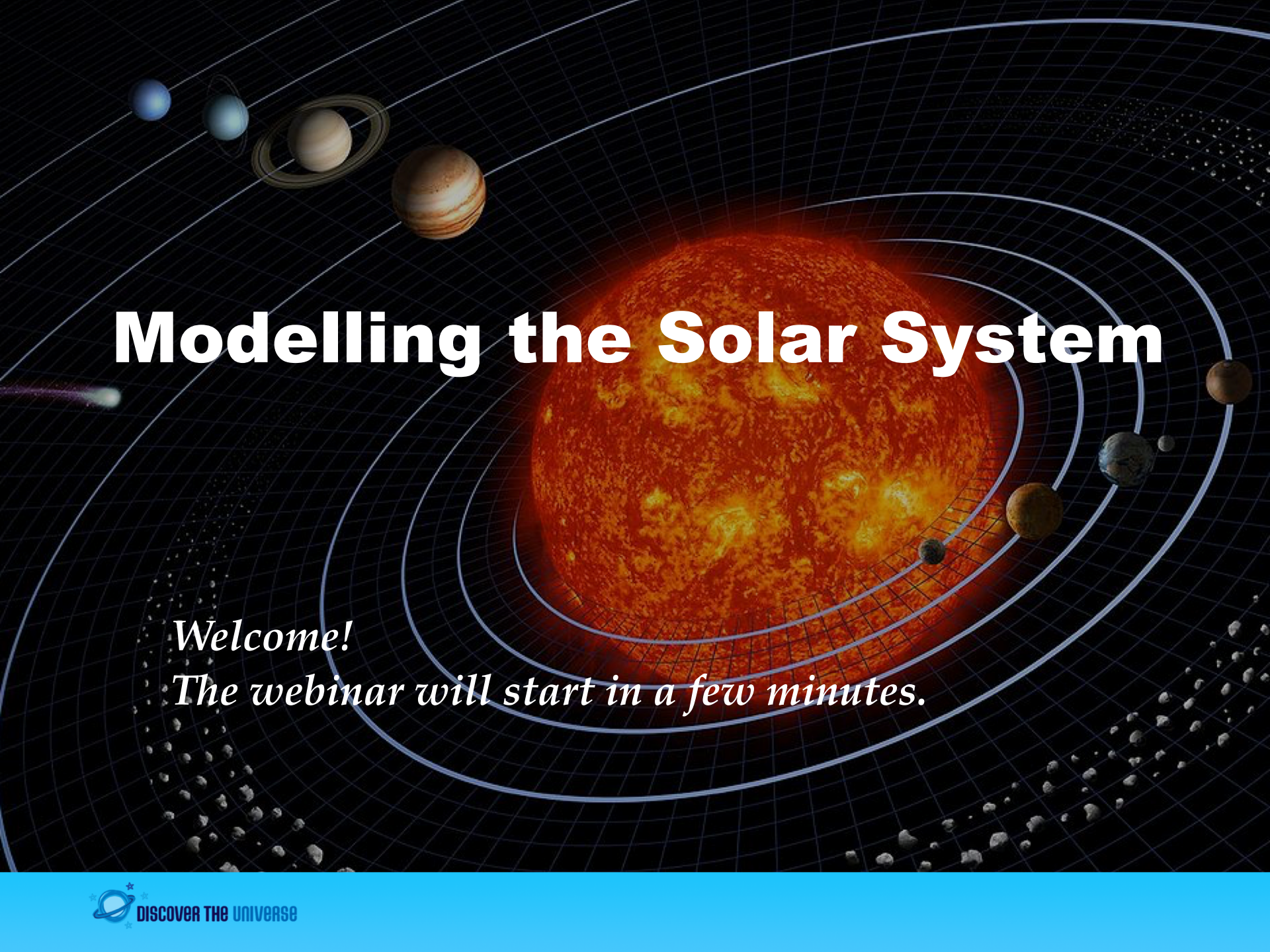




Modelling the Solar System

Welcome!

The webinar will start in a few minutes.

Discover the Universe

Astronomy training program for teachers and informal educators

- ★FREE, in English and French
- ★Available everywhere in Canada and worldwide!

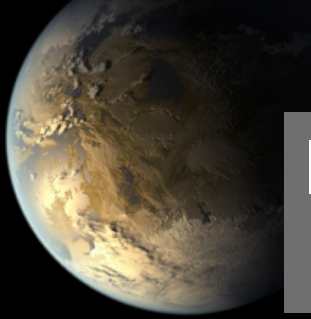
Thanks to our supporters:



Dunlap Institute for
Astronomy & Astrophysics
UNIVERSITY OF TORONTO



Upcoming Workshops



Is Pluto a Planet or Not?
- October 24, 2018



**Workshop for Teachers –
Level 2**
12 to 30 November 2018

Contact

www.discovertheuniverse.ca





Canadian Youth Exploring Space (Can-YES)

What we offer:

- Live one-on-one interactive video conferences with scientists.
- Preparatory astronomy material and interactive activities.
- Access to some of Canada's best research facilities and their data.



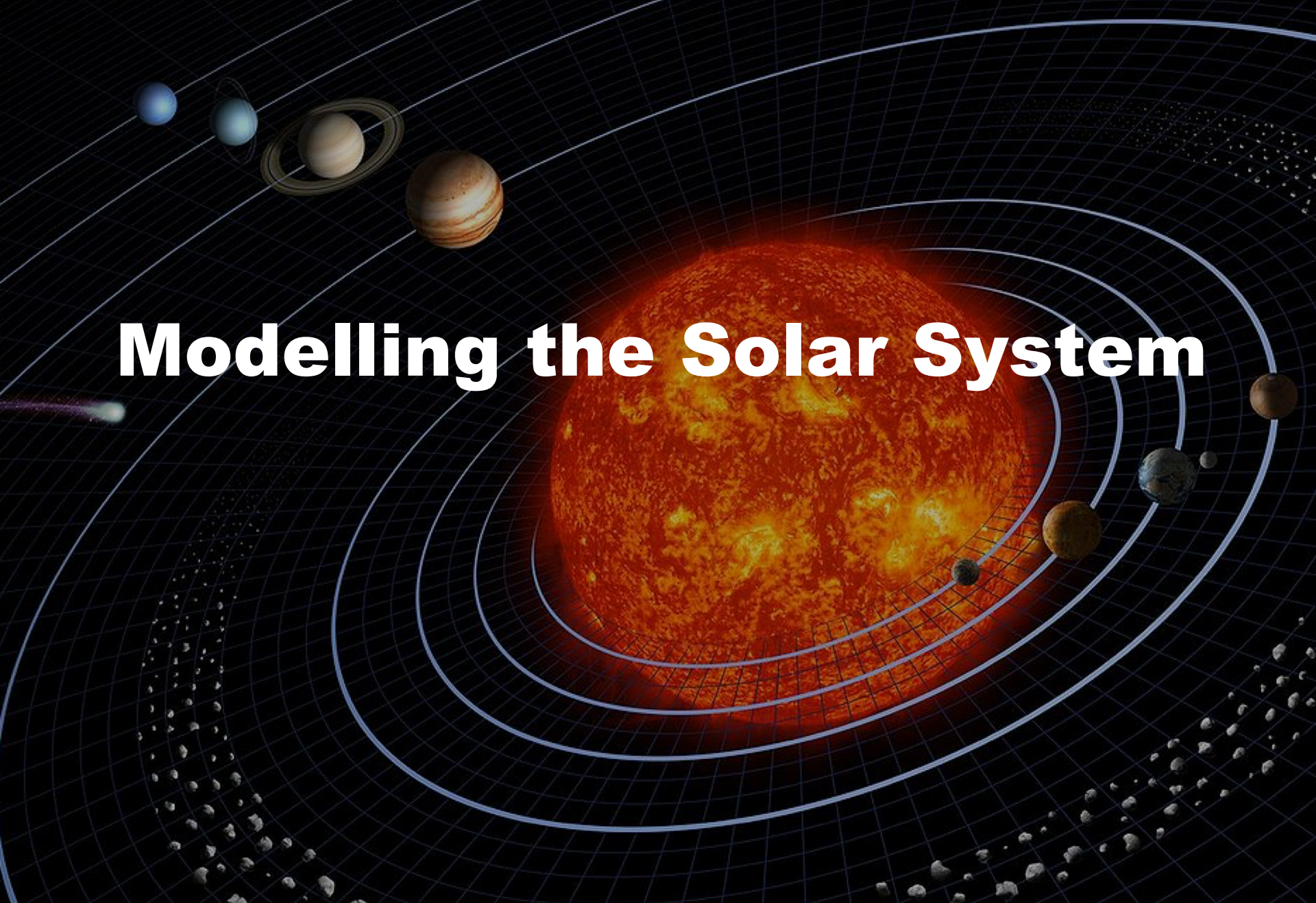
For more info and how to book a session

Contact:

nannau@observatoryhill.org

OR VISIT:

<https://thecentreoftheuniverse.net/canyes/>

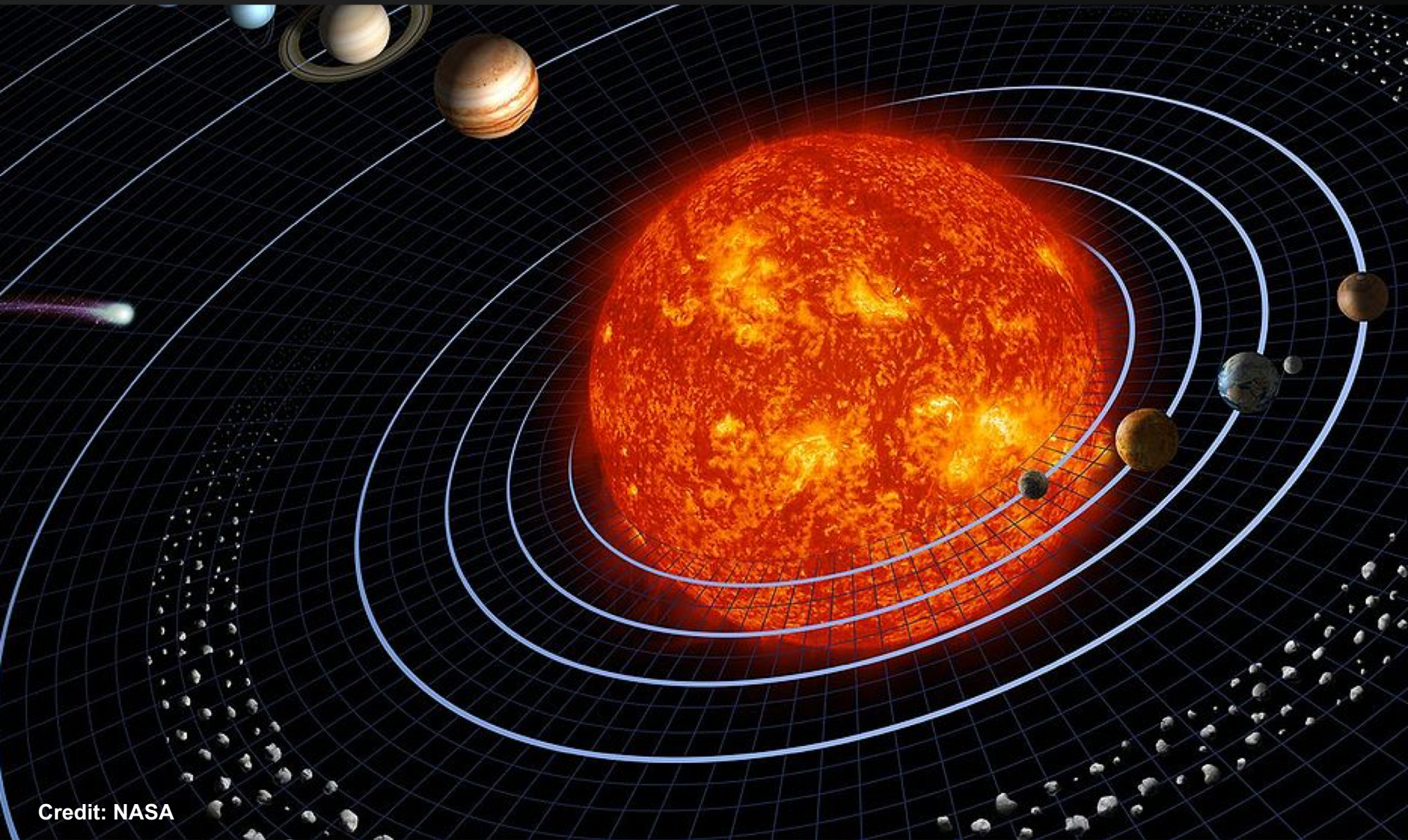


Modelling the Solar System

**It's impossible to represent
the solar system to scale on
a sheet of paper or a slide!**

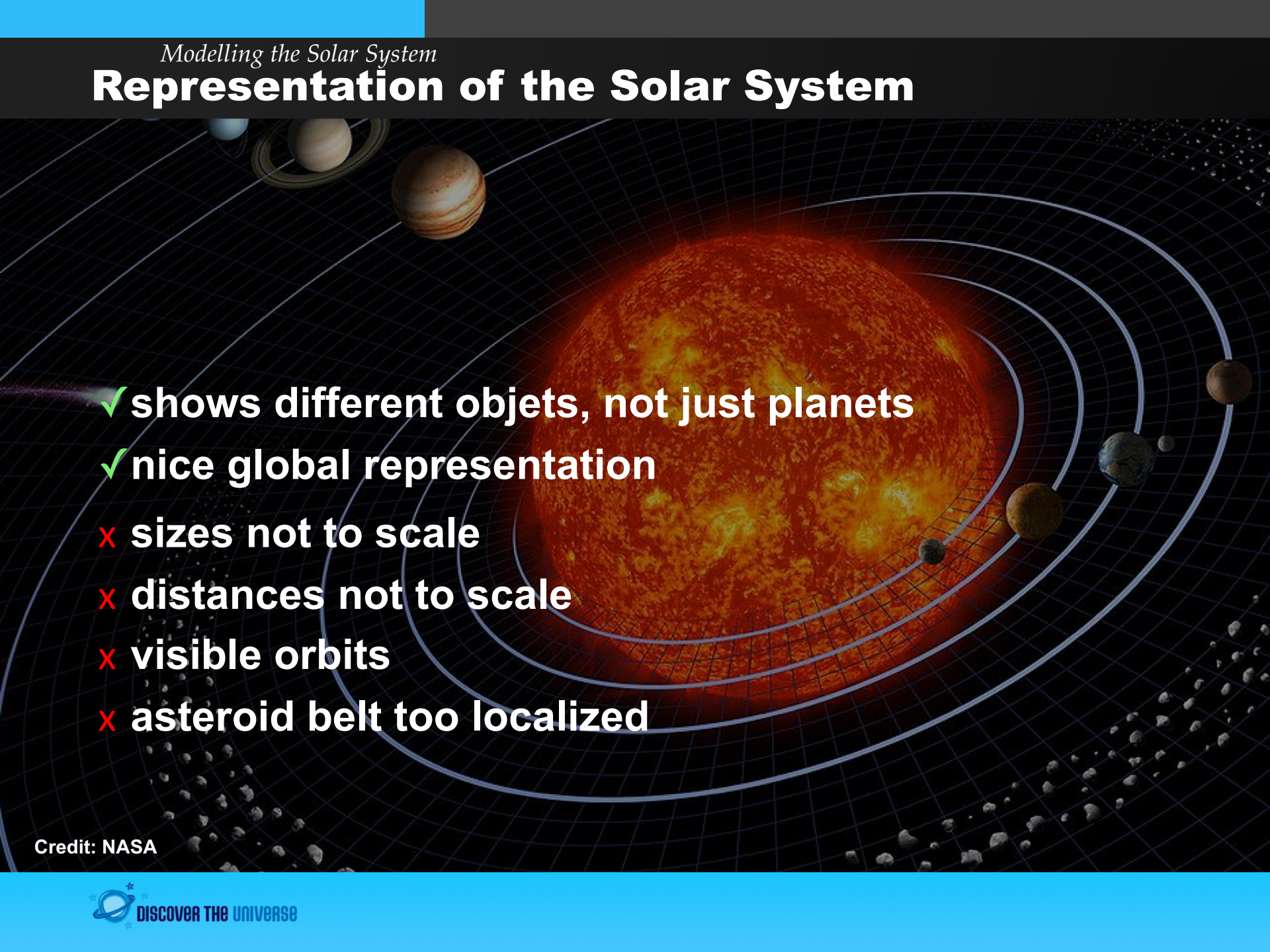
Modelling the Solar System

Representation of the Solar System



Credit: NASA

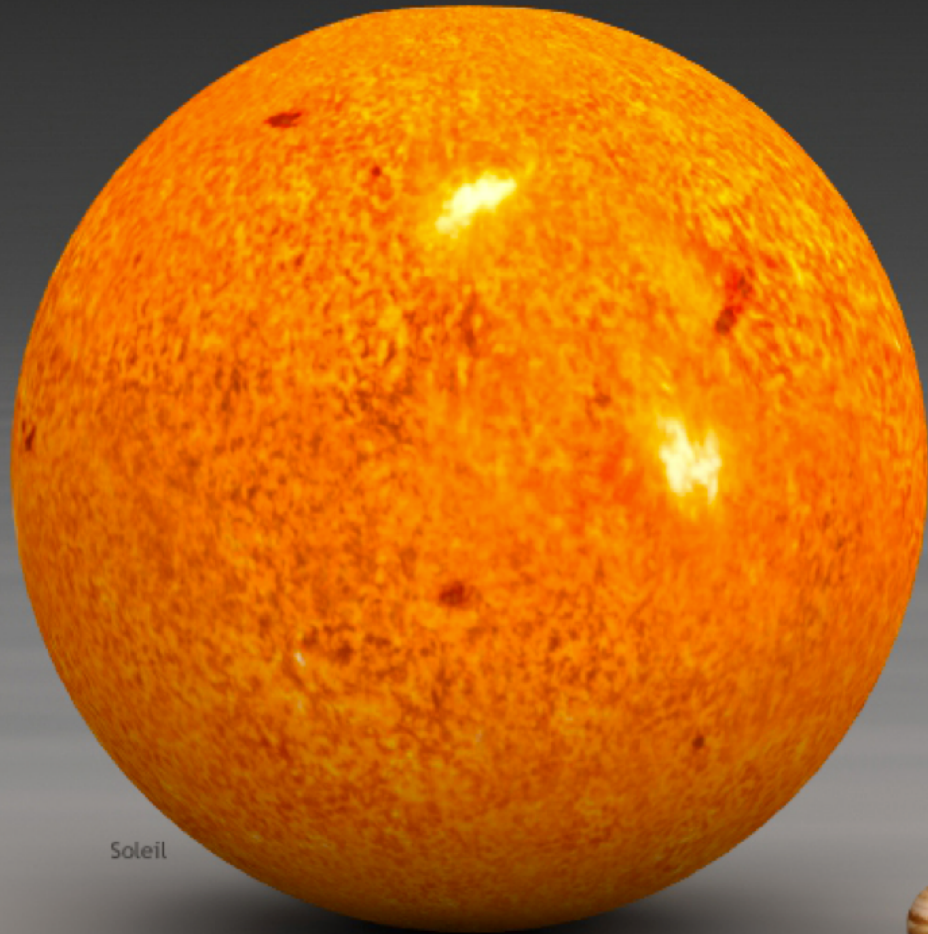
Representation of the Solar System

- 
- ✓ shows different objects, not just planets
 - ✓ nice global representation
 - x sizes not to scale
 - x distances not to scale
 - x visible orbits
 - x asteroid belt too localized

Credit: NASA

Modelling the Solar System

Representation of the Solar System



Soleil



Jupiter

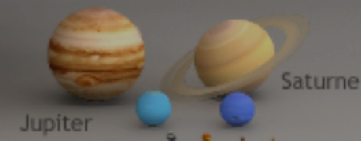
Saturne

Credit: Lsmpascal

Representation of the Solar System

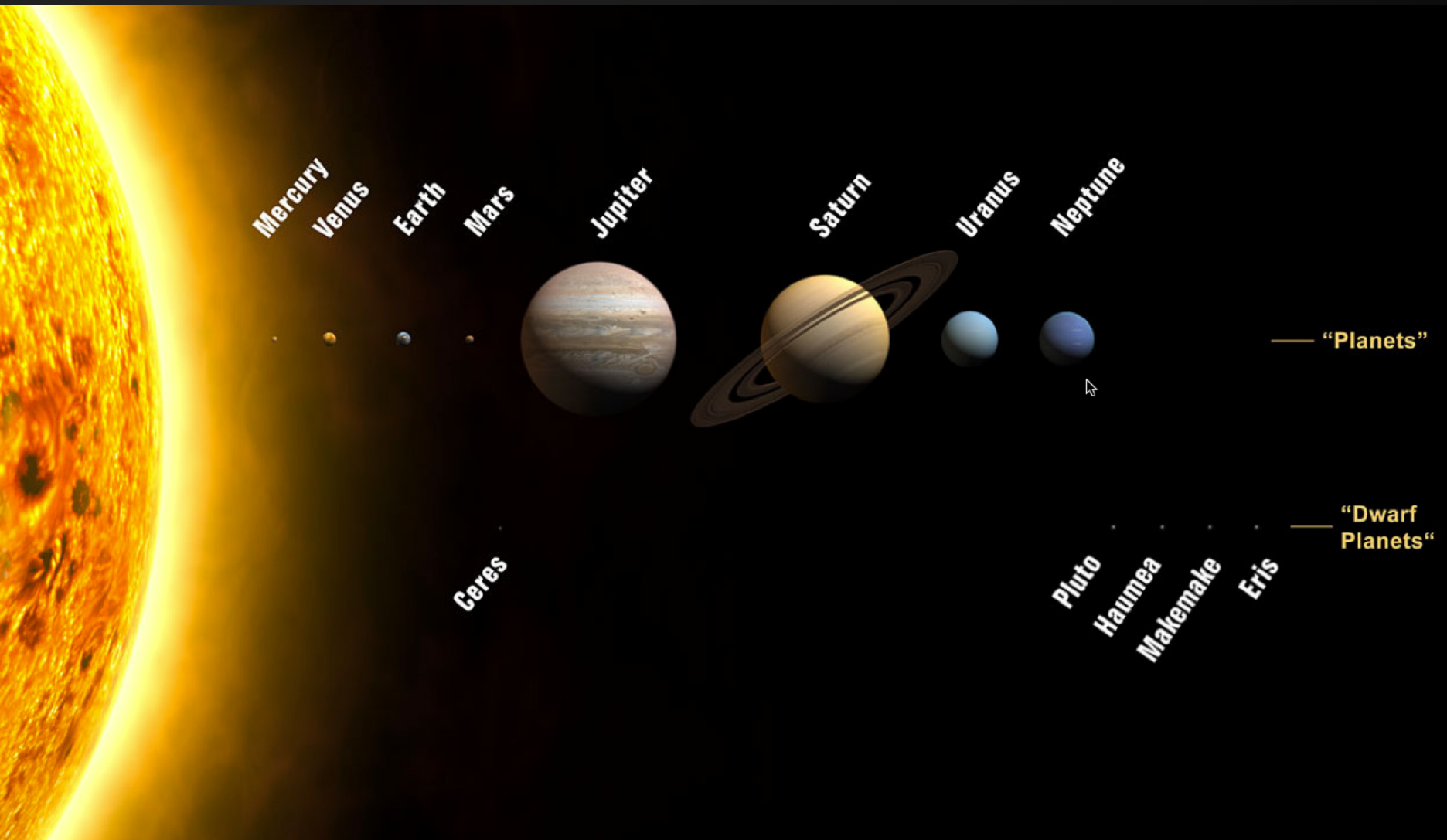
- ✓ sizes to scale
- ✓ nice rendering of the objets' surfaces
- x nothing about distances
- x only Sun and planets (everything else would be too small)

