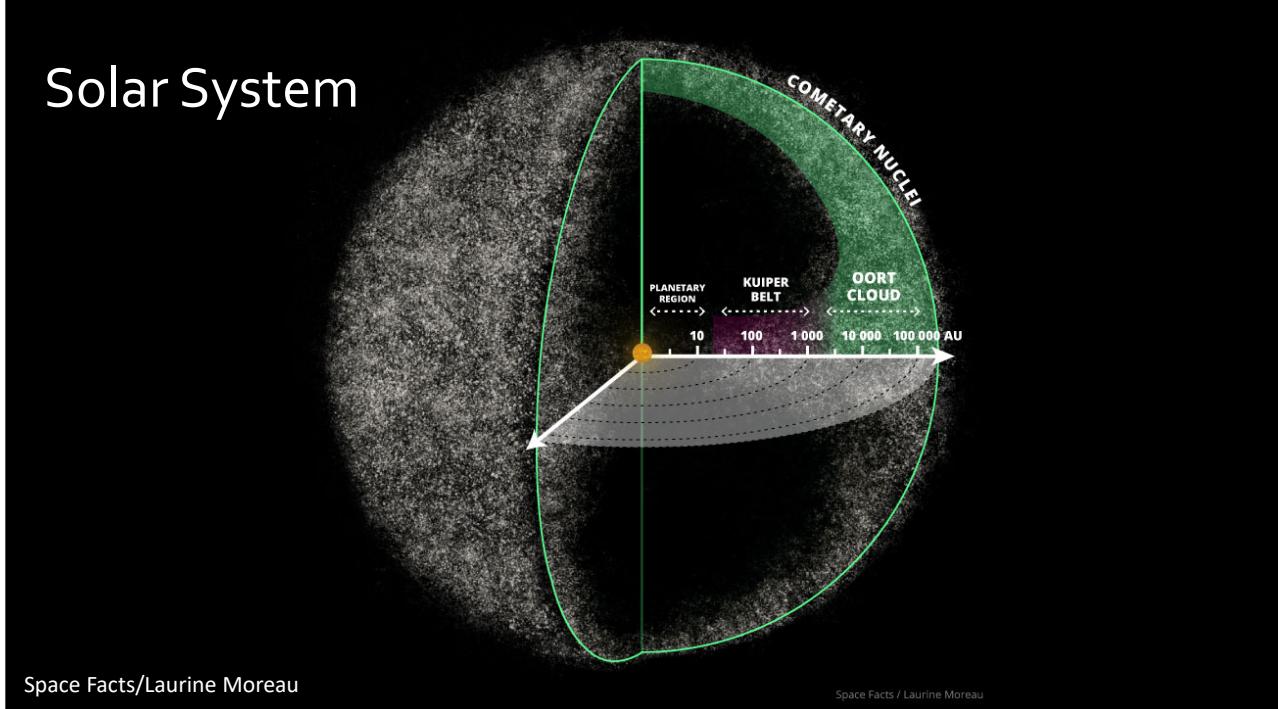
The Oort cloud extends to 1/5 the distance to the nearest star!

Notice the log scale

Termination shock – particles slow to less than the speed of sound  
 Heliopause – pressure from outside is the same as from the solar wind

Theoretical wall of Hydrogen just after the heliopause  
 Little to no bow shock around our Sun.

Oort cloud marks edge of gravitational influence of the Sun. All of that is embedded in the Local Cloud next to the G cloud which contains alpha Centauri. Outside the Oort cloud is interstellar space.



Zoomed out to see the spherical shape of the cloud

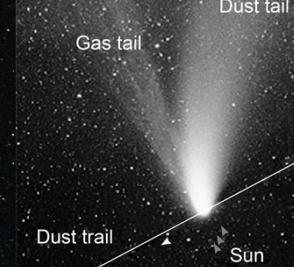
Hard to visualise large numbers try making as many tallies on a piece of paper that you can in 60 s. How long would it take us to make a million tallies? These are huge numbers!

Inner Oort cloud is disk shaped after Kuiper Belt and the outer cloud is spherical.  
Source of long period comets!

# Comets

## Comet Hale–Bopp

Short-period comets originate in the Kuiper belt or its associated scattered disc. Long-period comets are thought to originate in the Oort cloud.



NASA Ames Research Center/K. Jobse, P. Jenniskens

NASA Ames Research Center/K. Jobse, P. Jenniskens

Main image source unknown

There are 8 planets!

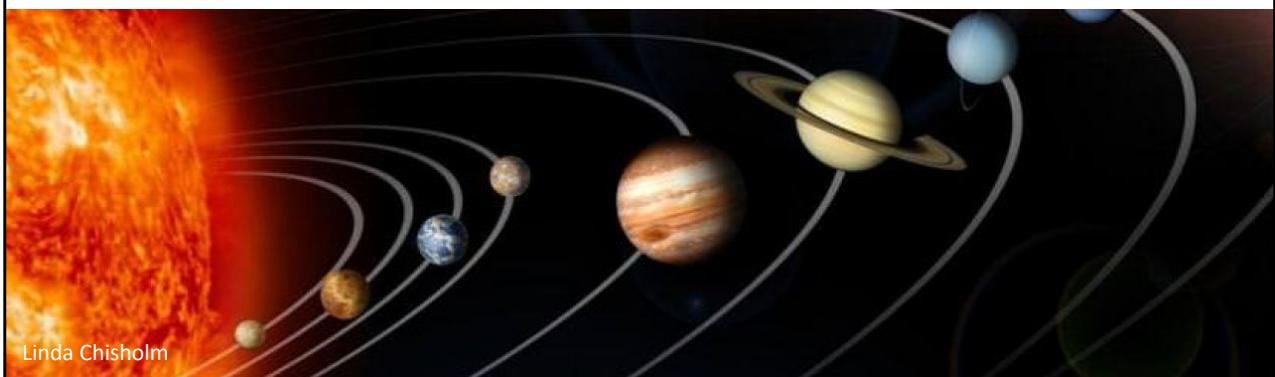


Can you name them?

