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# OPAG Science Goals: Rings

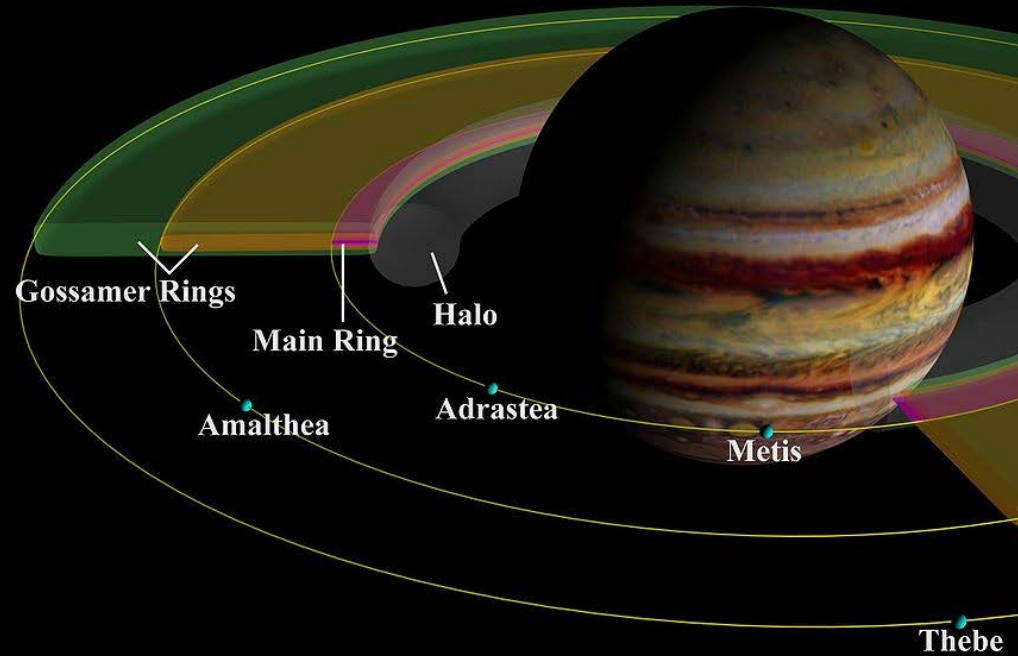
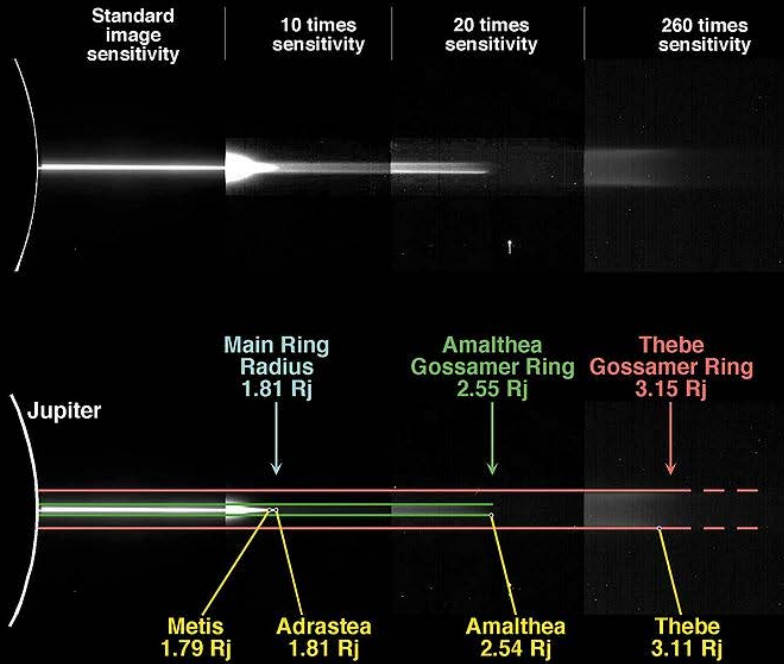
Linda Spilker

