

A wireframe sphere is located in the top-left corner of the slide, partially overlapping the title area. It consists of a grid of lines forming a spherical shape.

# Basics of Interplanetary Flight

**ONLINE**

Dave Doody

CASSINI REALTIME OPERATIONS



# Basics of Interplanetary Flight

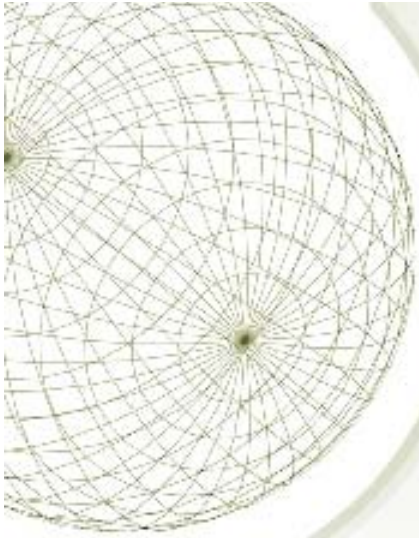
**ONLINE**

An Introduction to the **online** tutorial:

<http://www.jpl.nasa.gov/basics>

...which is a survey broad in scope, but limited in depth.

The online tutorial's goal is to describe the main concepts that apply to interplanetary space exploration, and how the relationships among them work.

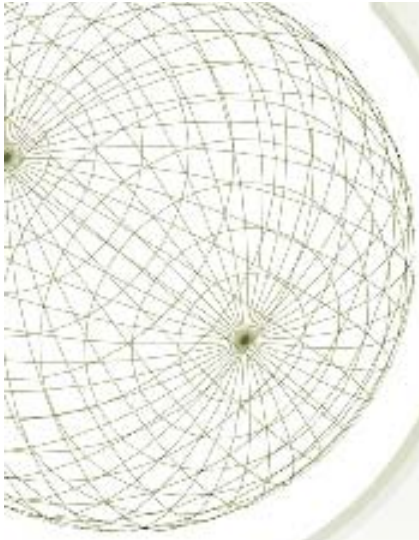


# Today's session

(1) The interplanetary environment

(2) Some spacecraft and their results

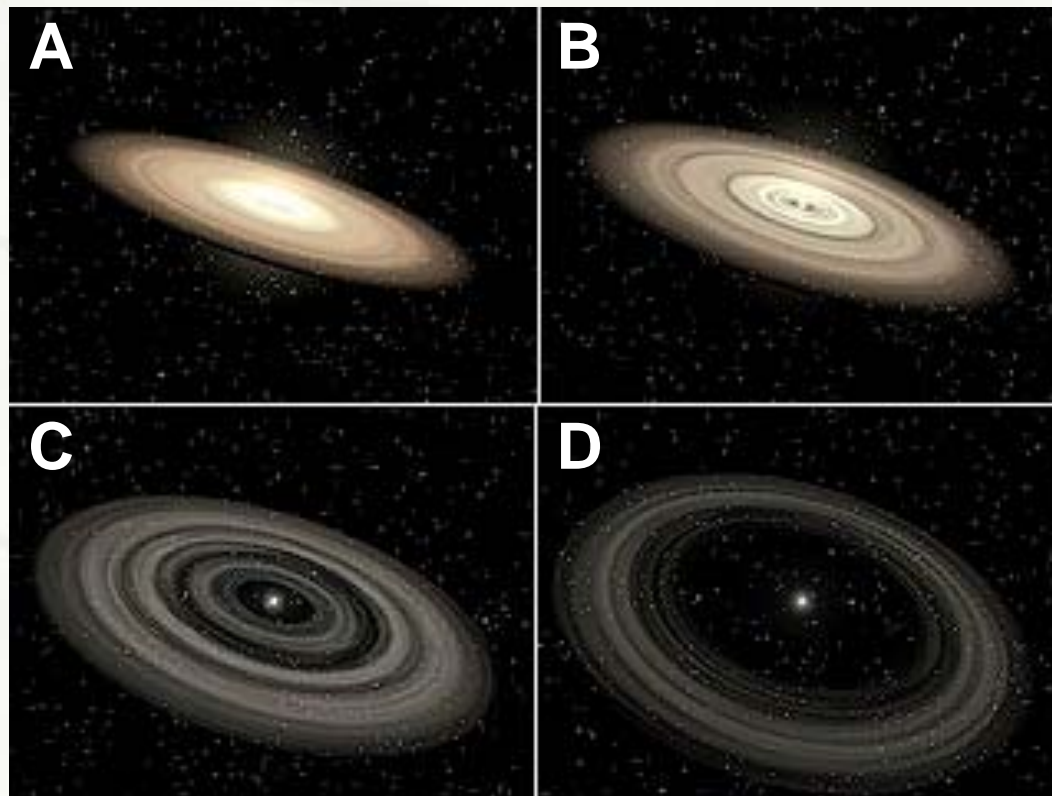
With ongoing Q & A - don't hesitate to interrupt!

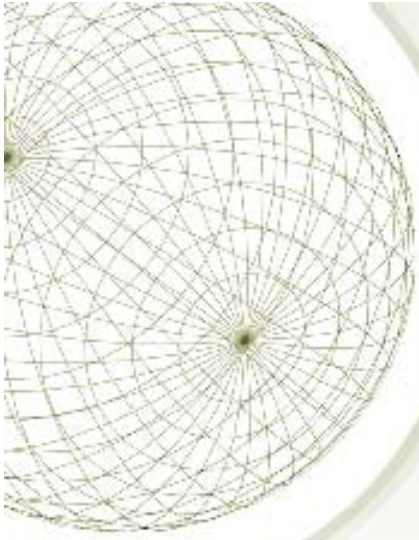


## Cartoon of a young star with protoplanetary disk

Movie available if you want to see it rotating and evolving:

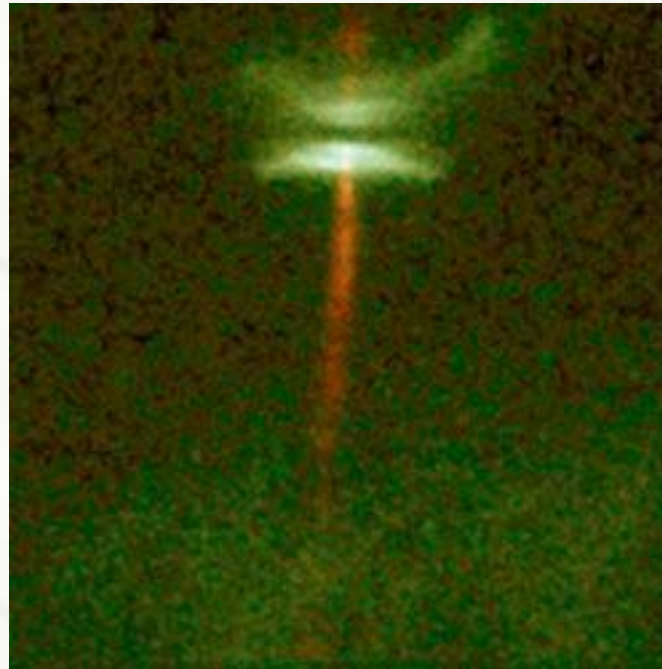
[http://ipac.jpl.nasa.gov/web\\_movies/pa/ssc2004-22v2\\_full.mov](http://ipac.jpl.nasa.gov/web_movies/pa/ssc2004-22v2_full.mov)





## Here's a real protoplanetary disk

HH-30 in Taurus, about 450 light years away.





**The results:**

A central star containing 99.85% the cloud's mass

Gravitation that rules everything in the area



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Radiation: heat, light, UV...





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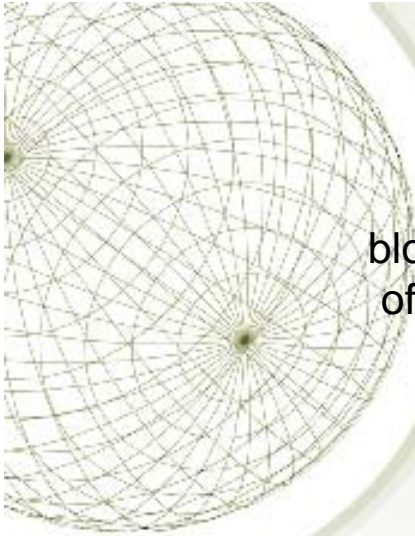
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Pre-existing, dominating motion

Radiation: heat, light, UV...

Extensive magnetic field

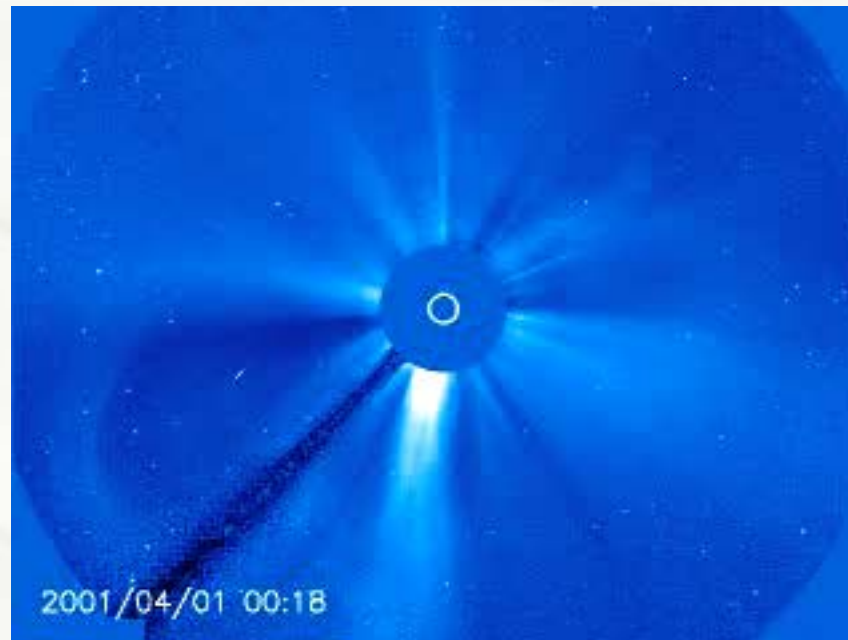
The solar wind and coronal mass ejections



This movie, from the SOHO spacecraft's LASCO instrument, blocks out the Sun's central glare to reveal the unrelenting stream of material in the corona: solar wind and coronal mass ejections.

Note the background stars moving left to right.