Image Author Unknown

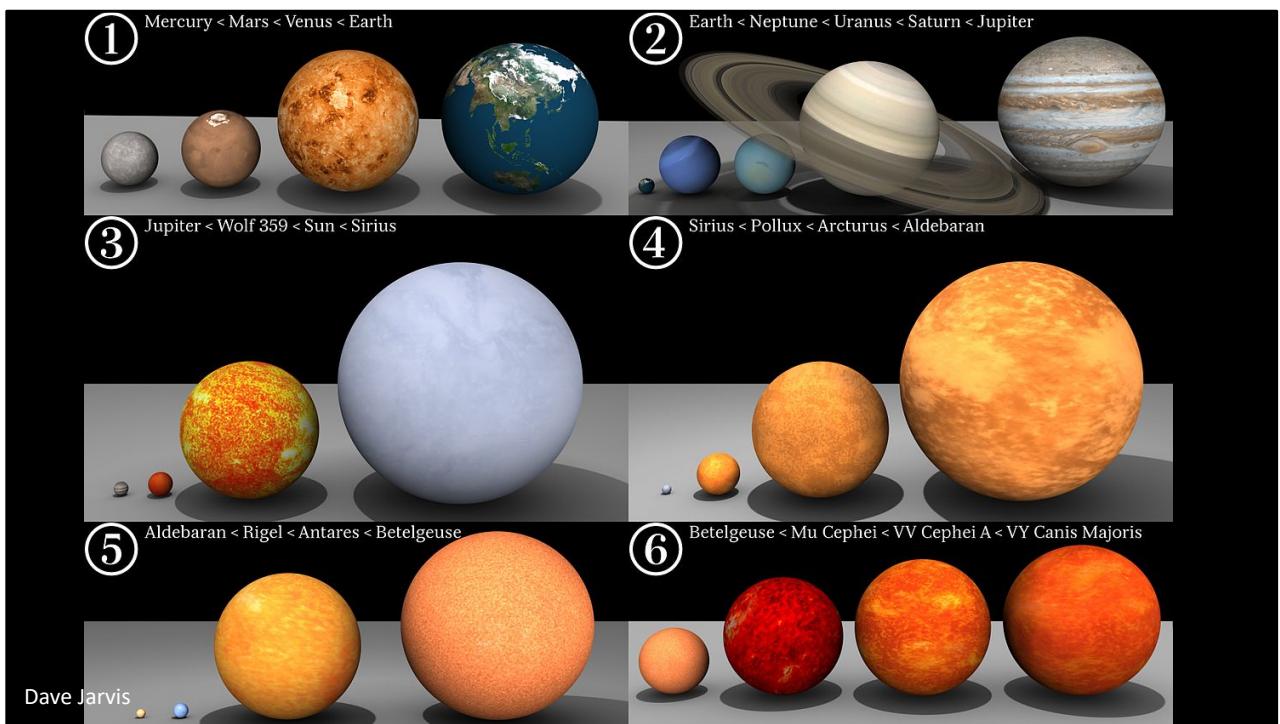
Can you name the planets in order?

Mercury	My
Venus	Vicious
Earth	Earthworm
Mars	Might
Jupiter	Just
Saturn	Swallow
Uranus	Us
Neptune	Now



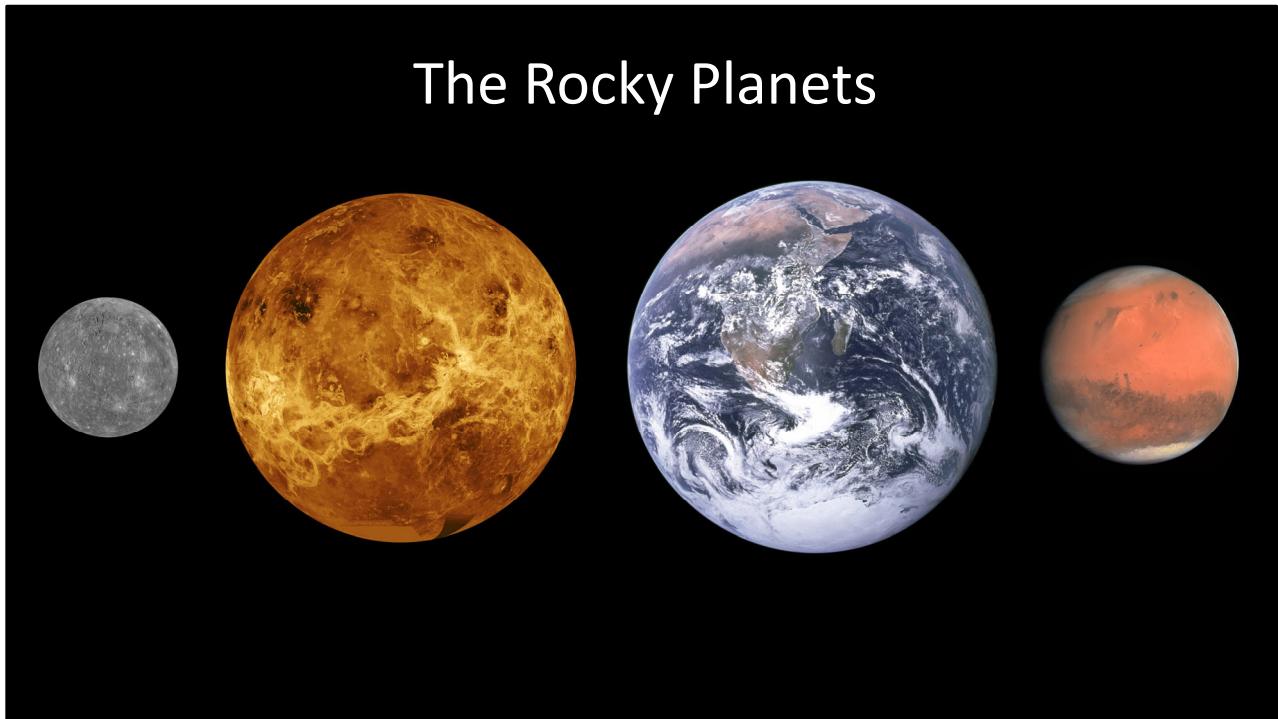
Linda Chisholm

Easy way to remember the order.



Planets to scale with stars for comparison.