Soleil



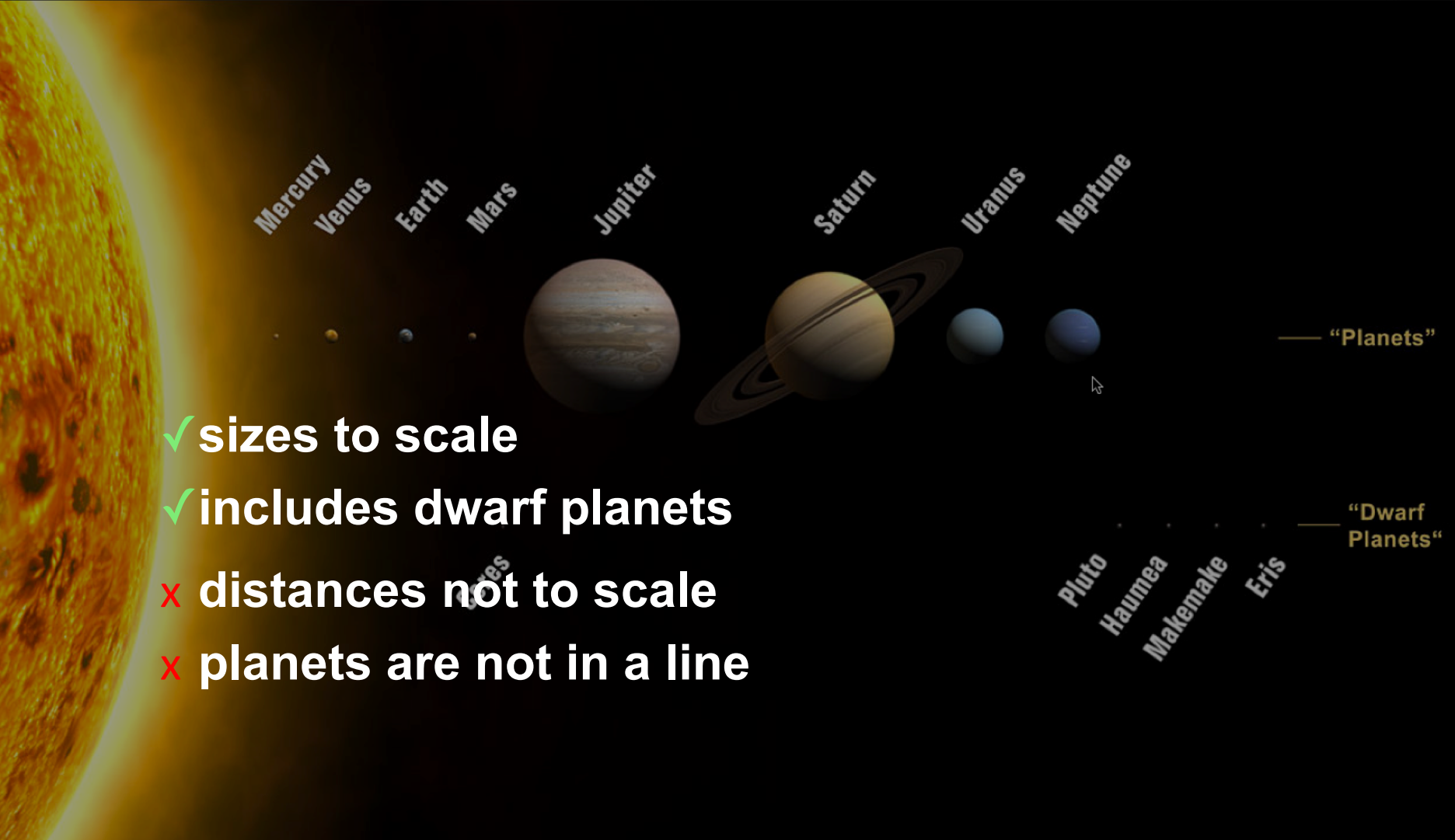
Credit: Lsmpascal

Representation of the Solar System



Credit: NASA

Representation of the Solar System



Credit: NASA

Modelling the Solar System

Representation of the Solar System

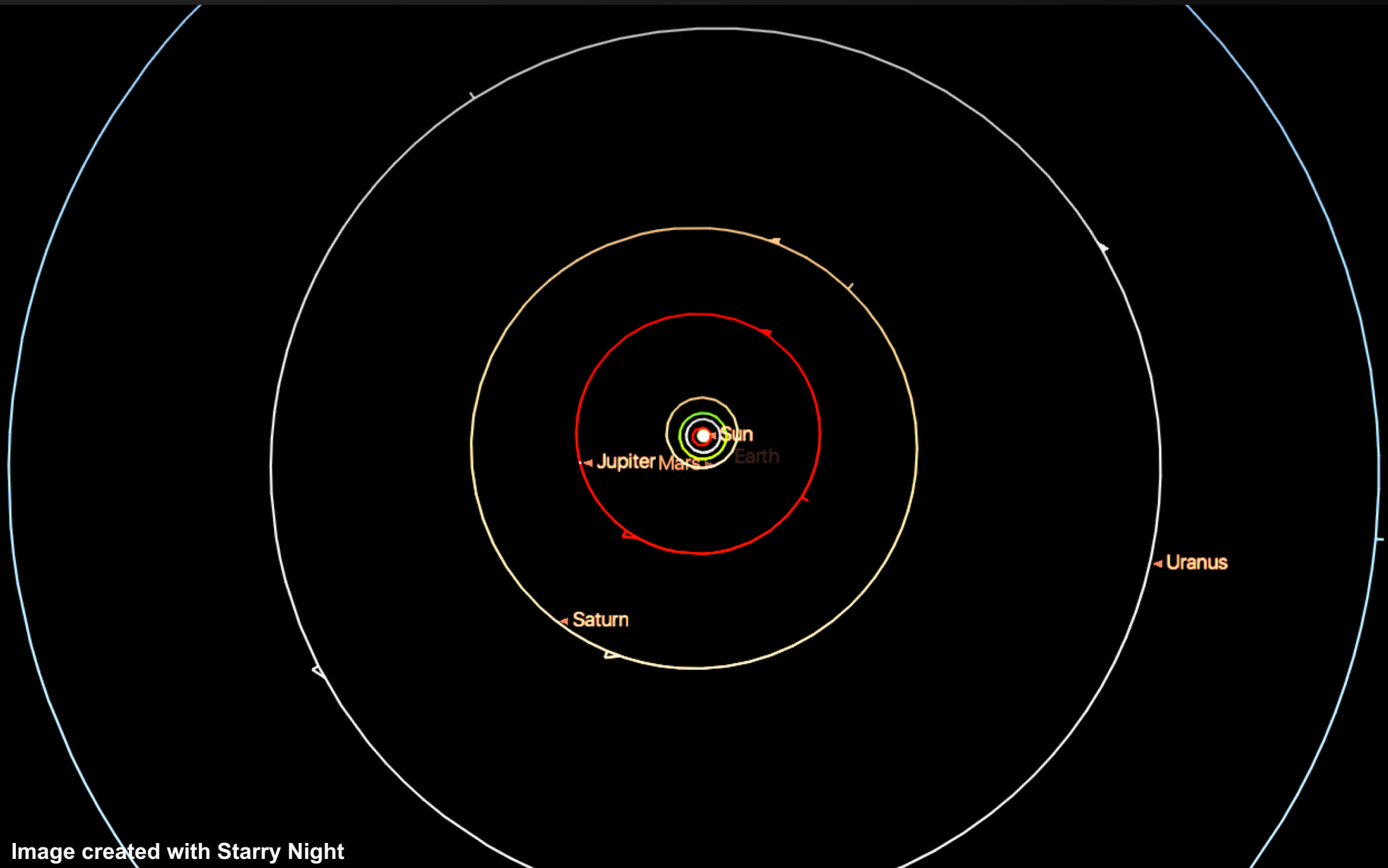


Image created with Starry Night

Representation of the Solar System

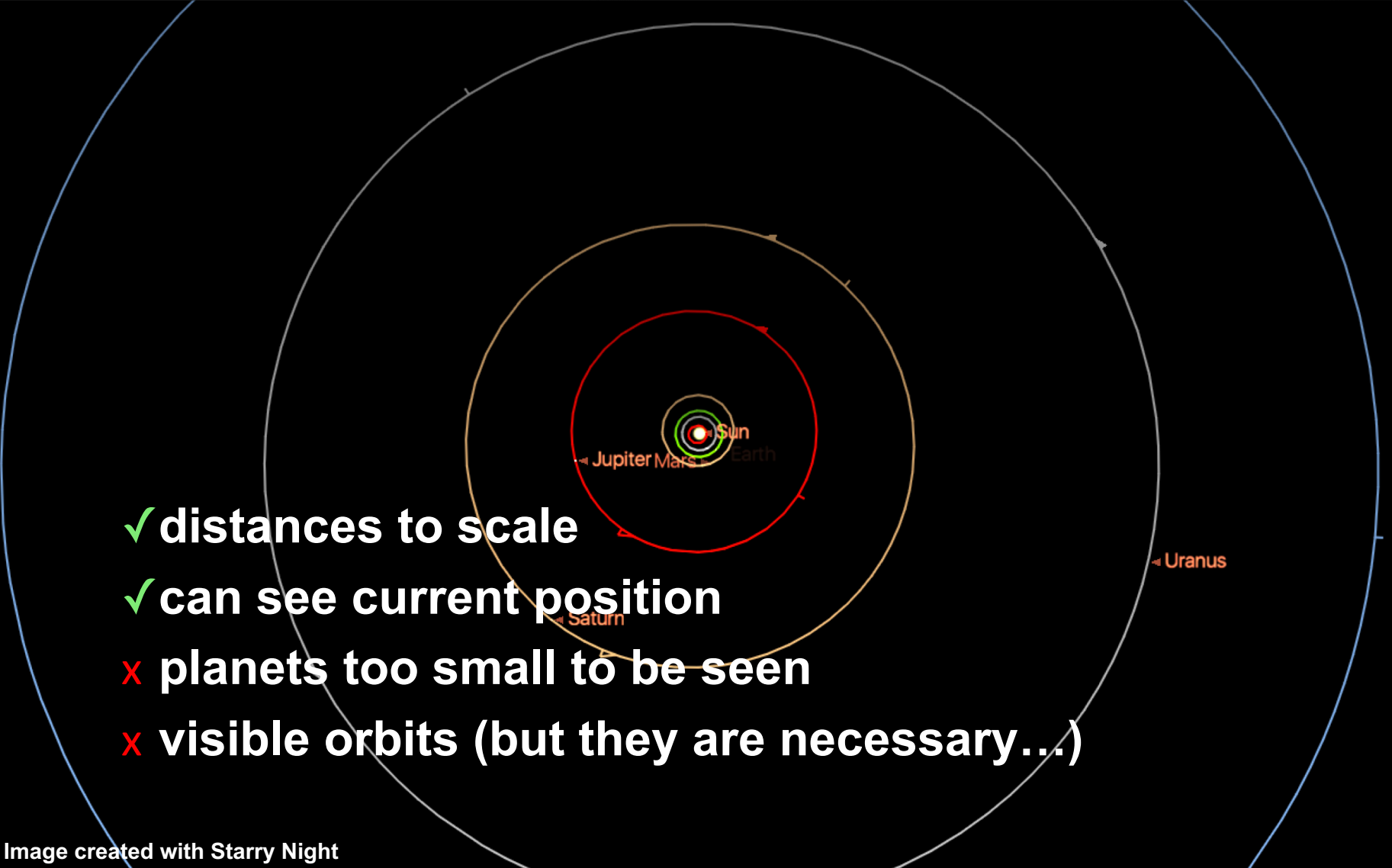
- 
- ✓ distances to scale
 - ✓ can see current position
 - x planets too small to be seen
 - x visible orbits (but they are necessary...)