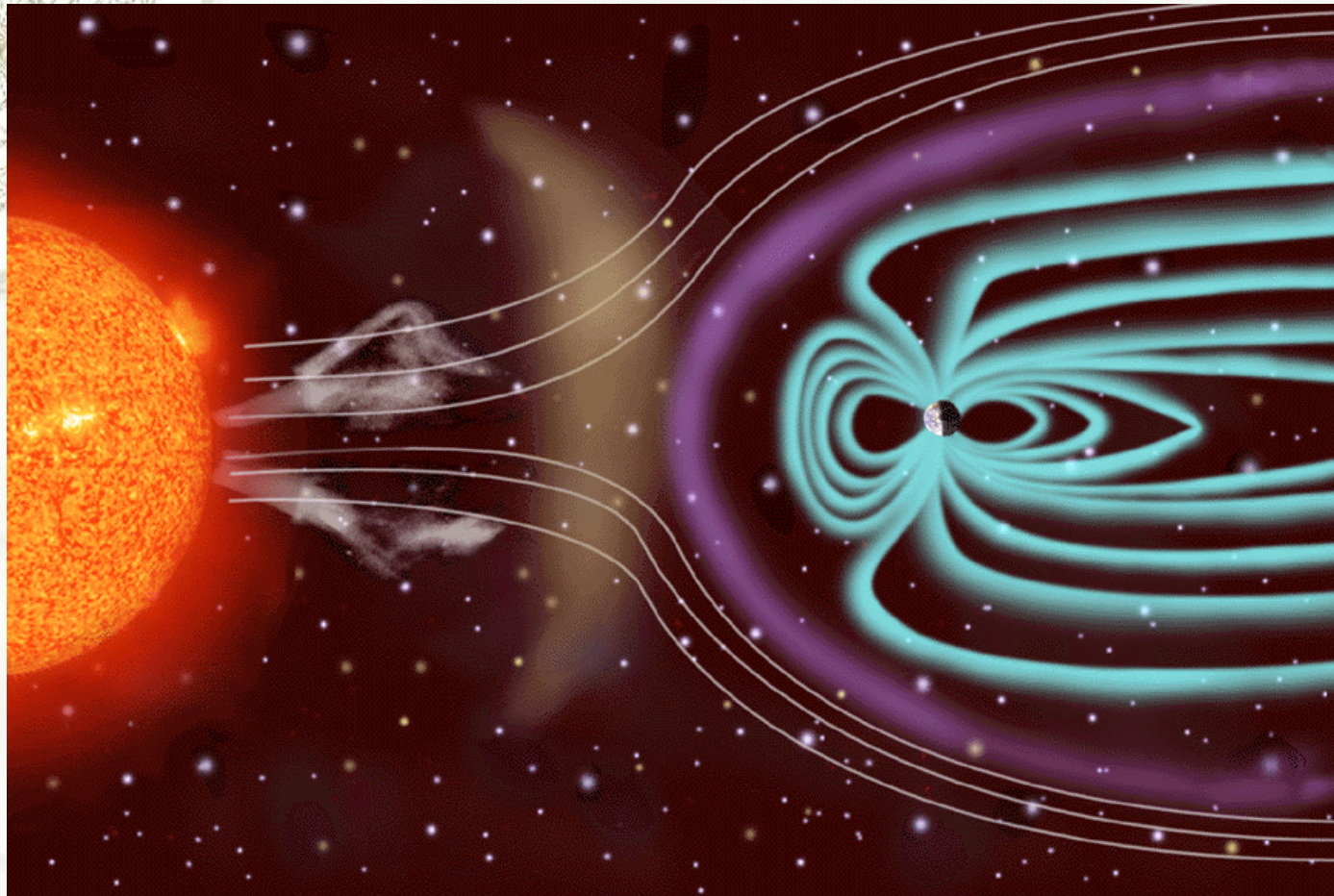
[http://sohowww.nascom.nasa.gov/gallery/Movies/C3\\_Apr01/C3\\_Apr01sm.mpg](http://sohowww.nascom.nasa.gov/gallery/Movies/C3_Apr01/C3_Apr01sm.mpg)



See also the brightest comet in thirty years pass near Mercury in SOHO's view

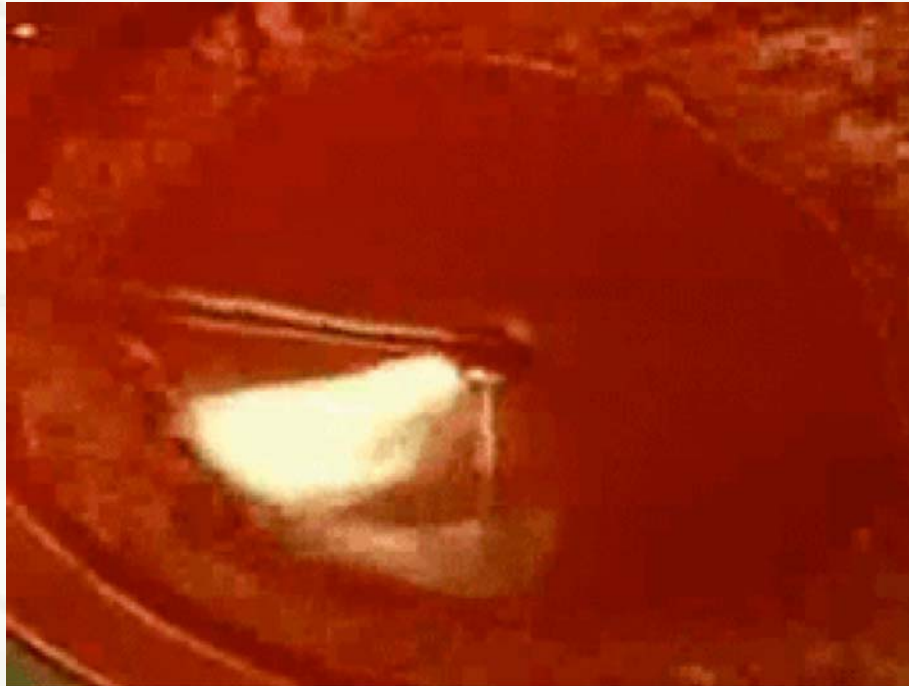
<http://sohowww.nascom.nasa.gov/hotshots>

## Earth's magnetic field shields us

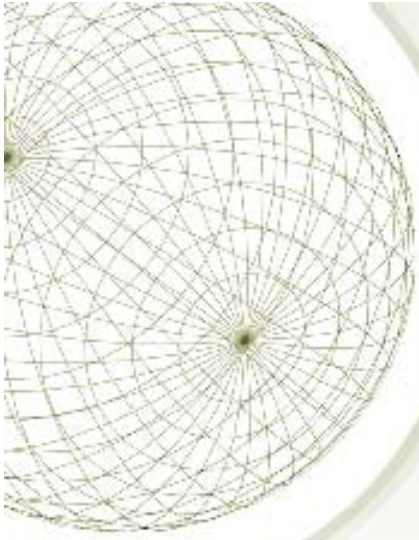


A wireframe sphere is positioned in the upper left corner of the slide. It consists of a grid of lines forming a spherical shape, with a small dark spot at its center.