## The Rocky Planets



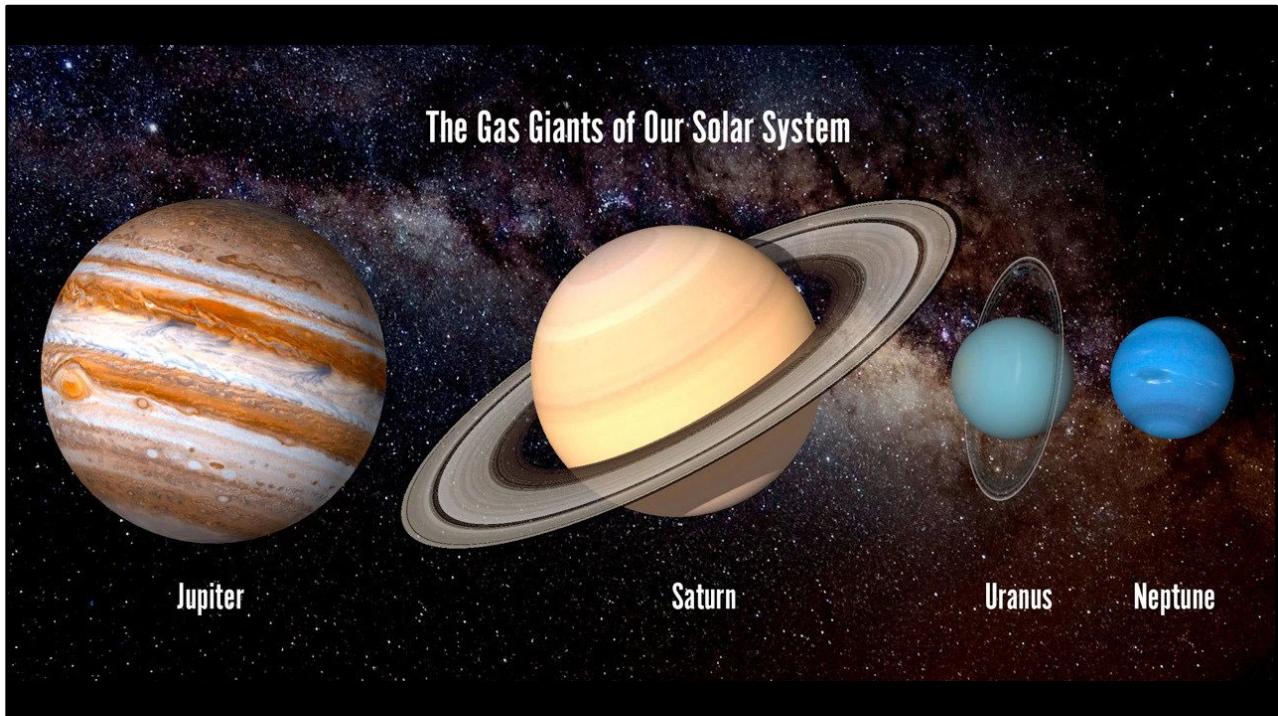
Mercury image: NASA/JHUAPL

Venus image: NASA

Earth image: NASA/Apollo 17 crew

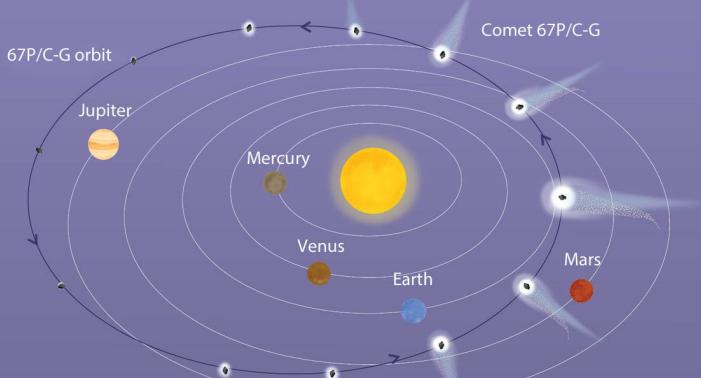
Mars image: ESA/MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA

Scales are roughly correct, distances between them not so much.



Author Unknown

## Jupiter Family Comets



These originate from the Kuiper belt. They are often collisional fragments thrown towards Jupiter by Neptune's gravity. Jupiter then traps them in orbit.

ESA

Beyond  
Neptune



Yeah, what's  
out there?

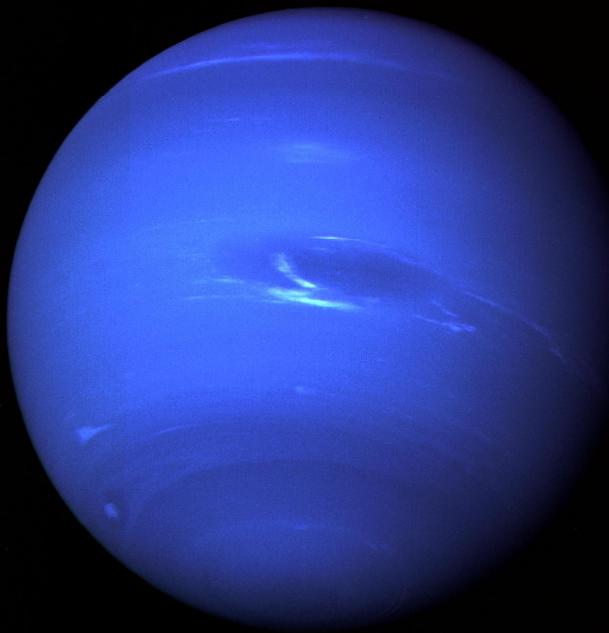
# TNO's

Trans-Neptunian Objects

Minor planets/small solar system bodies.

Orbit with semi major axis (a) greater than Neptune's – 30 AU.

These make up the Kuiper Belt and Oort Cloud



NASA/JPL

Voyager 2 30/10/1998 of Neptune, TNO \*2 mass asteroid belt (exc Oort), 10% binary, very red mostly ice and rock.