Image created with Starry Night

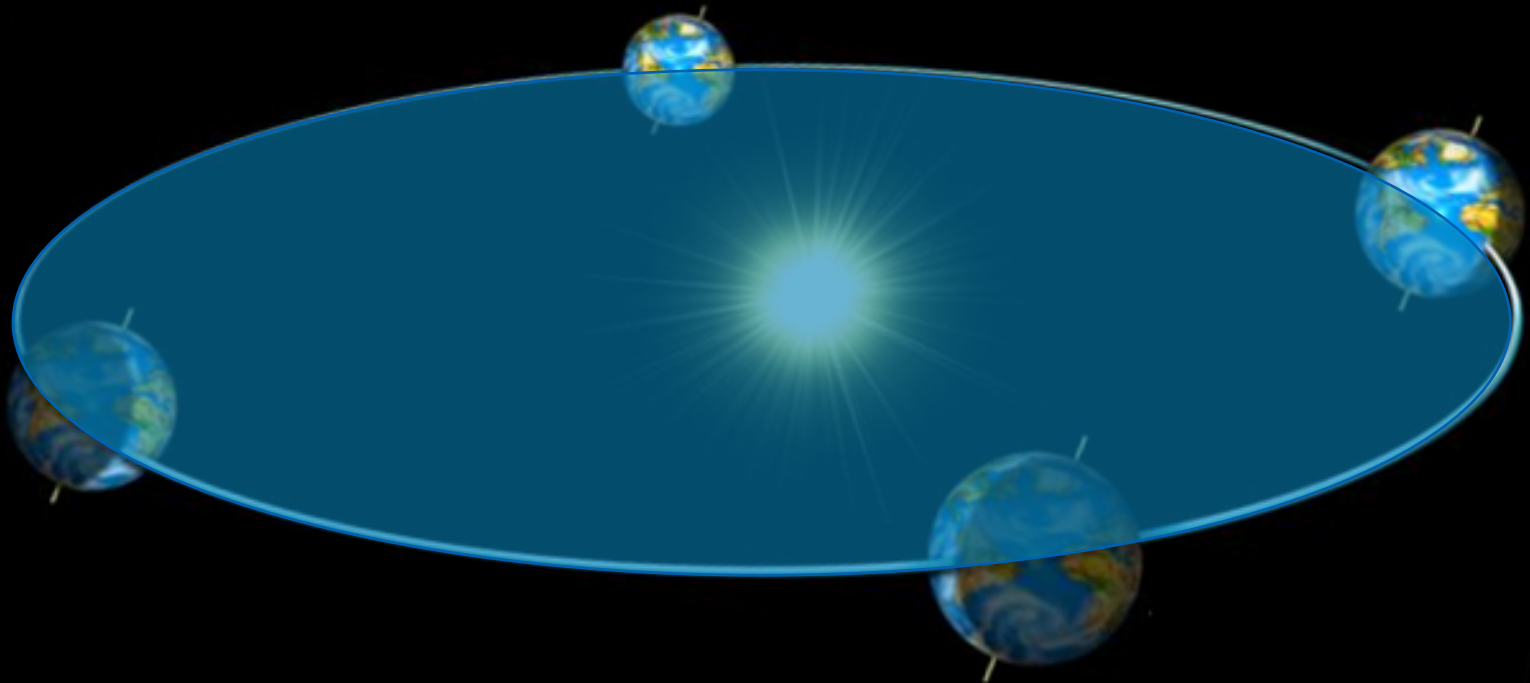
What should we do?

Create models!

A few basic concepts...

Ecliptic

The plane formed by the orbit of the Earth around the Sun is called the **ecliptic**.



Credit: FAAQ/Montreal Planetarium

Image not to scale

Ecliptic

The orbits of the other planets are also on the ecliptic, within a few degrees.

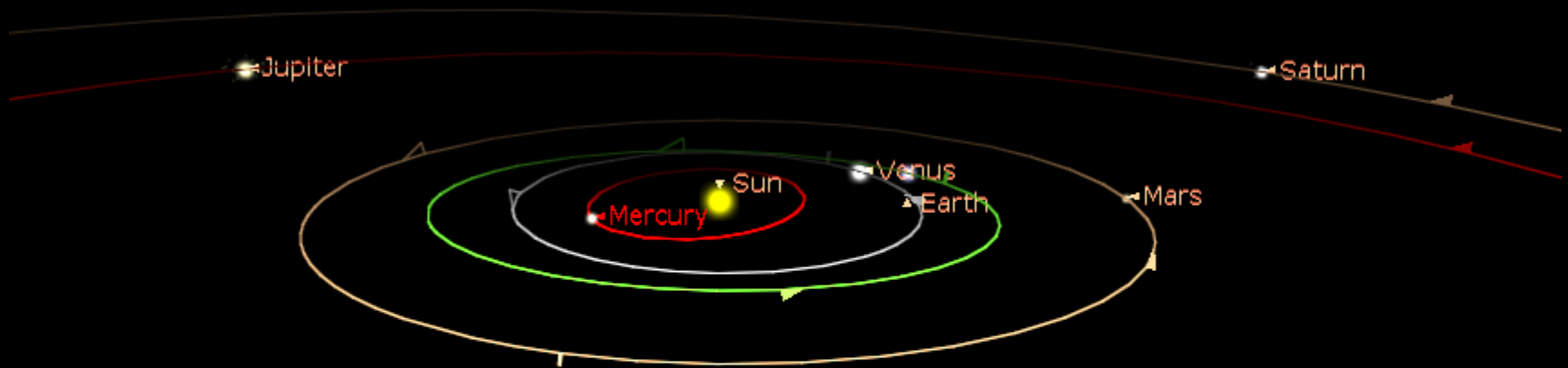
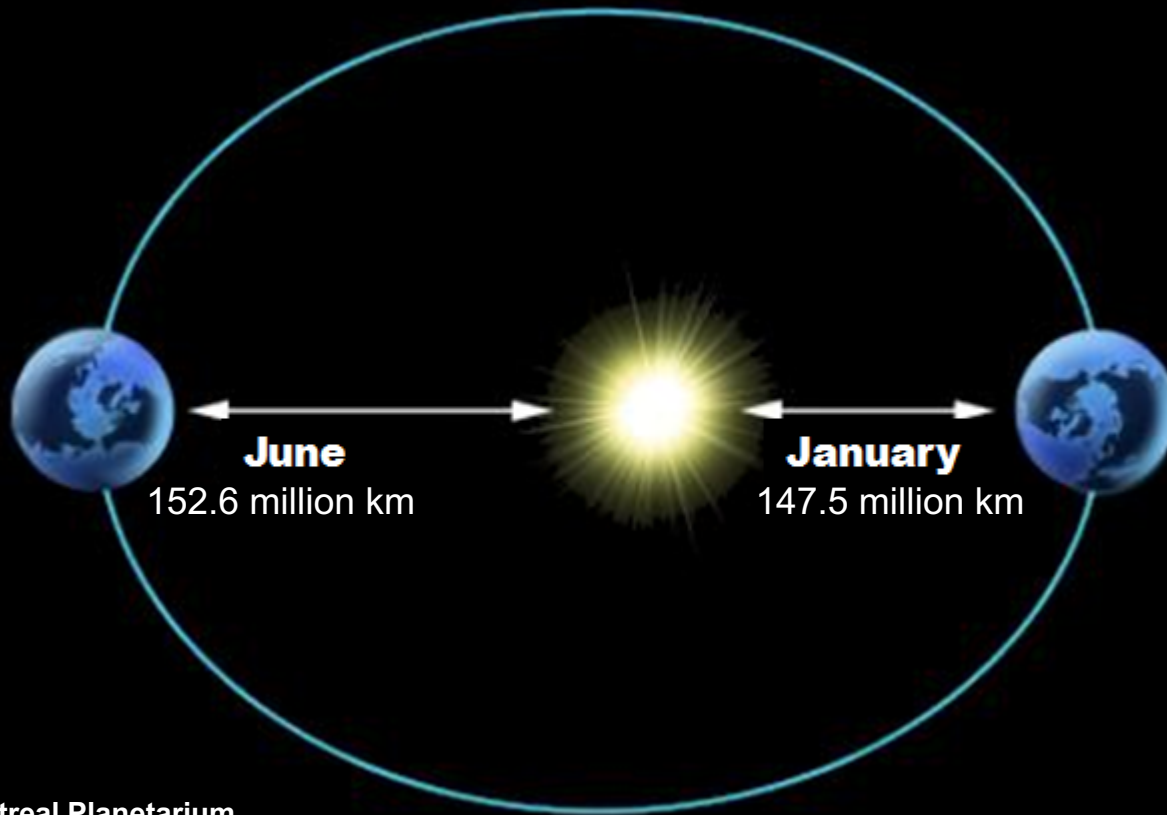