## Why are we looking at Ed Stone's kitchen sink?

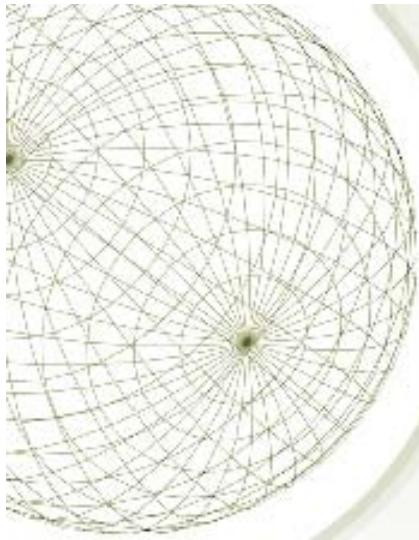


View the animation at <http://www.jpl.nasa.gov/basics/bsf1-1.html>



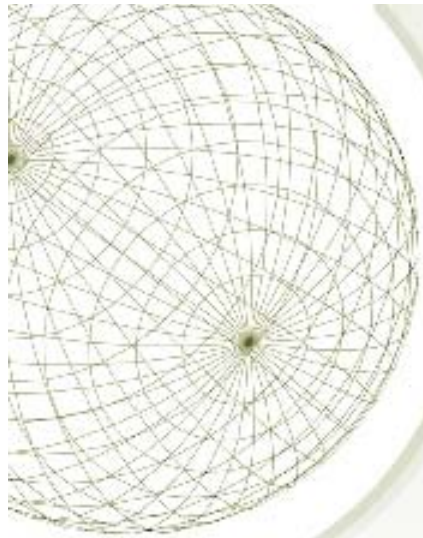
## Orbits





Mt. Apoapsis

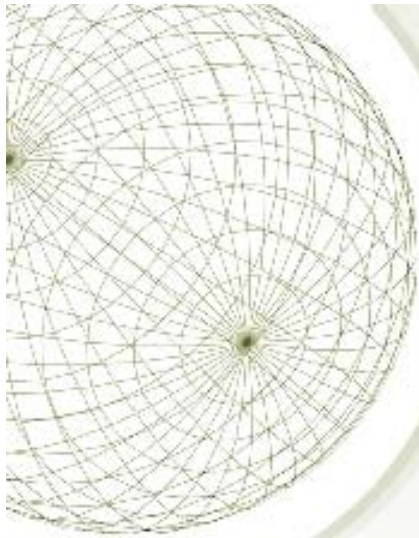




Apoapsis



Periapsis



So, you added energy up here at...

Apoapsis



And the effect was to increase altitude at...

Periapsis

...until the cannonball didn't hit the ground.





Apoapsis



The opposite is true, too: if you **add** energy at...

Periapsis

You'll increase the altitude of **Apoapsis**.



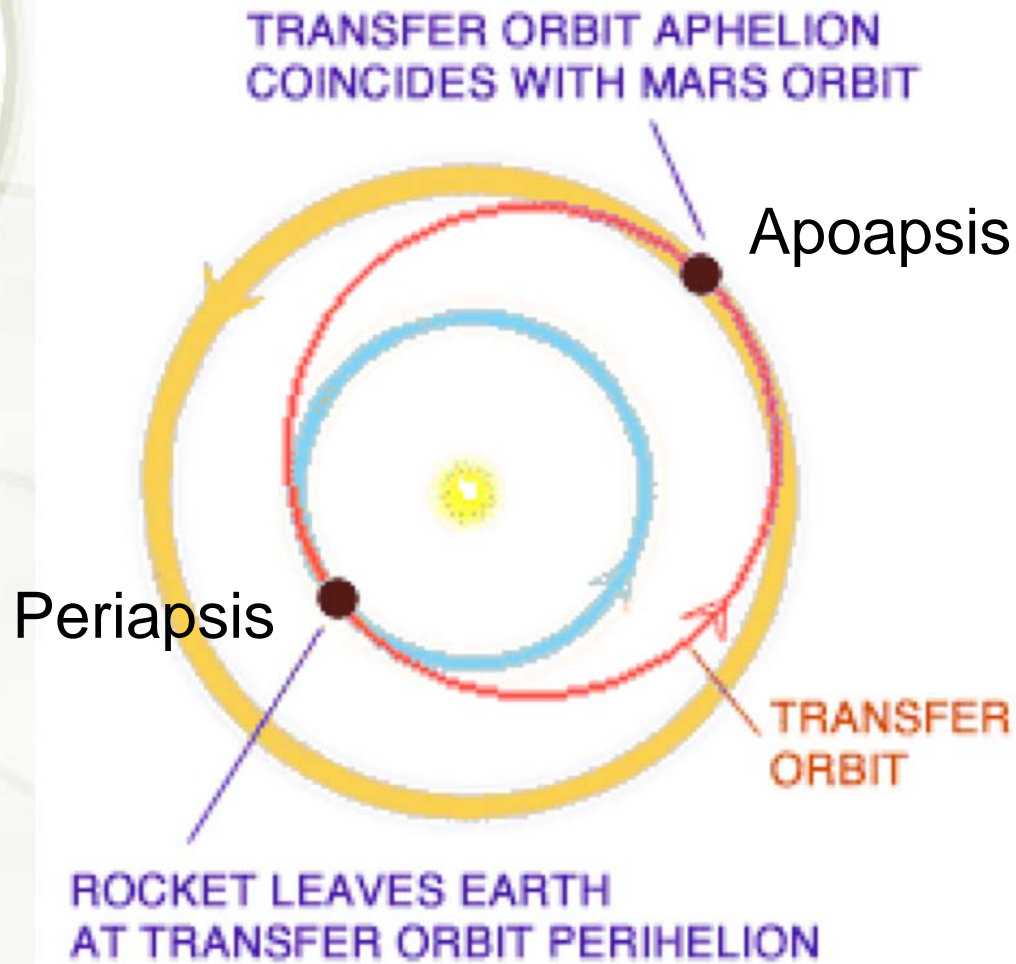
Apoapsis

The diagram illustrates Earth's elliptical orbit around the Sun. The Sun is represented by a yellow circle at the center. Earth is shown as a blue and white sphere with a white square highlighting the area around the Sun. The orbit is an ellipse with the Sun at one focus. The point farthest from the Sun is labeled 'Apoapsis' and the point closest to the Sun is labeled 'Periapsis'. A wireframe sphere is visible in the top-left corner.