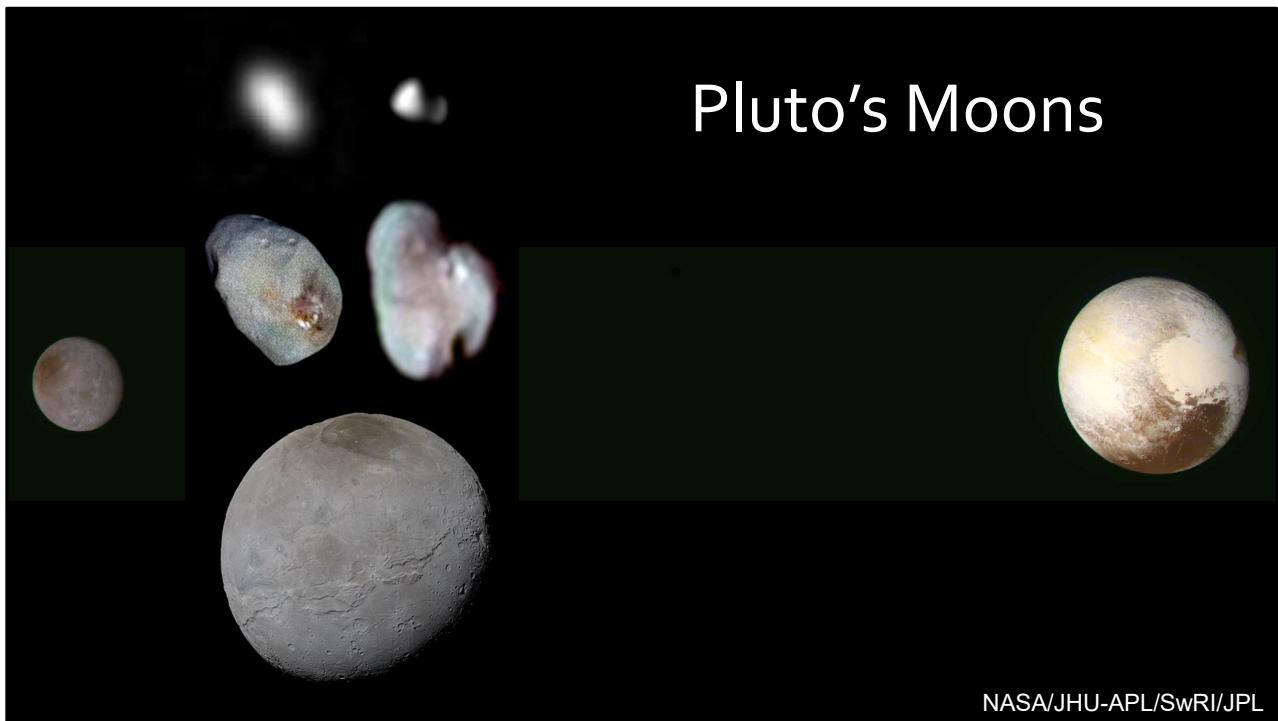
# Pluto

The first TNO



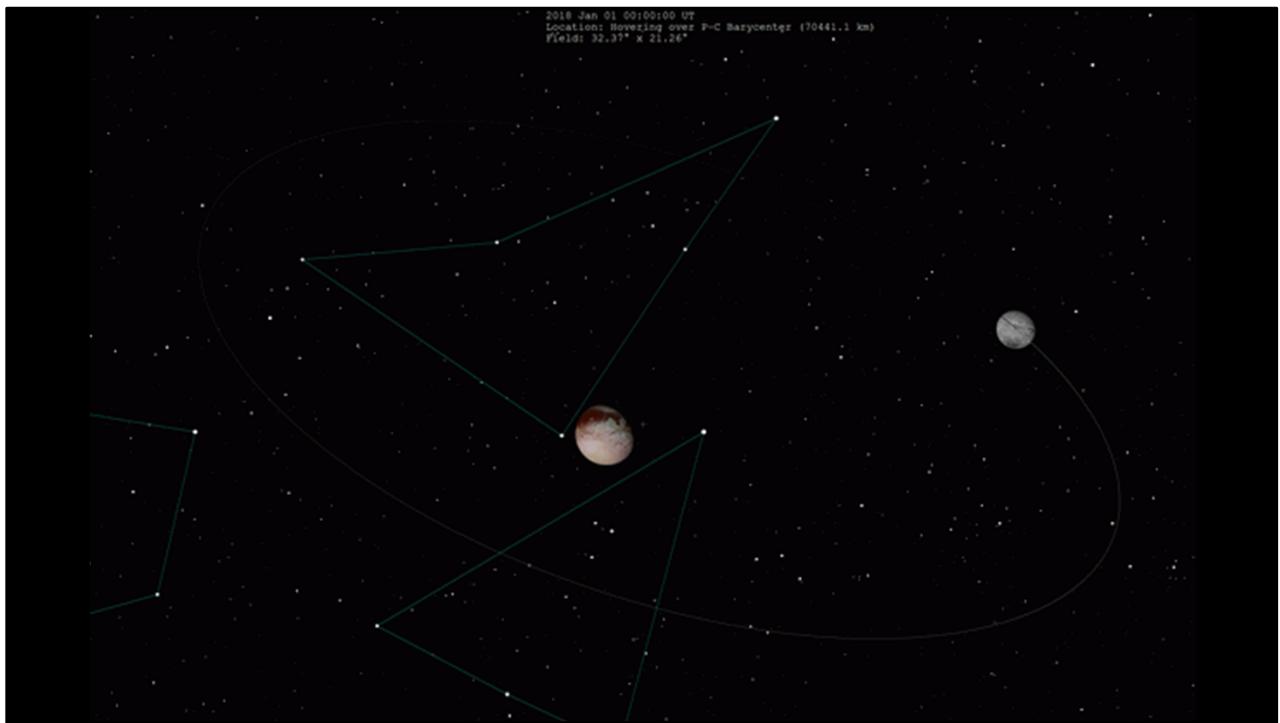
JPL/NASA

Visited by New Horizons in 2015 – extension Jan 2019 flyby of KBO (486958) 2014 MU<sub>69</sub> (PT1)  
Disc 1930, 70% rock and 30% ice. 2/3 moon radius , Charon ½ r pluto



Top: [Styx](#) (left) and [Kerberos](#) (right) Middle: [Nix](#) (left) and [Hydra](#) (right) Bottom:  
Pluto's largest moon, [Charon](#), with its dark [Mordor Macula](#)  
NTS

NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute PIA19856: A Binary Planet in Color

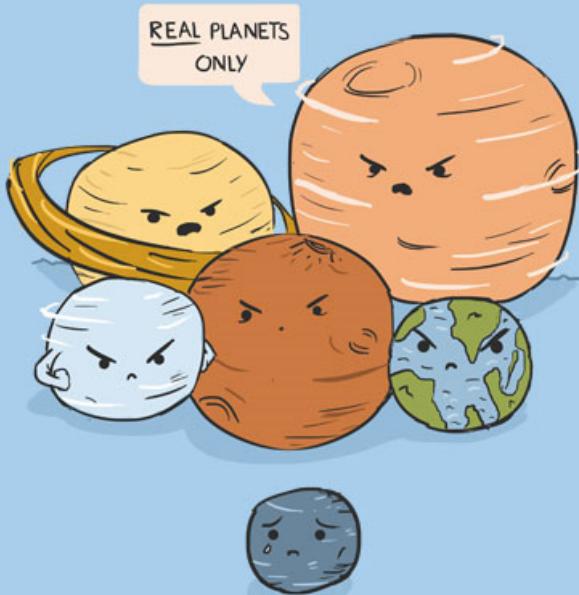


Animation of Charon and Pluto orbiting their barycentre (a point in space just outside the surface of Pluto)

# From Planet to Dwarf Planet

IAU Resolution 5B

*"A celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit."*



[https://www.iau.org/static/resolutions/Resolution\\_GA26-5-6.pdf](https://www.iau.org/static/resolutions/Resolution_GA26-5-6.pdf)

dragallur.wordpress.com

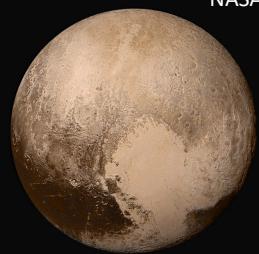
1992 Jewitt and Luu observed object 1992 QB1 (cubewano). Then started to find lots of other objects in resonance with Neptune (Plutinos).  
2006 IAU changed definition of Planet.