Image created with Starry Night

Astronomical Unit

1 astronomical unit (au) =
= average Earth-Sun distance
= 149.6 million km

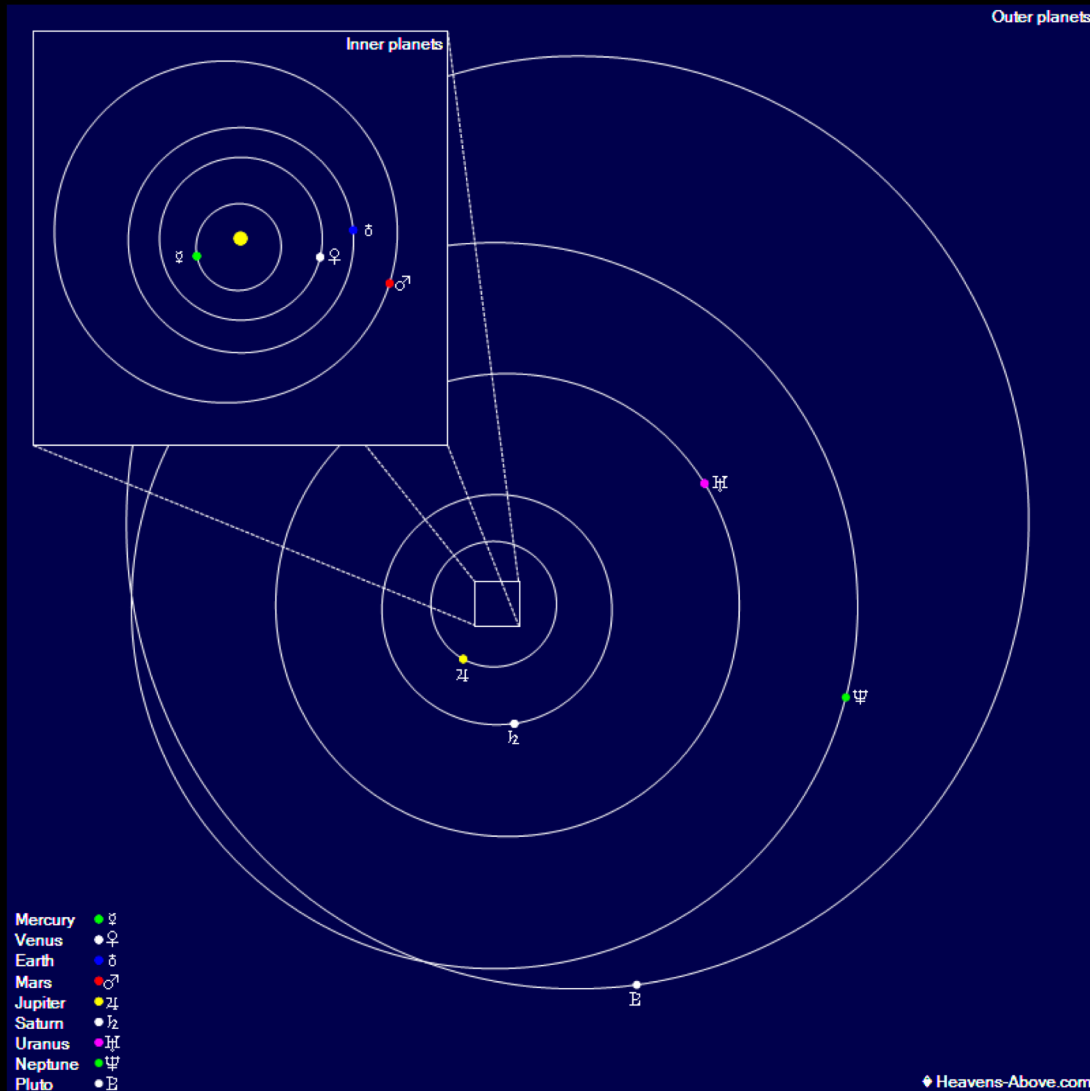


Credit: FAAQ/Montreal Planetarium

Image not to scale

Modelling the Solar System

Orbits of the Planets

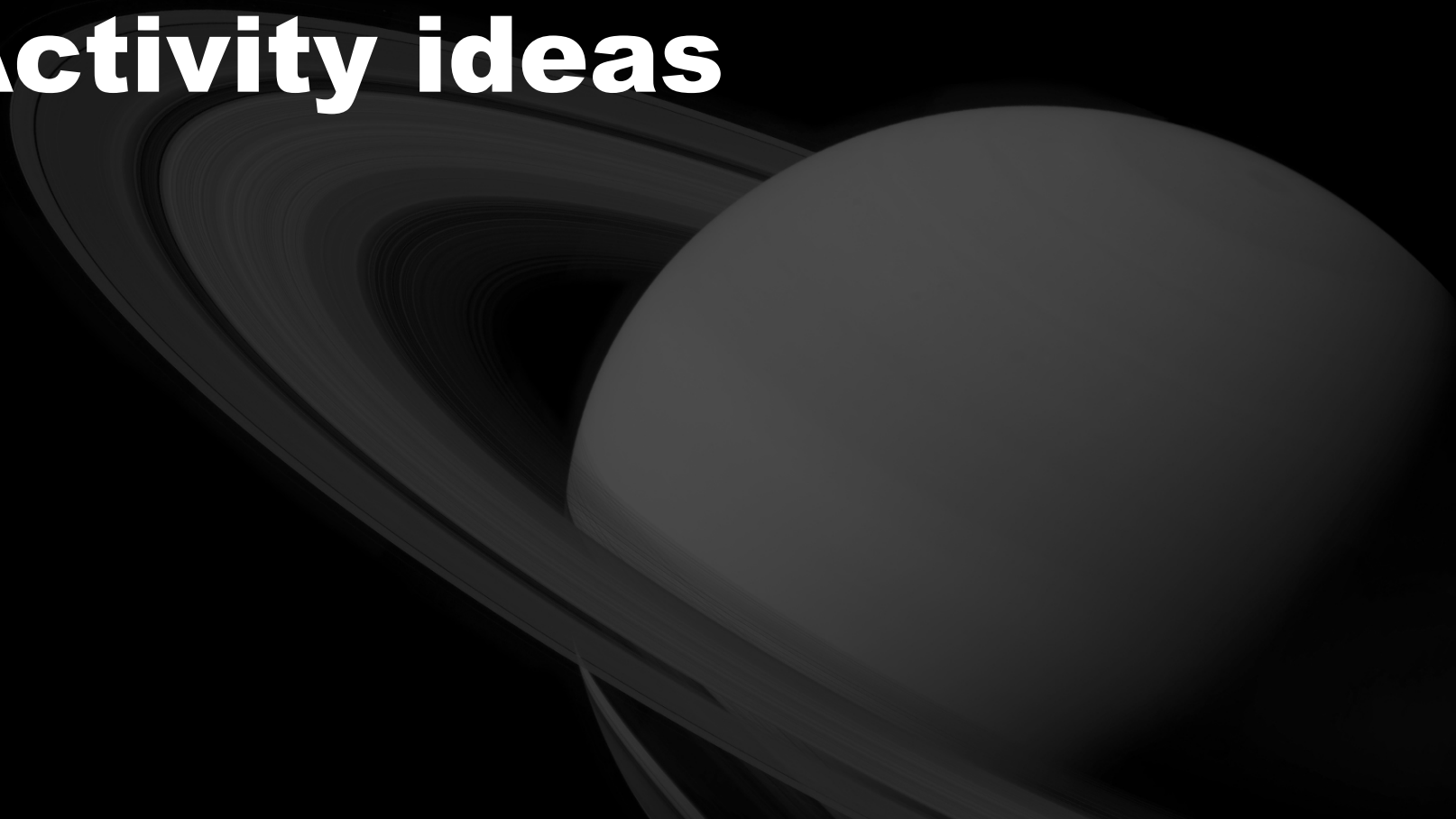


The orbits are not circles, but almost. They are ellipses with the Sun at one focus.

Size of the Solar System

Object	Diameter (km)	Distance from Sun (km)	Distance from Sun (au)
Sun	1 392 530	---	---
Mercury	4879	57 900 000	0.4
Venus	12 104	108 200 000	0.7
Earth	12 756	149 600 000	1.0
Mars	6792	227 900 000	1.5
Ceres (asteroid belt)	952	414 000 000	2.8
Jupiter	142 984	778 600 000	5.2
Saturn	120 536	1 433 500 000	9.6
Uranus	51 118	2 872 500 000	19.2
Neptune	49 528	4 495 100 000	30.1
Pluto (Kuiper belt)	2390	5 906 400 000	39.5

Activity ideas



Pocket Solar System



Pocket Solar System

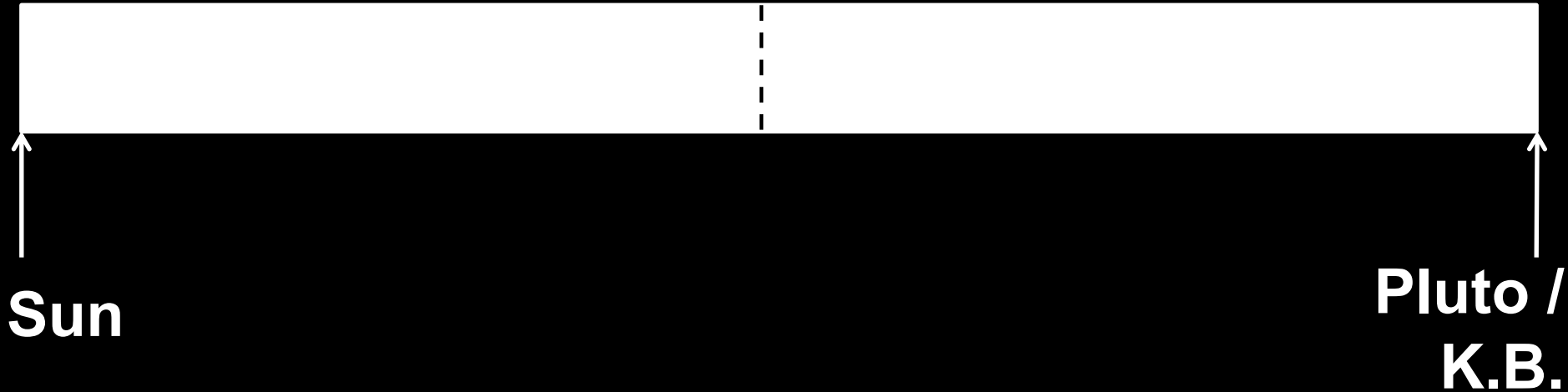
Simple and surprising activity to learn about the distances in the solar system.

Adapted from « Pocket Solar System » from the *Astronomical Society of the Pacific*/Night Sky Network:

http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=392

Cut out a piece of paper tape – about 1m long.

Write “Sun” at one end and “Pluto – Kuiper Belt” at the other end.



Sun

Mercury

Venus

Earth

Mars

Ceres (asteroid belt)

Jupiter

Saturn

Uranus

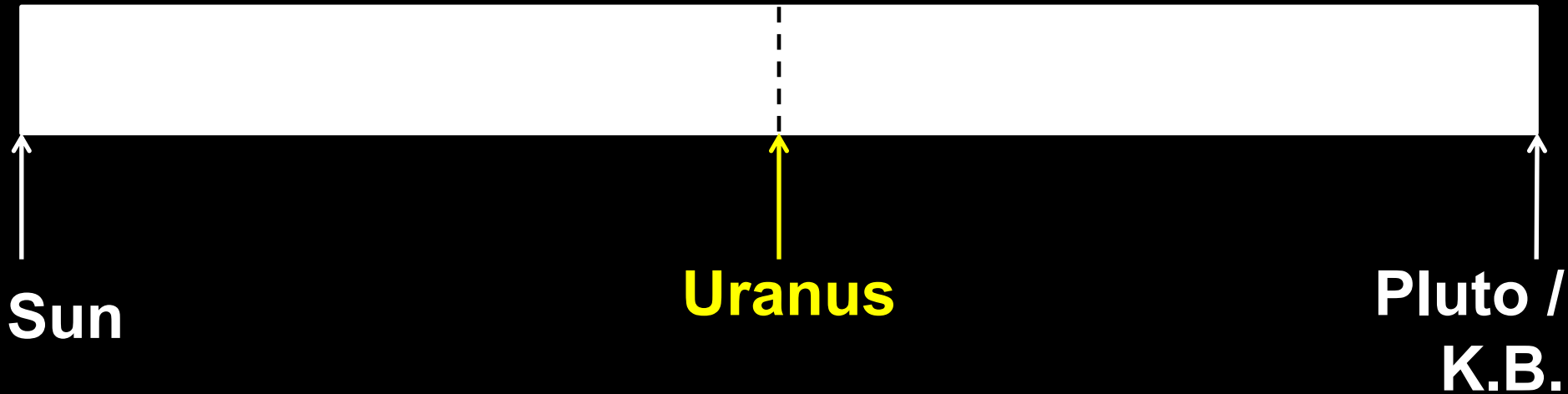
Neptune

Pluto (Kuiper belt)

We now need to place all these objects between the Sun and Pluto.