Periapsis



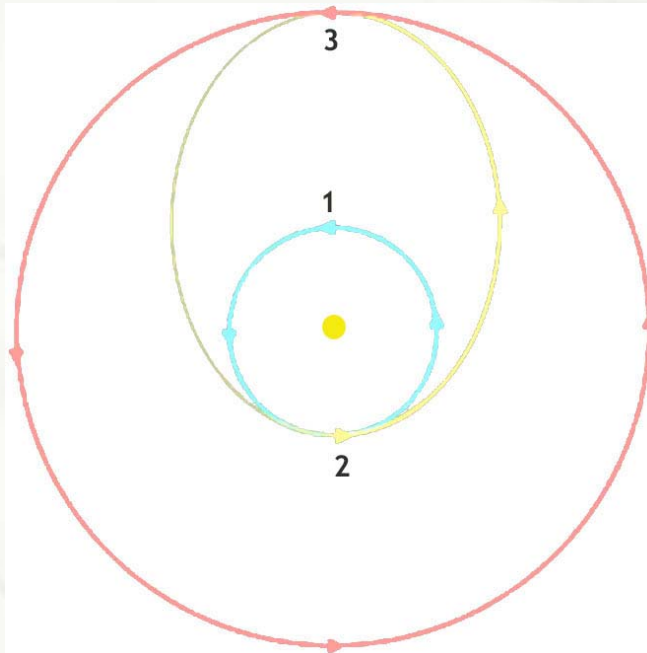
PAY NO ATTENTION TO THE  
DIRECTION REVERSAL ON THIS  
PAGE



## The Hohmann Transfer

A Hohmann transfer is a fuel-efficient way to transfer from one circular orbit to another that is in the same plane, but at a different distance from the central body. Named for Walter Hohmann, the German scientist who published it in 1925.

Half an elliptic orbit touches both the orbit you wish to leave (1) and the orbit you wish to reach (3). The transfer (2) is initiated by firing the spacecraft's engine to accelerate it to follow the elliptical orbit.



Consider a flight from Earth to Mars. At the beginning, the spacecraft will already have velocity associated with its Earth orbit  $\approx$  this velocity will not need to be found when the spacecraft enters the transfer orbit (around the Sun). At the other end, the spacecraft will have to decelerate and allow Mars' gravity to capture it.

## The Gravity Assist Mechanical Simulator





## The Gravity Assist Mechanical Simulator

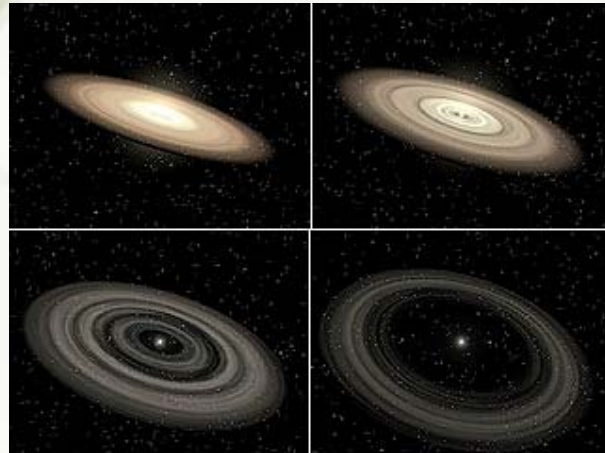
View movie at <http://people.artcenter.edu/doody/gams>



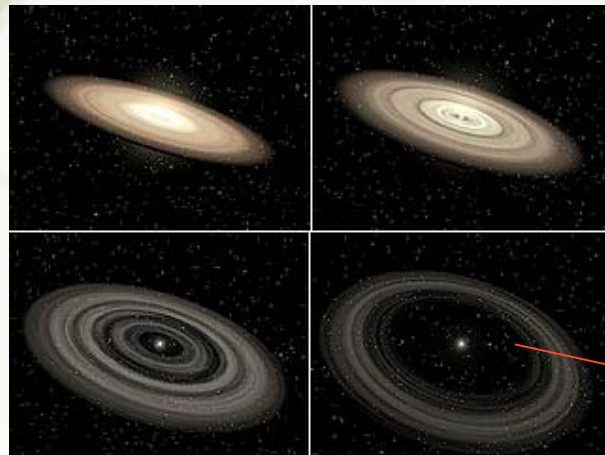
Jane Houston Jones demonstrates a gravity assist to Saturn by stealing momentum from Jupiter. Thanks, Jane!