# New Definitions

"(2) A "dwarf planet" is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

(3) All other objects, except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

NASA/JHUAPL/SwRI



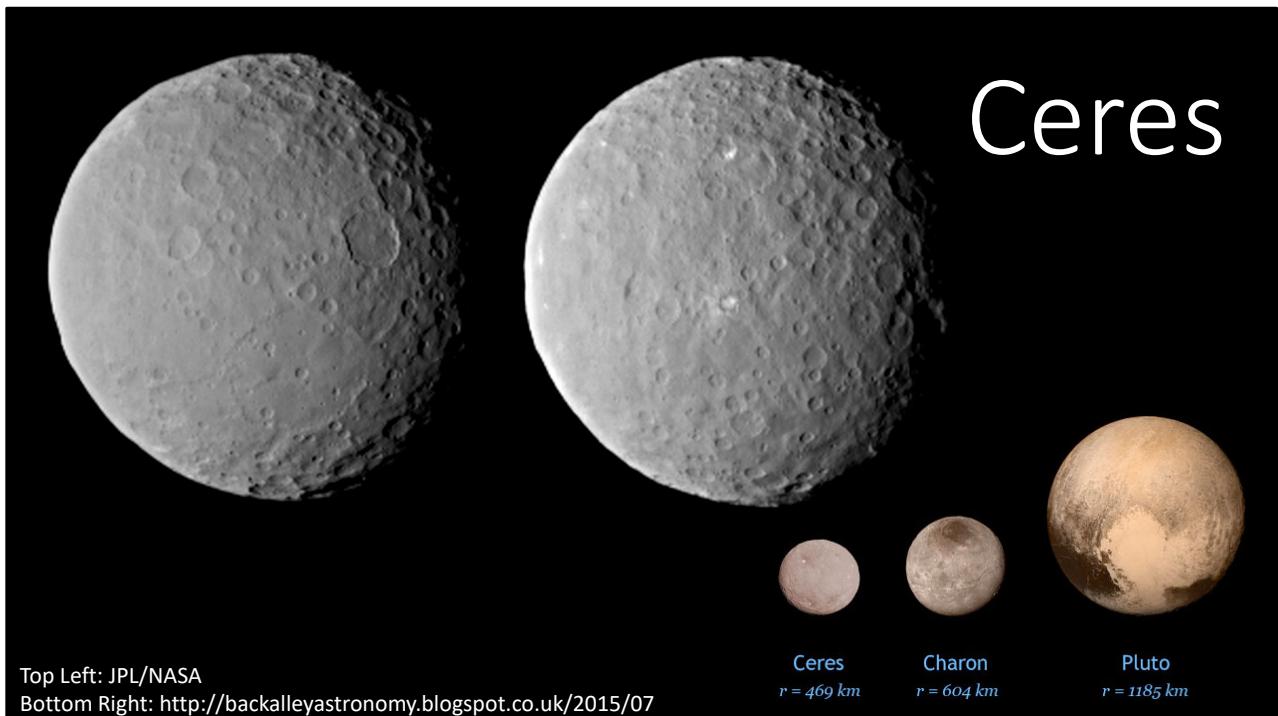
Oumuamua



[https://www.iau.org/static/resolutions/Resolution\\_GA26-5-6.pdf](https://www.iau.org/static/resolutions/Resolution_GA26-5-6.pdf)

European Southern Observatory/M. Kornmesser Artist's Concept

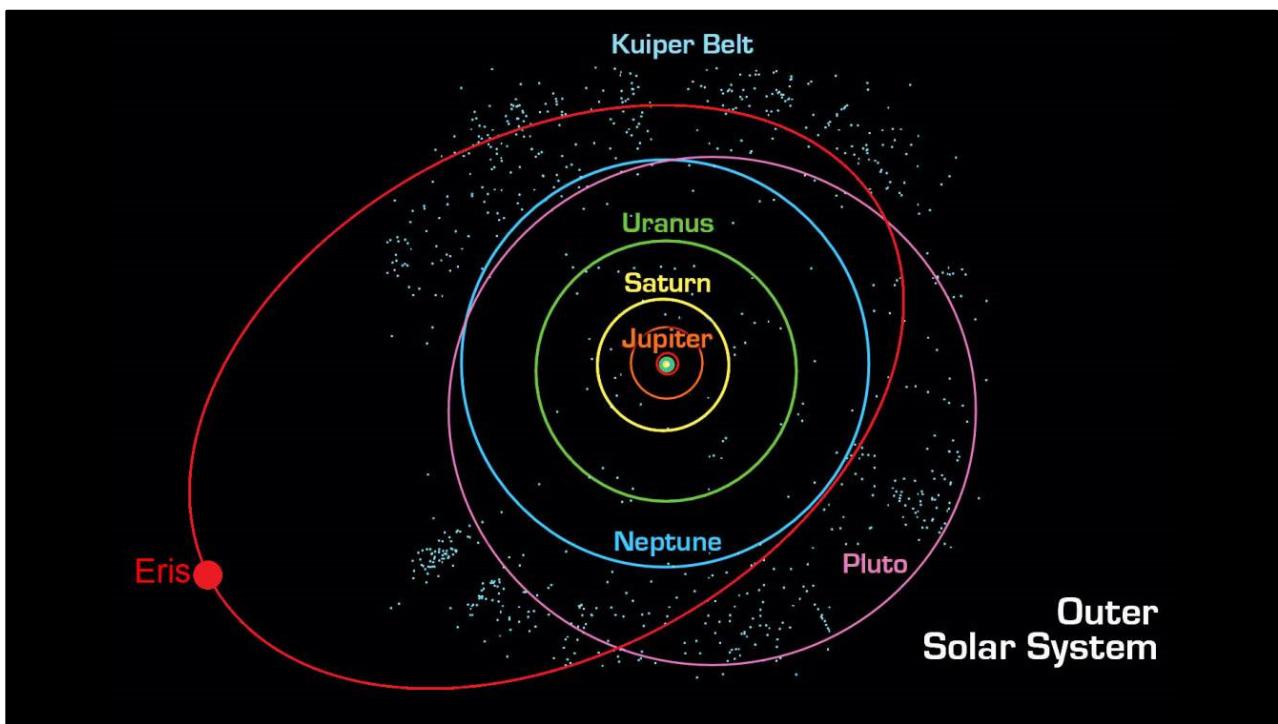
interstellar asteroid 1I/2017 U1 (Oumuamua) 10:1 from where star Vega is now 400 metres long.