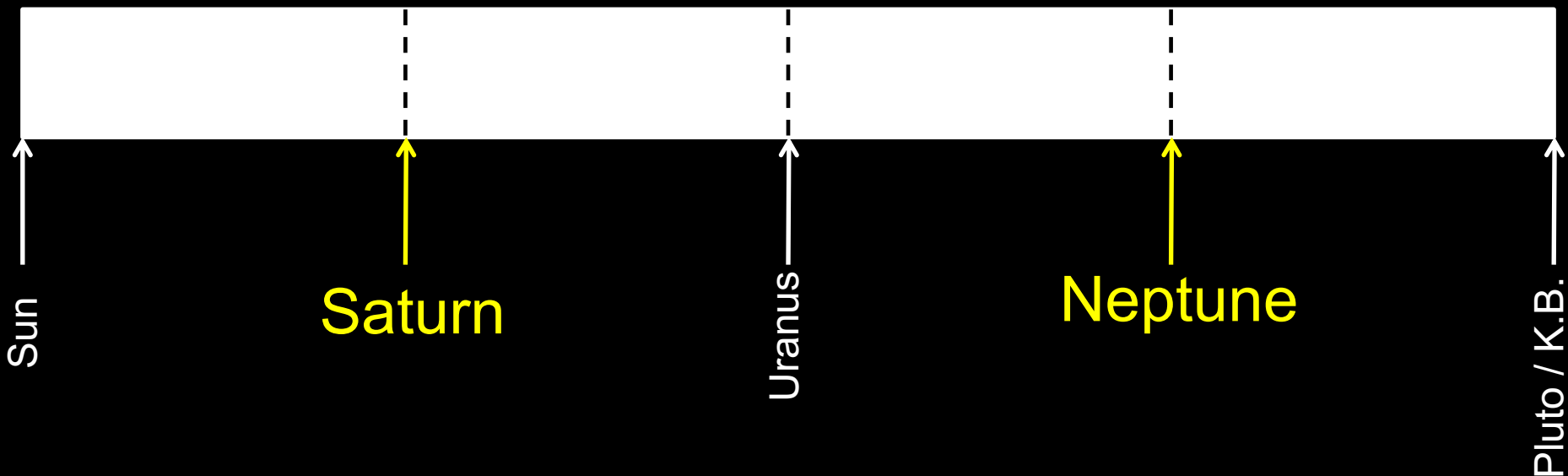
You can ask your students to predict where they go, either on the other side of the paper or with another colour. We'll then make the real model.

Which object would be in the middle of the tape?

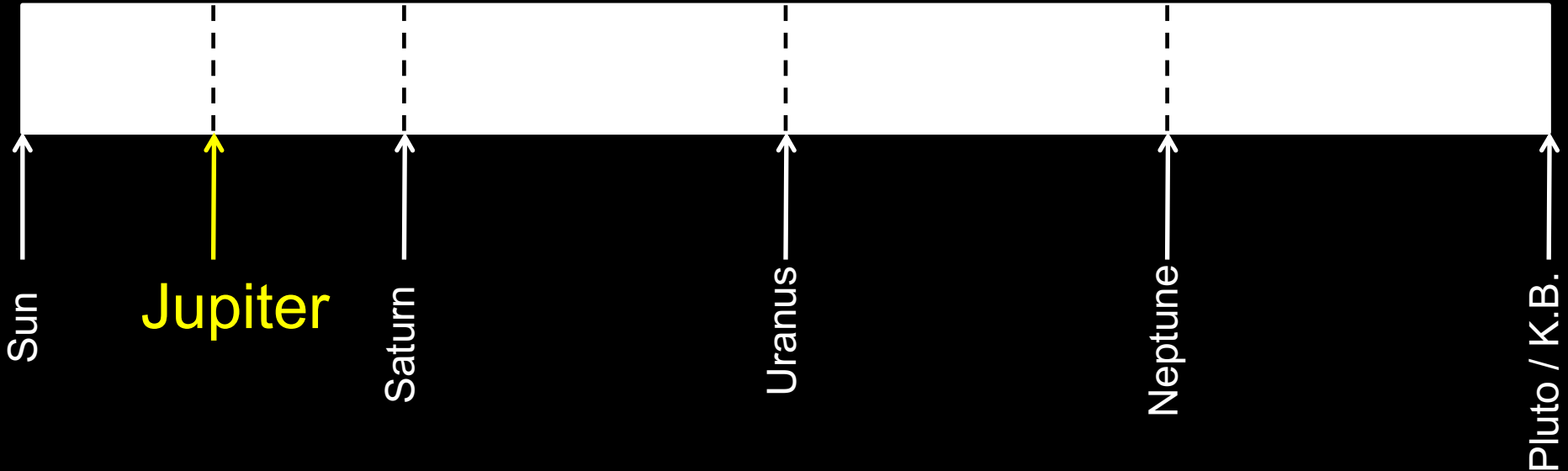


Which object is halfway between Uranus and Pluto?

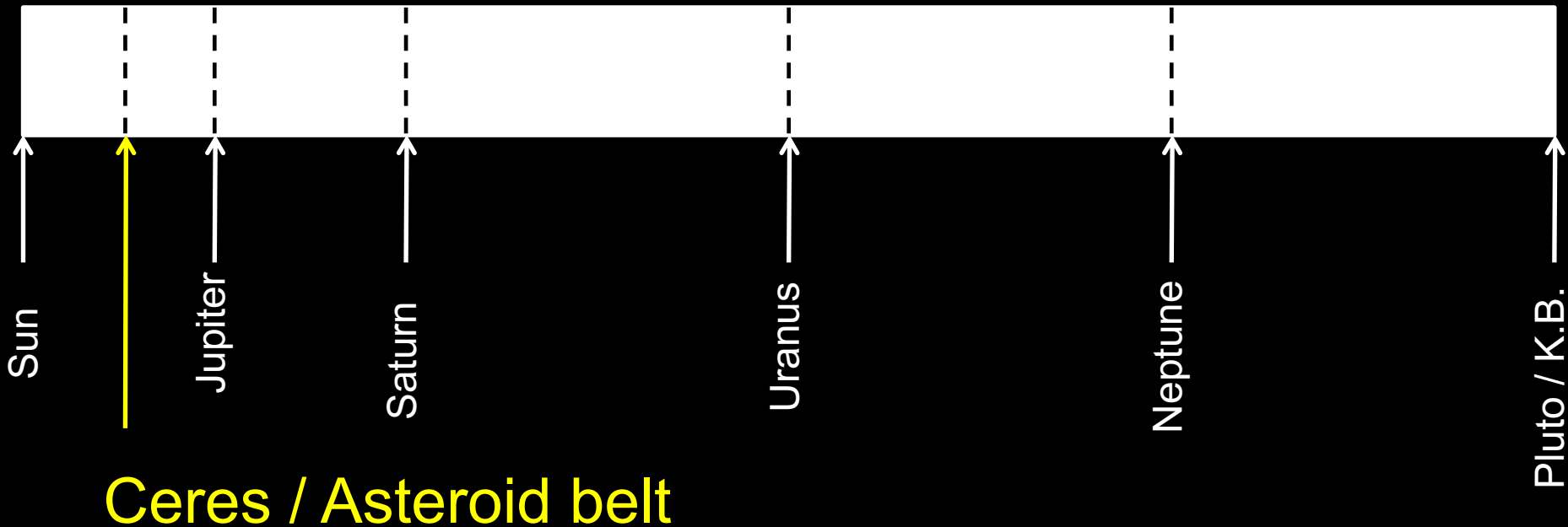
Which object is halfway between the Sun and Uranus?



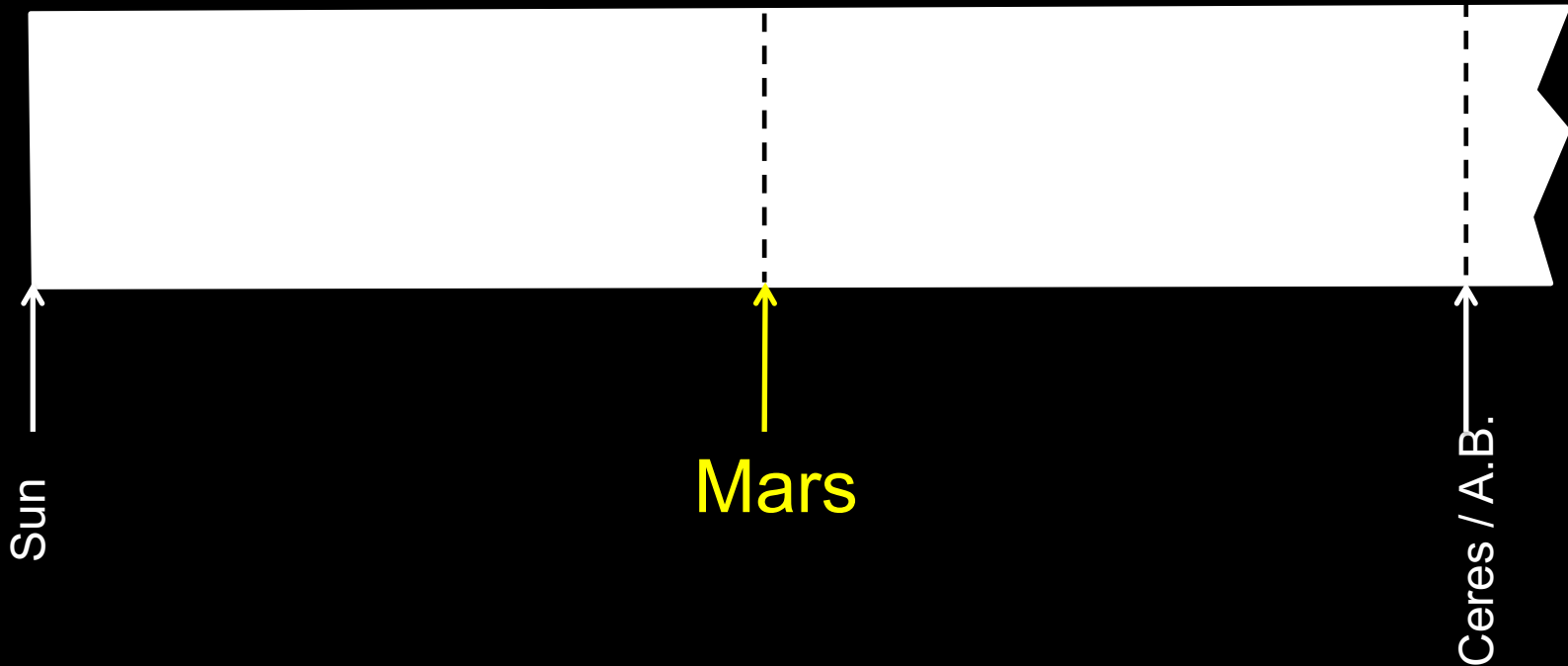
Which object is halfway between the Sun and Saturn?