**Oh, and one more result...**



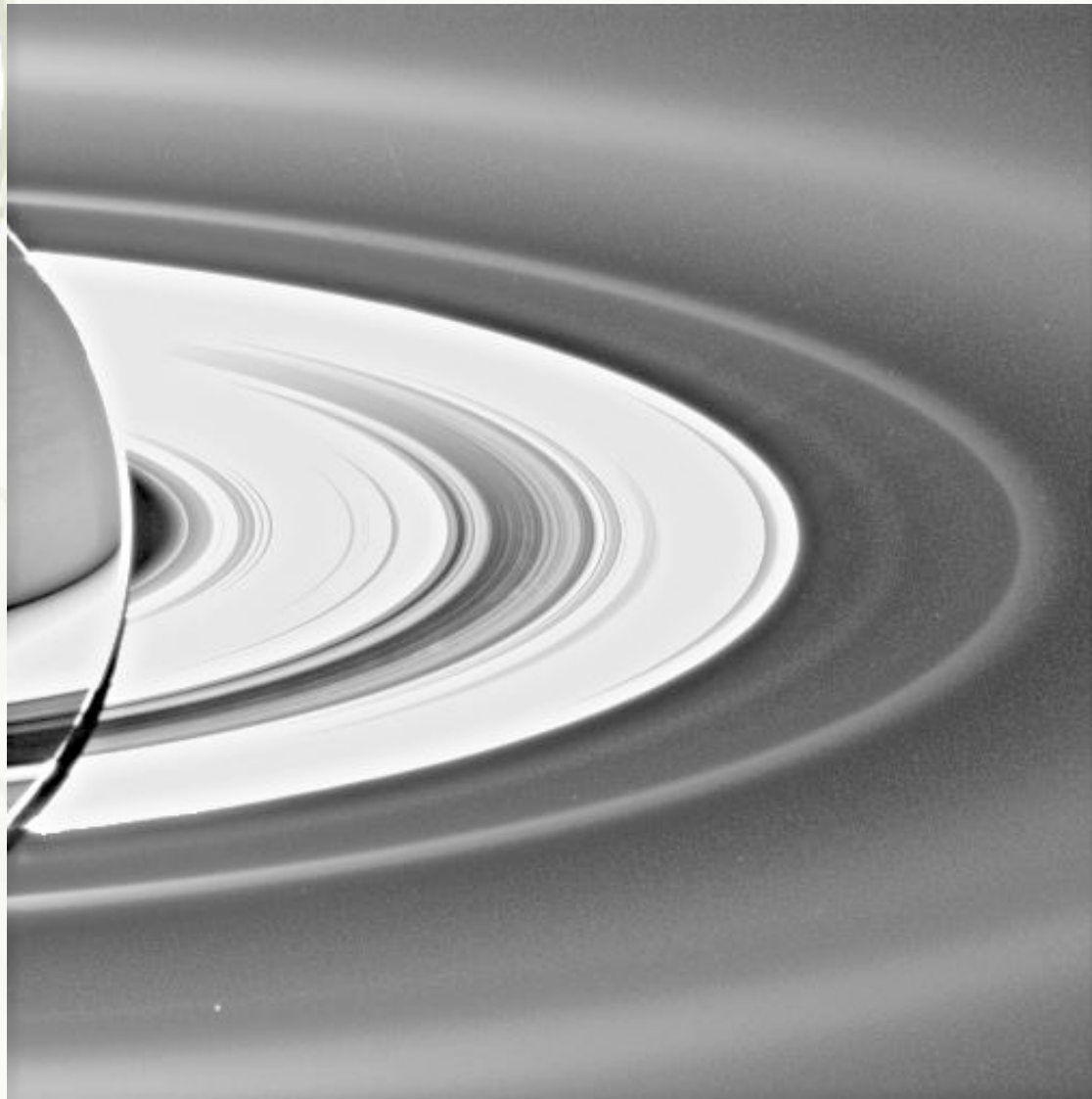
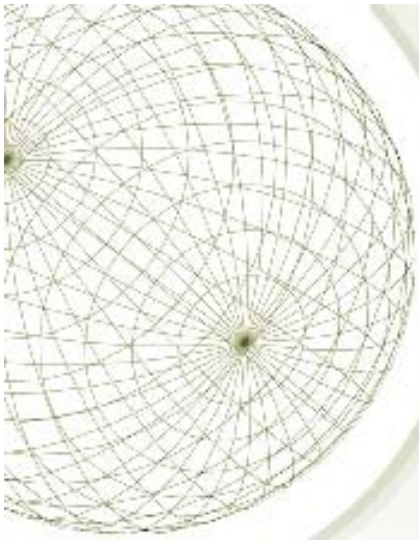
Oh, and one more result...



**Planets!**

*And stuff*





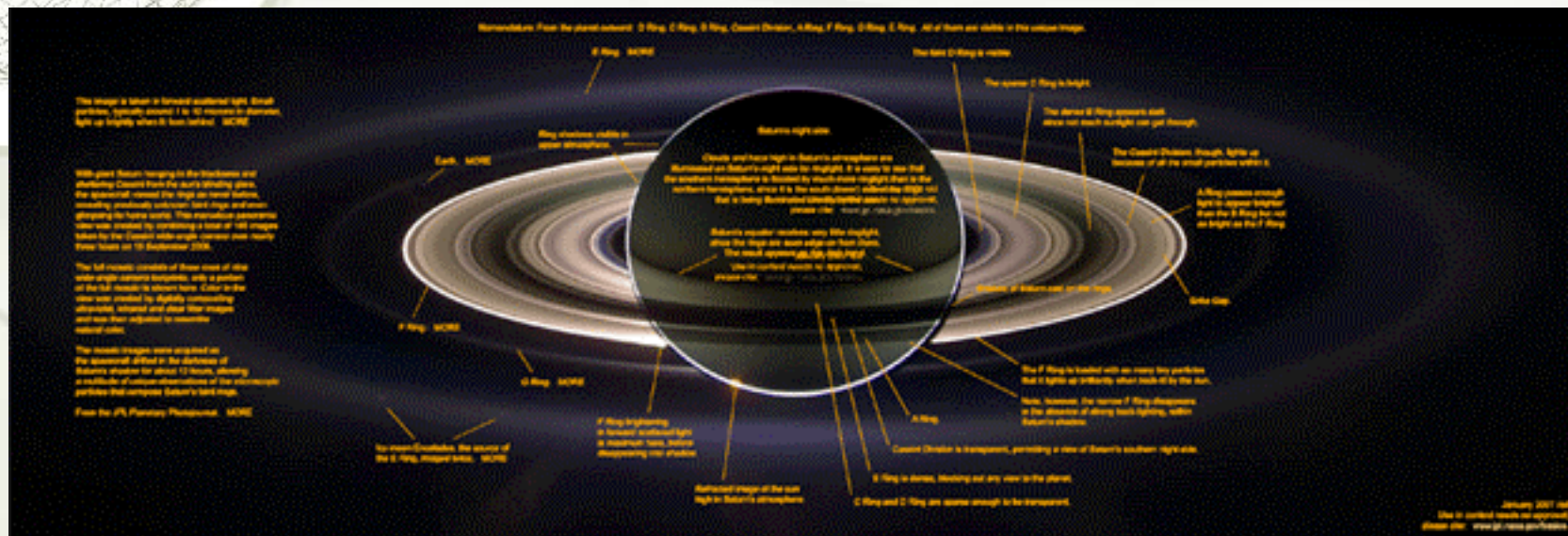
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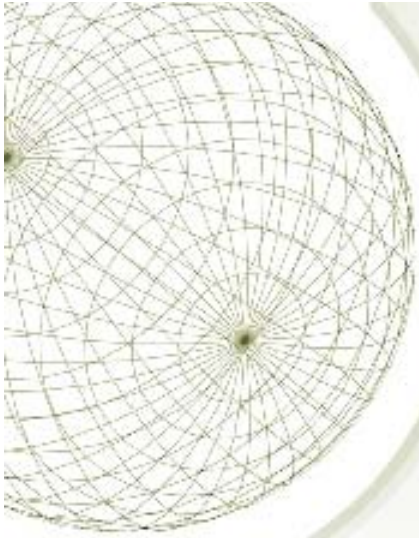
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<http://www.jpl.nasa.gov/basics/saturn>

Annotated natural color image as Cassini observed Saturn from within its shadow, 15 September 2006



A large image of Saturn in "normal" backscattered light is also annotated on the web page.