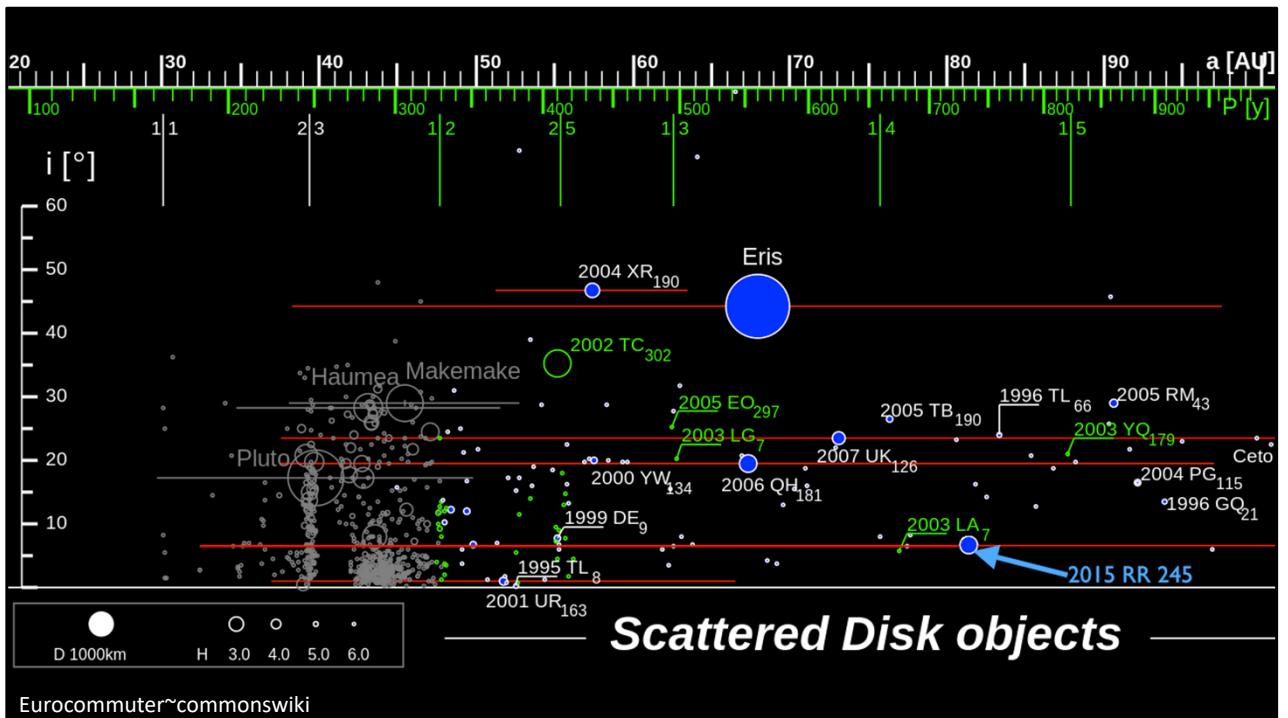


Ceres from NASA's Dawn mission to the Asteroid belt (only non TNO dwarf)