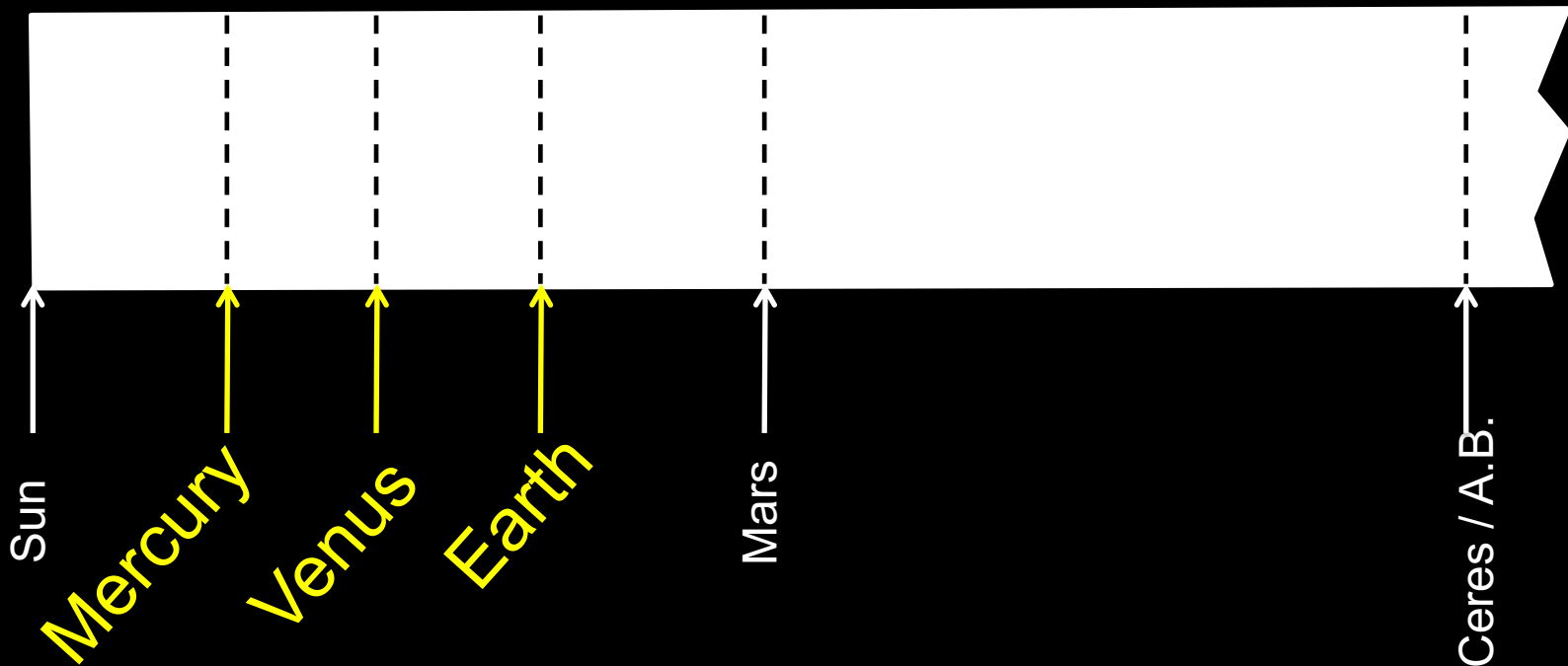
Which object is halfway between the Sun and Jupiter?



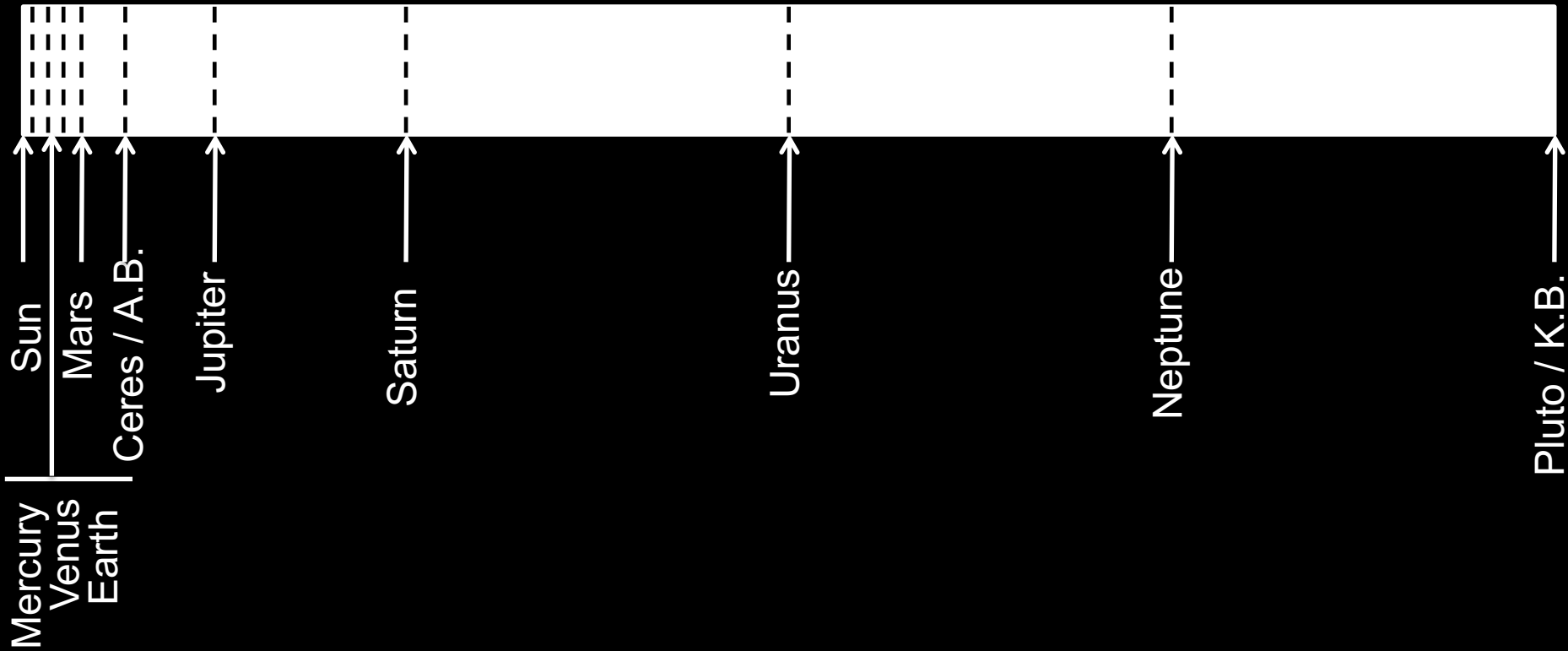
Which object is halfway between the Sun and Ceres?



Finally, we draw three lines between the Sun and Mars for Mercury, Venus and the Earth.



**Now look at the entire solar system.
Any surprise?!?**



	Real distance (au)	Approximate distance (au)
Mercury	0,39	0,4
Venus	0,72	0,7
Earth	1	1
Mars	1,52	1,5
Ceres	2,77	2,8
Jupiter	5,20	5
Saturn	9,54	10
Uranus	19,19	20
Neptune	30,06	30
Pluto	39,44	40

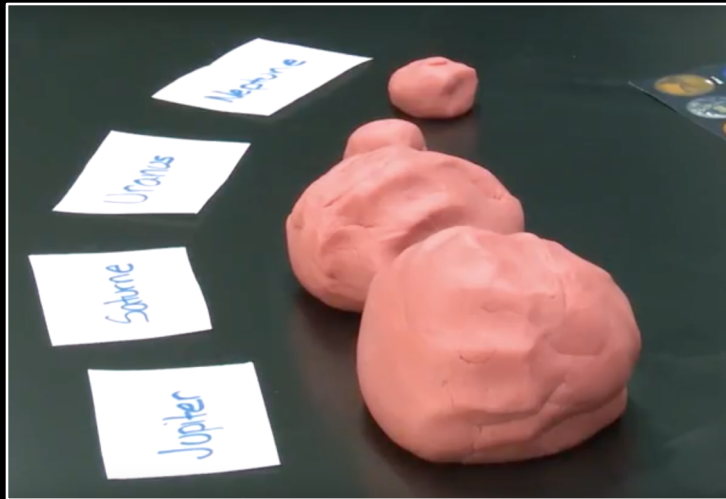
Pocket Solar System

- ✓ very simple, short and efficient
- ✓ shows distances to scale
- x shows objects in a straight line
- x no information about sizes of the objects
- x may be too abstract for some people (tip: draw planets instead of writing names...)

Planets in Playdough

Modelling the Solar System Planets in Playdough

Models the volumes of the planets to scale.



Info:

<http://astronomy.sdsu.edu/projectastro/resources/WorldsInComparison.pdf>

Worlds in Comparison

By Dennis Schatz (*Pacific Science Center*)

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390 Ashton Avenue, San Francisco, CA 94112 ~~~ www.astrosociety.org/afgu



What's This About?

This activity demonstrates the different sizes of the nine planets in our solar system. Follow the steps outlined below to see the relative size (volume) of each planet. Start with a big 3-pound ball of playdough, which represents the volume of all the planets combined.

1. Divide the Entire Ball of Playdough into 10 Equal Parts

You may find it easiest to start by rolling the ball into one big hot dog shape.

- Combine 6 parts together, roll them into a ball, and put the ball into the Jupiter box.
- Similarly combine 3 parts and put them into the Saturn box.

2. Cut the Remaining Part Into 10 Equal Parts

- Take 5 parts and combine them with the ball in the Saturn box.
- Combine 2 parts to put into the Neptune box.
- Put 2 parts into the Uranus box.

3. Cut the Remaining Part Into 4 Equal Parts

- Take 3 parts and combine them with the ball in the Saturn box.

4. Cut the Remaining Part Into 10 Equal Parts

Put 3 parts into the Earth box.

Planets in Playdough

- ✓ excellent activity to model sizes (volume, not just diameter)
- ✓ very surprising!
- x needs a lot of playdough
- x impossible to do perfectly (but that's part of the challenge!)
- x nothing about distances
- x planets only – the other objects would be too small

Scale Model of the Solar System

Scale Model of the Solar System

Recreates the main objects in the solar system using the right scale for both size AND distance.

You can find everyday items to represent the planets and put them at the right distance from your Sun (get ready for a long walk!)

Calculate your Model

If you want the Sun to be 30 cm in diameter, how big should Earth be?

$$\frac{30 \text{ cm}}{1392530 \text{ km}} = \frac{x}{12756 \text{ km}}$$



$$x = \frac{30 \text{ cm} \times 12756 \text{ km}}{1392530 \text{ km}} = 0.27 \text{ cm} = 2.7 \text{ mm}$$

Calculate your Model in Excel

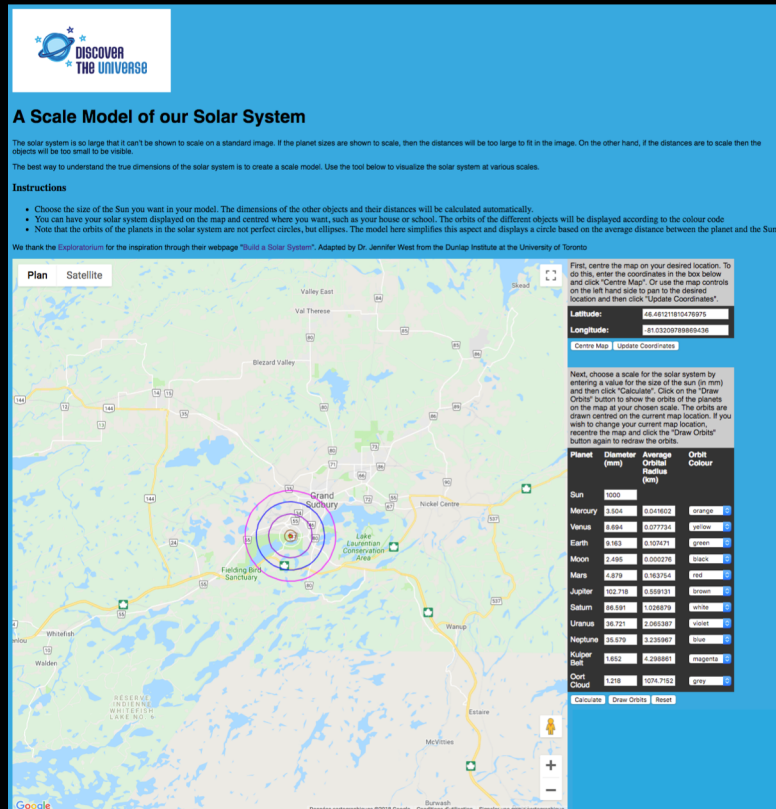
Paste				
B I U				
SUM				
fx =D5*C9/C5				
	A	B	C	D
1				
2				
3				
4			Real (km)	Model (cm)
5		Sun	1392530	30
6				
7		Mercury		
8		Venus		
9		Earth	12756	=D5*C9/C5
10				
11				
12				
13				

O10					
fx					
	A	B	C	D	E
1					
2					
3					
4			Real (km)	Model (cm)	
5		Sun	1392530	30	
6					
7		Mercury			
8		Venus			
9		Earth	12756	0.27	
10					
11					
12					
13					
14					
15					

Modelling the Solar System

Scale Model of the Solar System

<http://www.discovertheuniverse.ca/solarsystem.html>



A Scale Model of our Solar System

The solar system is so large that it can't be shown to scale on a standard image. If the planet sizes are shown to scale, then the distances will be too large to fit in the image. On the other hand, if the distances are to scale then the objects will be too small to be visible.