<http://www.jpl.nasa.gov/basics/saturn>

**Backscatter**

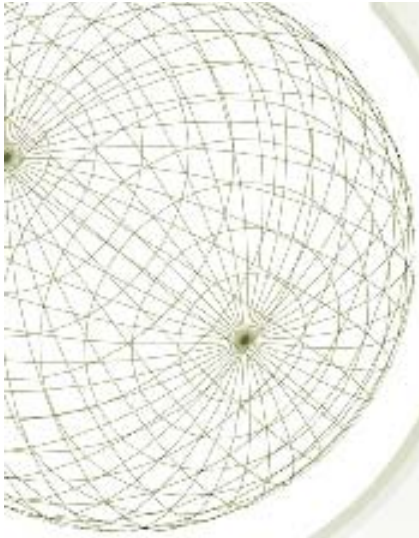


**ABOVE:** An observer standing on the same side as the laser, looking at the light beam

**Forward Scatter**



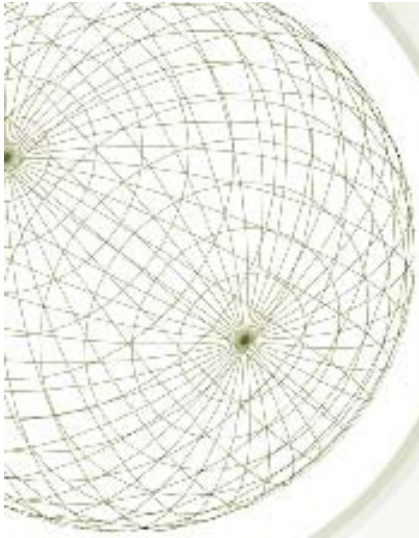
**ABOVE:** Standing on the other side of the jar, looking back toward the laser (visible in the



# Science Instruments

**Cassini's Narrow Angle Camera (for closeups)**

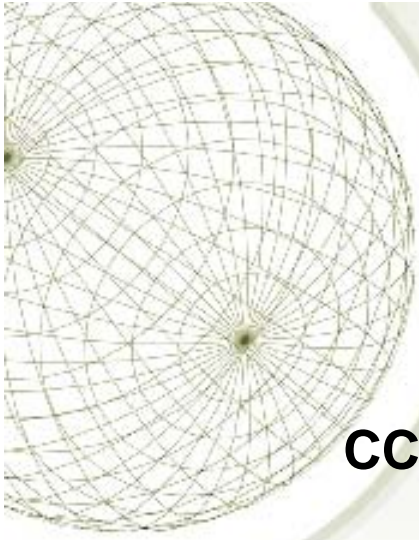
19  
- cm aperture telescope  
(7 <sup>3</sup>/<sub>4</sub> - inch)  
f/10.5 Cassegrain  
1 - megapixel CCD (.35° FOV)



# Science Instruments

## Cassini's **Wide Angle** Camera

5.7 - cm aperture telescope  
(2 1/4 - inch)  
f/3.5 refractor  
1 - megapixel CCD (3.5° FOV)