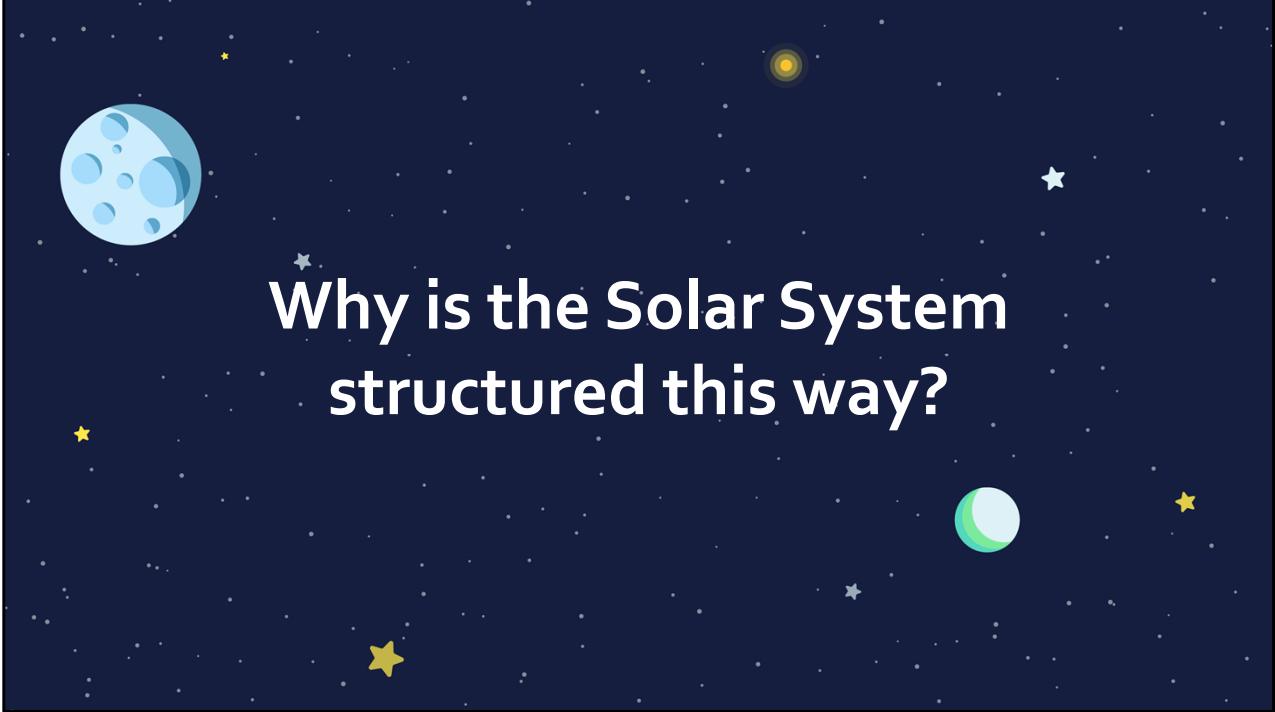


Haumea collisional family, 7:12 resonance, 3.9 hr rotation

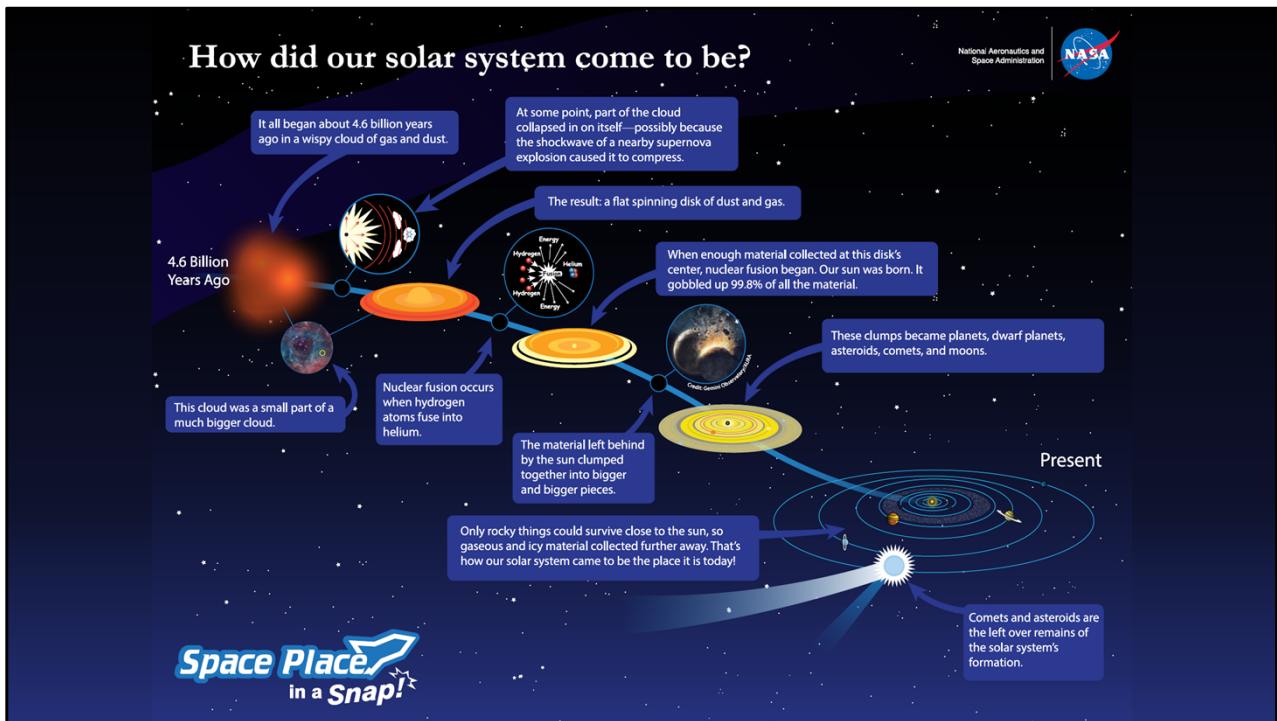




All the planets lie in a plane (a disk) the scattered disk starts to thicken out and reach higher and lower above the planet's plane – they are at a higher inclination.

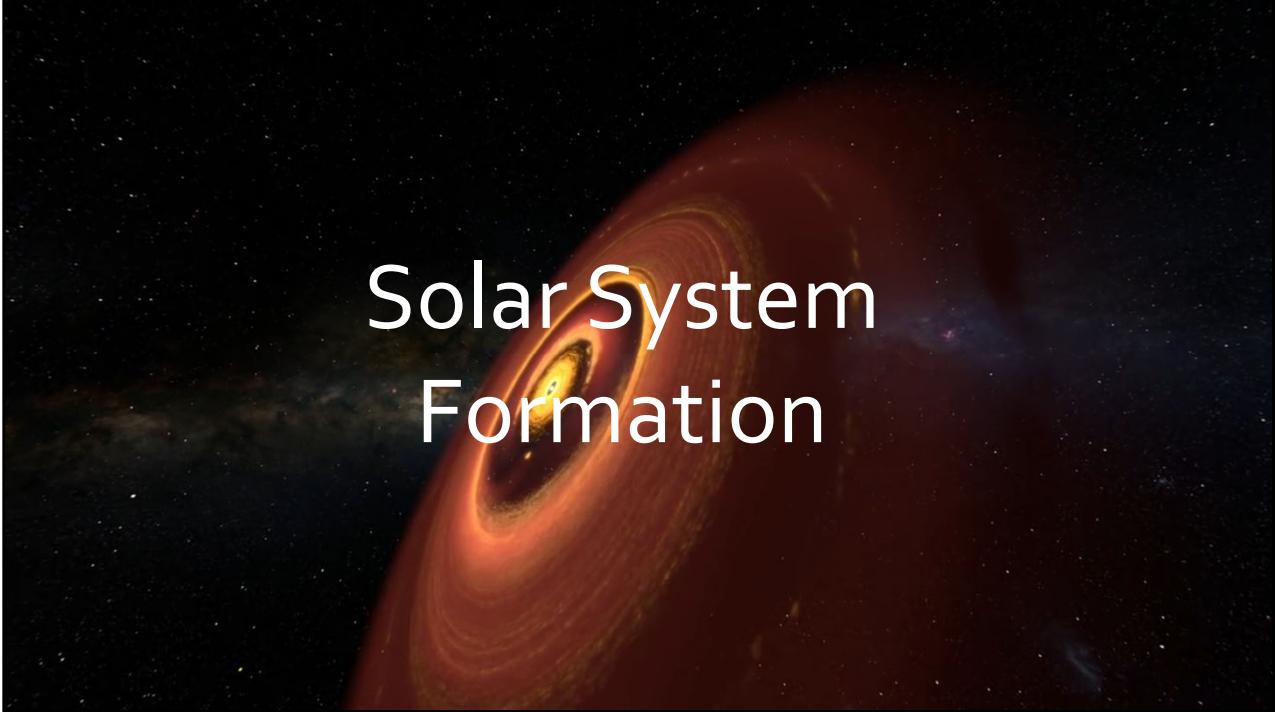


**Why is the Solar System  
structured this way?**



Nice accompanying video on SS formation:

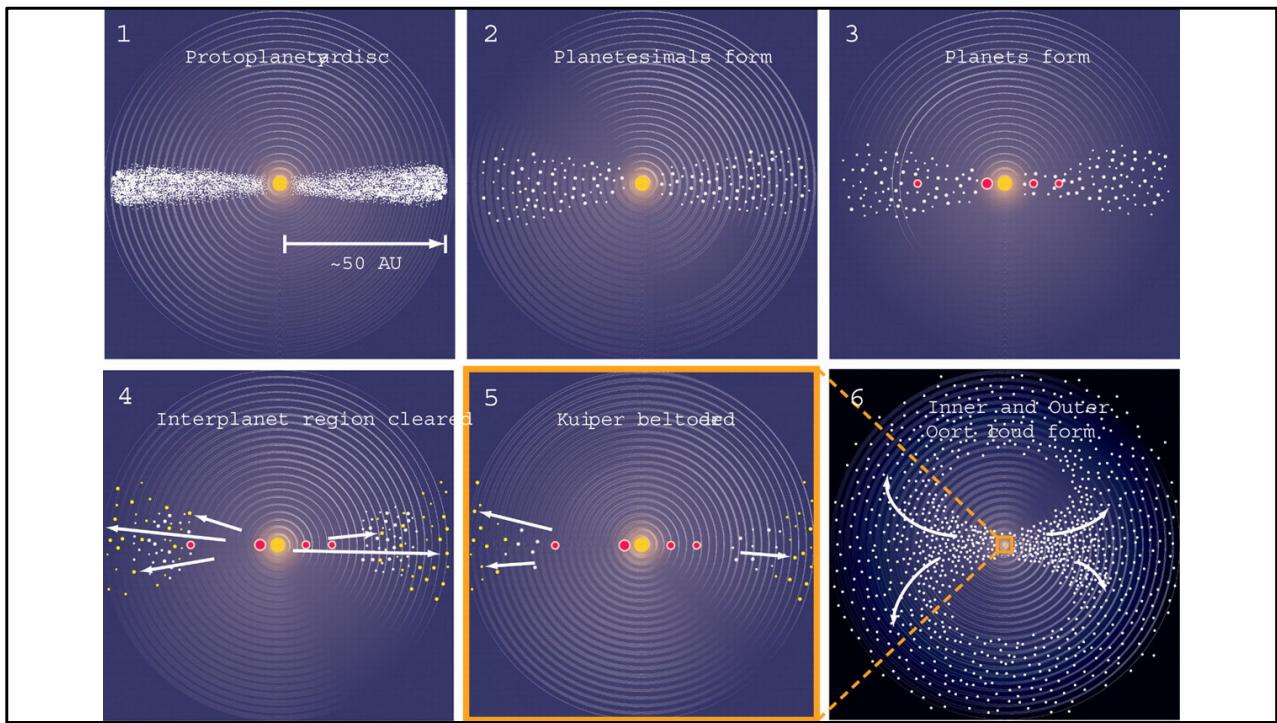
[https://www.youtube.com/watch?v=RT4OO0TFLHw&feature=emb\\_title](https://www.youtube.com/watch?v=RT4OO0TFLHw&feature=emb_title)

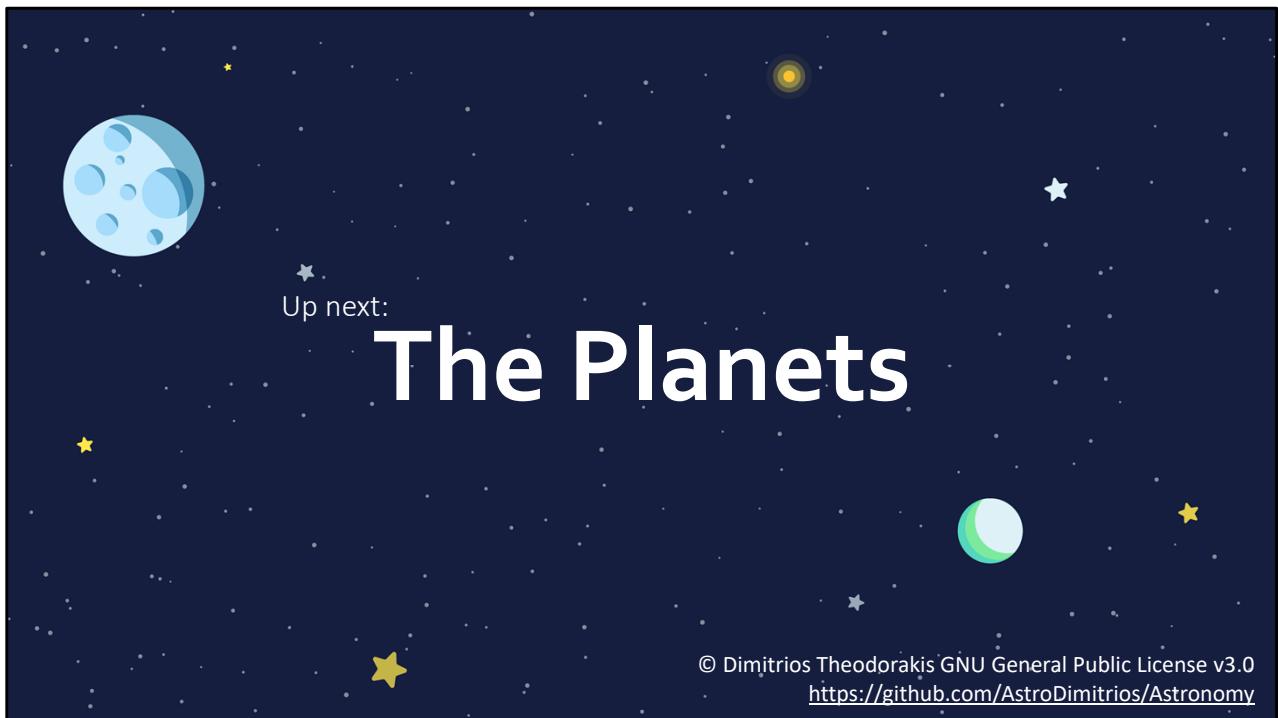


# Solar System Formation

Million years infall heating up disk EVOLUTION: then form small chunks – planetesimals – planetary embryo's runaway growth. Clearing face dust cleared by embryo's and planets.

Neptune and Uranus swapped position!





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<https://github.com/AstroDimitrios/Astronomy>

Name	Diameter	Distance from Sun	Length of Year:
Mercury	4,879 km	57,909,227 km	88 Earth days
Venus	12,104 km	108,209,475 km	225 Earth days
Earth	12,742 km	149,598,262 km	365.24 days
Mars	6,779 km	227,943,824 km	1.9 Earth years
Jupiter	139,822 km	778,340,821 km	11.9 Earth years
Saturn	116,464 km	1,426,666,422 km	29.5 Earth years
Uranus	50,724 km	2,870,658,186 km	84.0 Earth years
Neptune	49,244 km	4,498,396,441 km	164.8 Earth years

[https://joshworth.com/dev/pixelspace/pixelspace\\_solarsystem.html](https://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html)