The best way to understand the true dimensions of the solar system is to create a scale model. Use the tool below to visualize the solar system at various scales.

Instructions

- Choose the size of the Sun you want in your model. The dimensions of the other objects and their distances will be calculated automatically.
- You can have your solar system displayed on the map and centered where you want, such as your house or school. The orbits of the different objects will be displayed according to the colour code.
- Note that the orbits of the planets in the solar system are not perfect circles, but ellipses. The model here simplifies this aspect and displays a circle based on the average distance between the planet and the Sun.

We thank the *Exploratorium* for the inspiration through their webpage "Build a Scale System". Adapted by Dr. Jennifer West from the Dunlap Institute at the University of Toronto.

Plan Satellite

First, centre the map on your desired location. To do this, enter the coordinates in the box below and click "Centre Map". Or use the map controls on the left hand side to pan to the desired location and then click "Update Coordinates".

Latitude: 46.4811810478975
Longitude: -81.0320768888438

Centre Map Update Coordinates

Next, choose a scale for the solar system by entering a value for the size of the sun (in mm) and then click "Calculate". Click on the "Draw Orbits" button to show the orbits of the planets on the map at your chosen scale. The orbits are drawn centred on the current map location. If you wish to change your current map location, recenter the map and click the "Draw Orbits" button again to redraw the orbits.

Planet	Diameter (mm)	Average Orbital Radius (km)	Orbit Colour
Sun	1000		
Mercury	0.004	0.041602	orange
Venus	0.004	0.07734	yellow
Earth	0.003	0.107471	green
Moon	0.0002	0.000276	black
Mars	0.001	0.163764	red
Jupiter	0.02719	0.001911	brown
Saturn	0.009	0.000879	white
Uranus	0.002	0.000387	violet
Neptune	0.002	0.000387	blue
Kuiper Belt	0.002	0.000387	magenta
Ort Cloud	0.002	0.000387	grey

Calculate Draw Orbits Reset

Enter the size of the Sun you want for your model. Everything else is calculated automatically.

Show the scale solar system on the map, centred where you want.

Modelling the Solar System

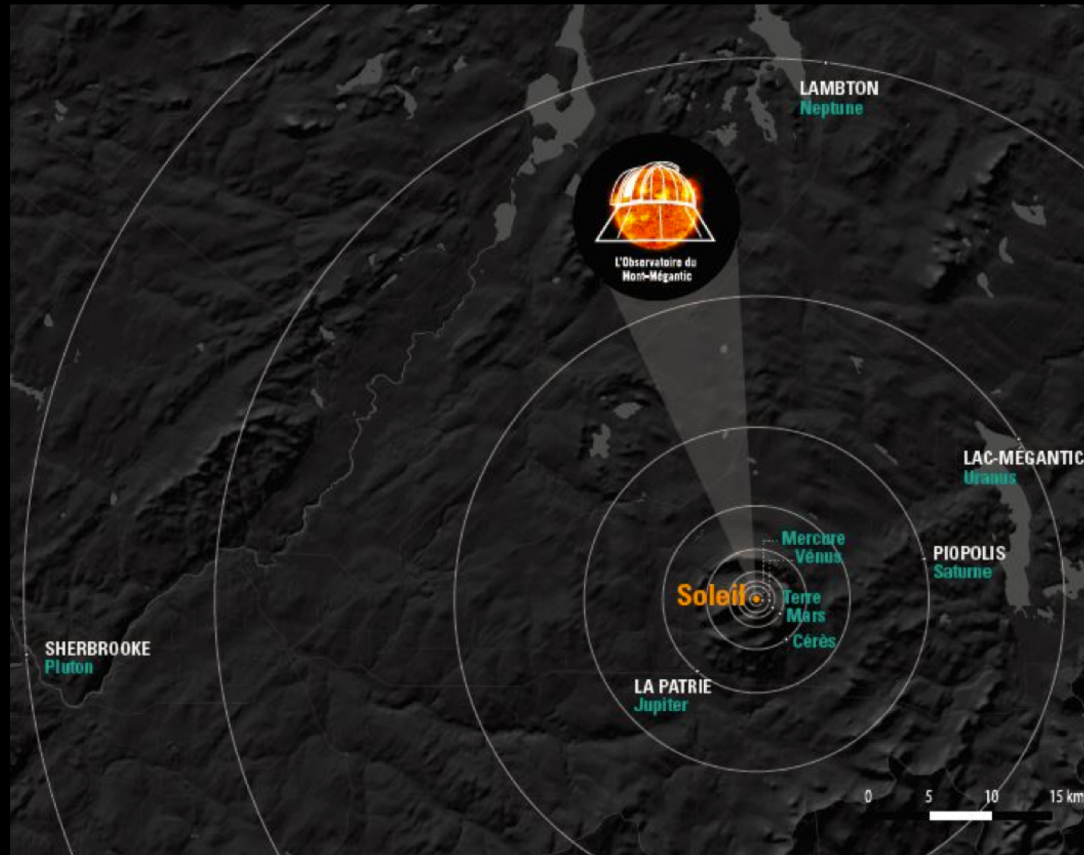
Scale Model of the Solar System

Also available in our Resources section.



Scale Model of the Solar System - Example

Giant scale model based on the Observatory of Mont Mégantic, near Sherbrooke, QC.



Scale Model of the Solar System - Example



Uranus, in Lac-Mégantic

Info : <http://www.astrolab-parc-national-mont-megantic.org/en/giant.solar.system.htm>

Scale Model of the Solar System - Example



Excellent video— Solar system to scale in the Nevada desert: <https://youtu.be/zR3lgc3Rhfg>

Scale Model of the Solar System

- ✓ **models distances AND sizes**
- ✓ **gives an excellent idea of the true scale of the solar system**
- x **needs many items and long distance**
- x **might be difficult to have a general overview**
- x **might give the impression that planets are all in a line**
- x **very difficult to model the smaller objects**

The image features three Sphero robotic balls arranged in a triangular pattern against a dark, starry background with a white grid. The top ball is orange and white with a small orange logo. The bottom-left ball is white with a blue logo. The bottom-right ball is blue with a white logo. The text "Sphero Solar System by X-Chem Outreach Program" is centered in white, bold font.

Sphero Solar System by X-Chem Outreach Program

Sphero Solar System

Activity developed by X-Chem Outreach and Actua

★ includes robotics, coding, and math to calculate orbital periods and speeds to scale



Sphero Solar System



What you'll need:

- ★ **4-5 Sphero SPRK+ or Sphero Mini**
- ★ **4-5 tablets to control each Sphero**
- ★ **large surface (up to Mars: radius of 1.6 m; up to Jupiter: radius of 5.3 m)**

Sphero Solar System

We know:

- ★ distances to each planet (1au becomes 1m in the model);
- ★ orbital speeds in km/s of each planet.

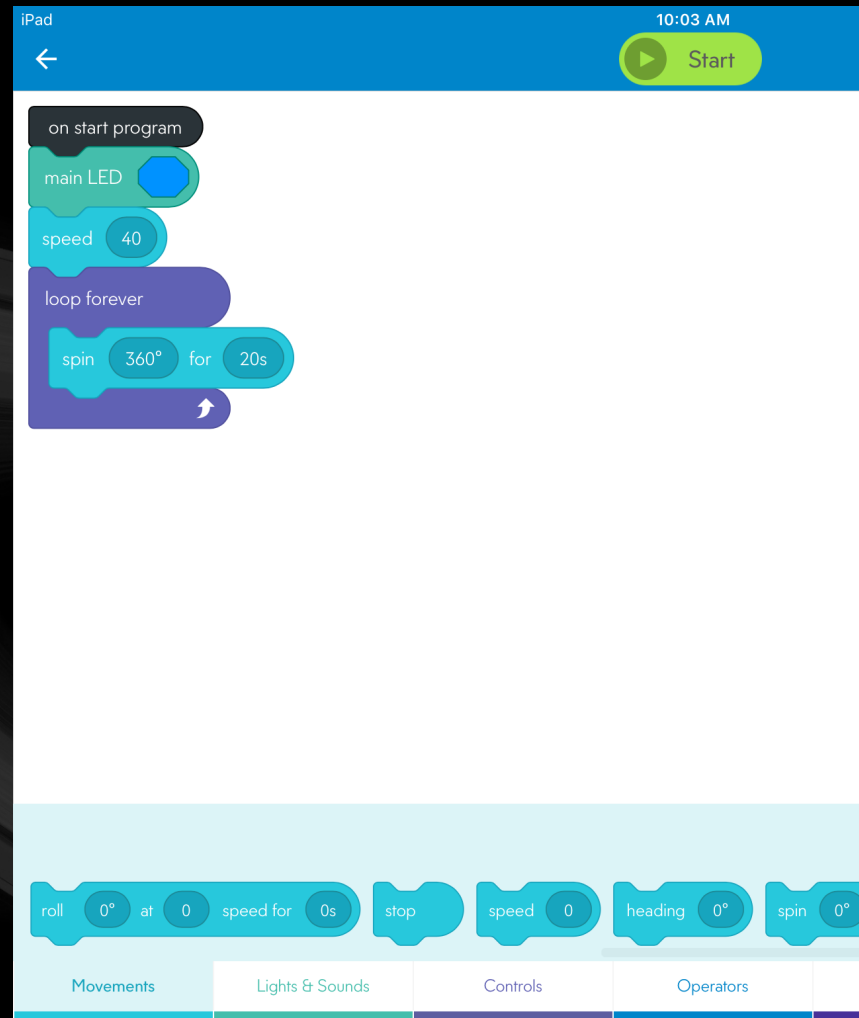
Need to calculate:

- ★ speeds in Sphero unit (or use calculated values in activity description);
- ★ orbital periods, using the speeds and circumferences (or use values in activity description).

Sphero Solar System

**Coding in
blocks using
the app Sphero
Edu:**

**And we get 4 or 5
planets orbiting
the Sun at
different speeds
and with different
colours!**



Sphero Solar System



Detailed description:

<https://actua.ca/en/activities/sphero-solar-system-by-x-chem-outreach-program>

Sphero Solar System

- ✓ **multidisciplinary activity: astronomy, robotics, coding and math**
- ✓ **models distances and motion to scale**
- x **needs equipment**
- x **sizes of planets not to scale**
- x **system becomes unstable after a few orbits**

Modelling the Solar System

No model is perfect but they are better than still images.

Don't hesitate to discuss limitations of the models with your students.



Questions?

Thank you!