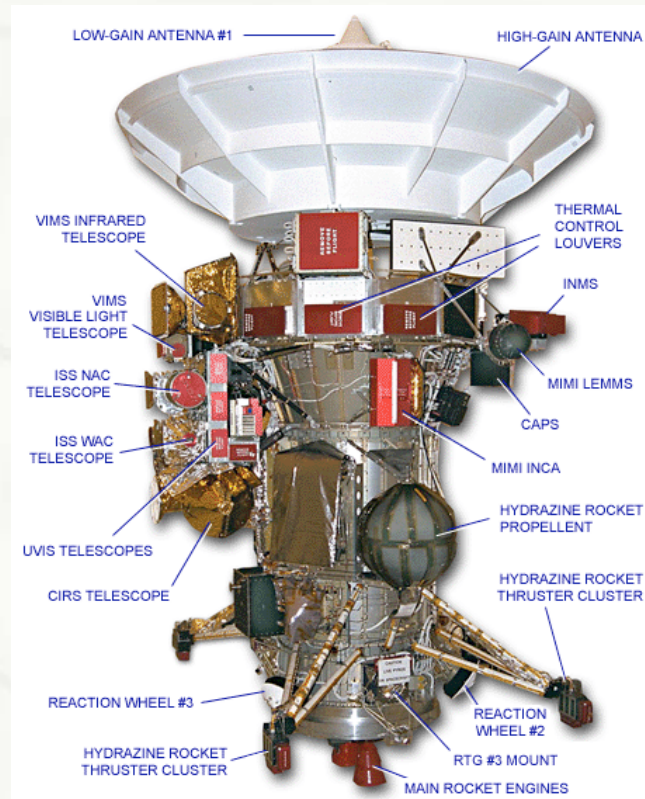
# Science Instruments

**CCDs: Charge Coupled Device imaging sensors**



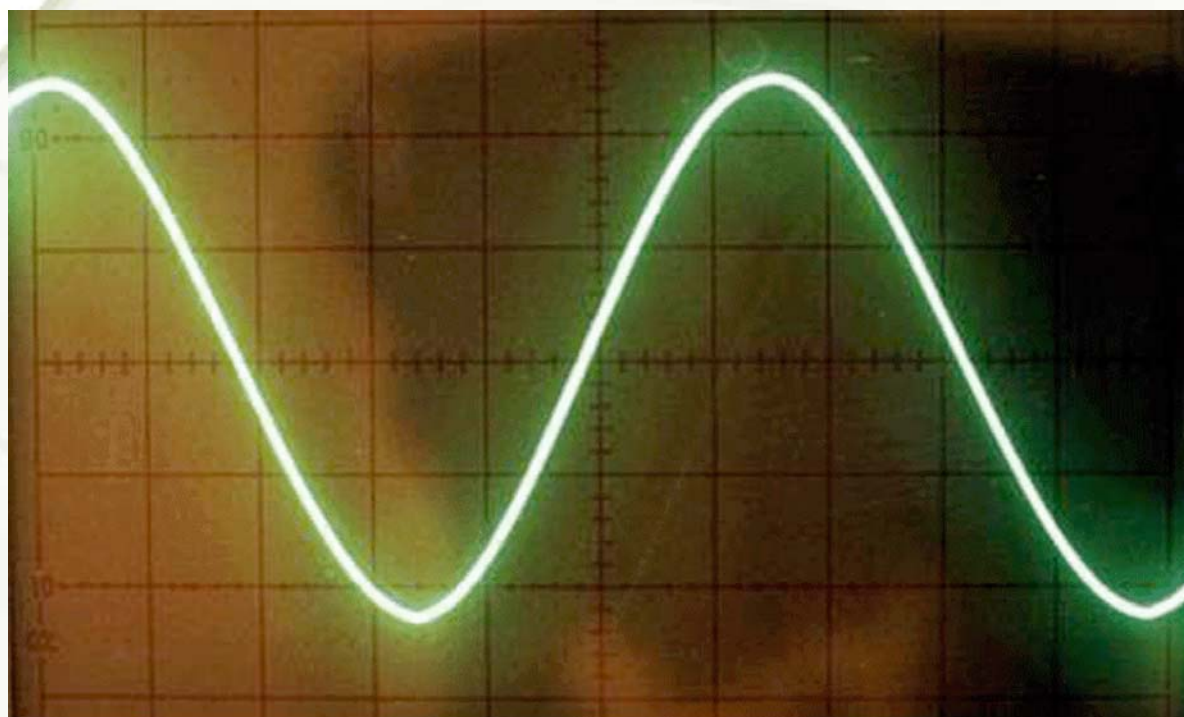
# Science Instruments

And other components of the Cassini Spacecraft

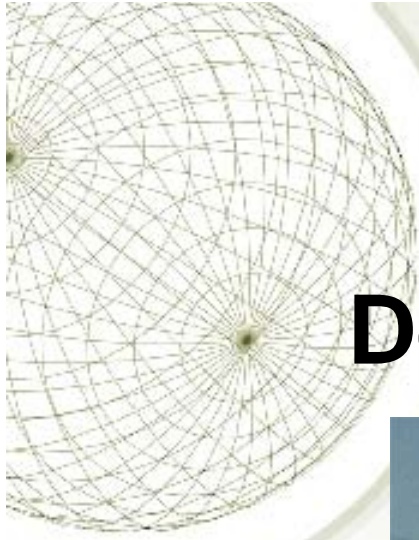


<http://www.jpl.nasa.gov/basics/cassini>

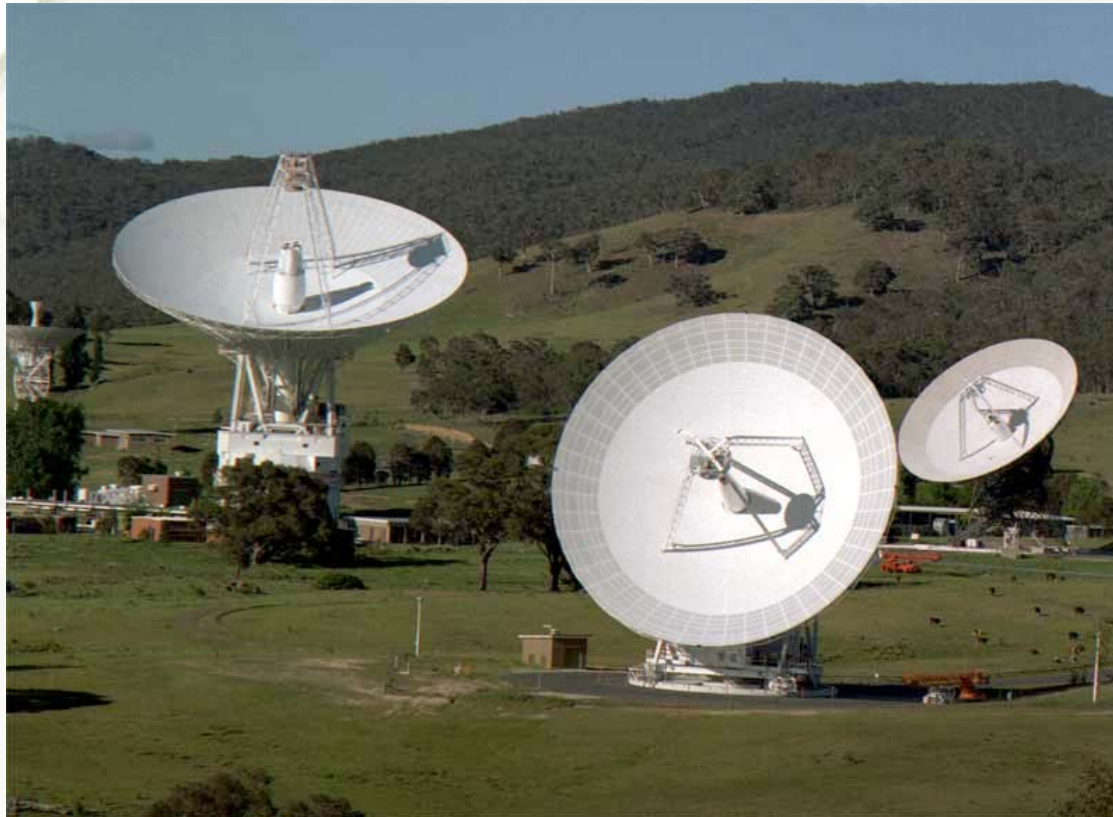
# Sending image data back to Earth







# Deep Space Network - DSN



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A wireframe sphere is visible in the top-left corner of the slide, partially overlapping the main text area.

# Download & build your own DSN Station!



<http://www.jpl.nasa.gov/scalemodels>

A wireframe sphere is located in the top-left corner of the slide. It is composed of a grid of thin lines forming a spherical shape, with a central point from which the lines radiate outwards.

# Thanks

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**for participating!**

[dave.doody@jpl.nasa.gov](mailto:dave.doody@jpl.nasa.gov)