Cassini Project Scientist

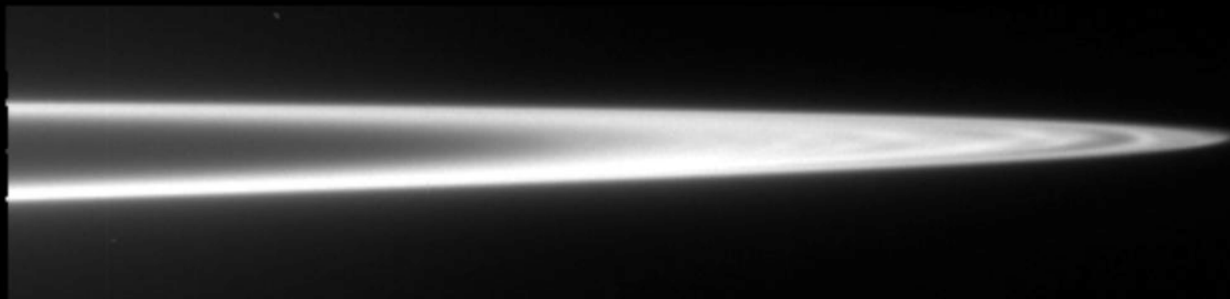
*Outer Planets Assessment Group*

24 July 2014

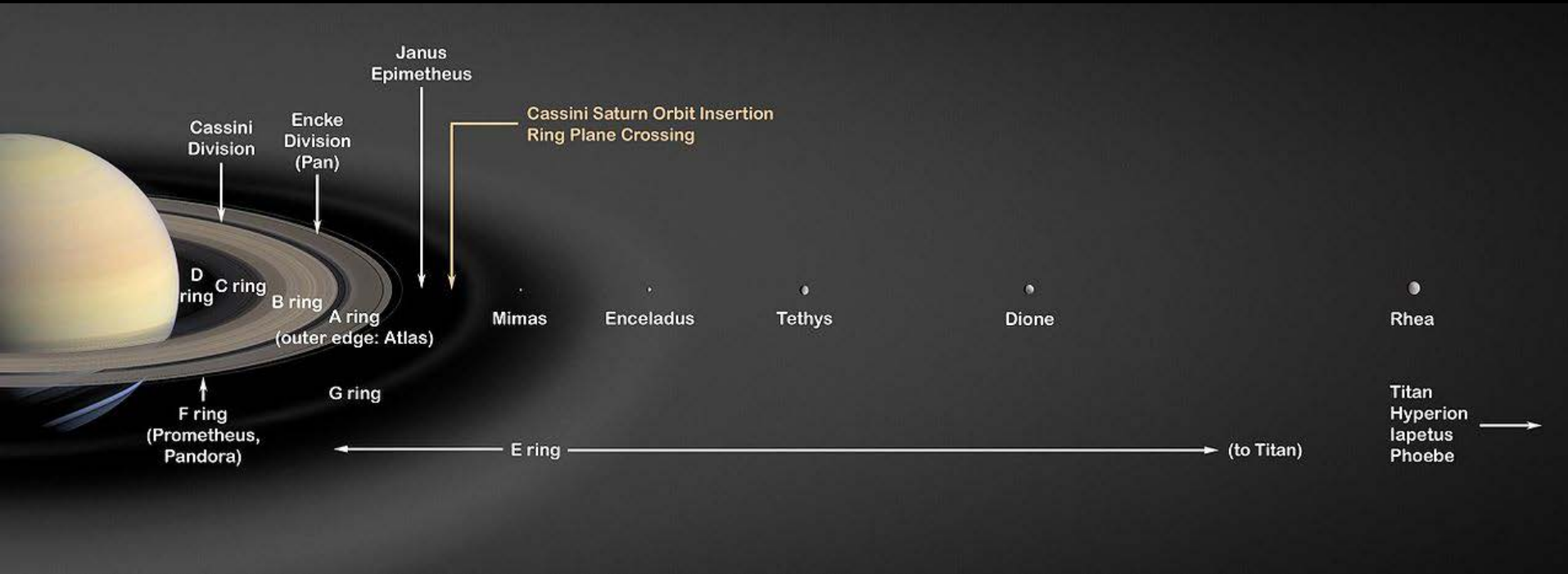
# Rings of Jupiter



● = Earth for scale

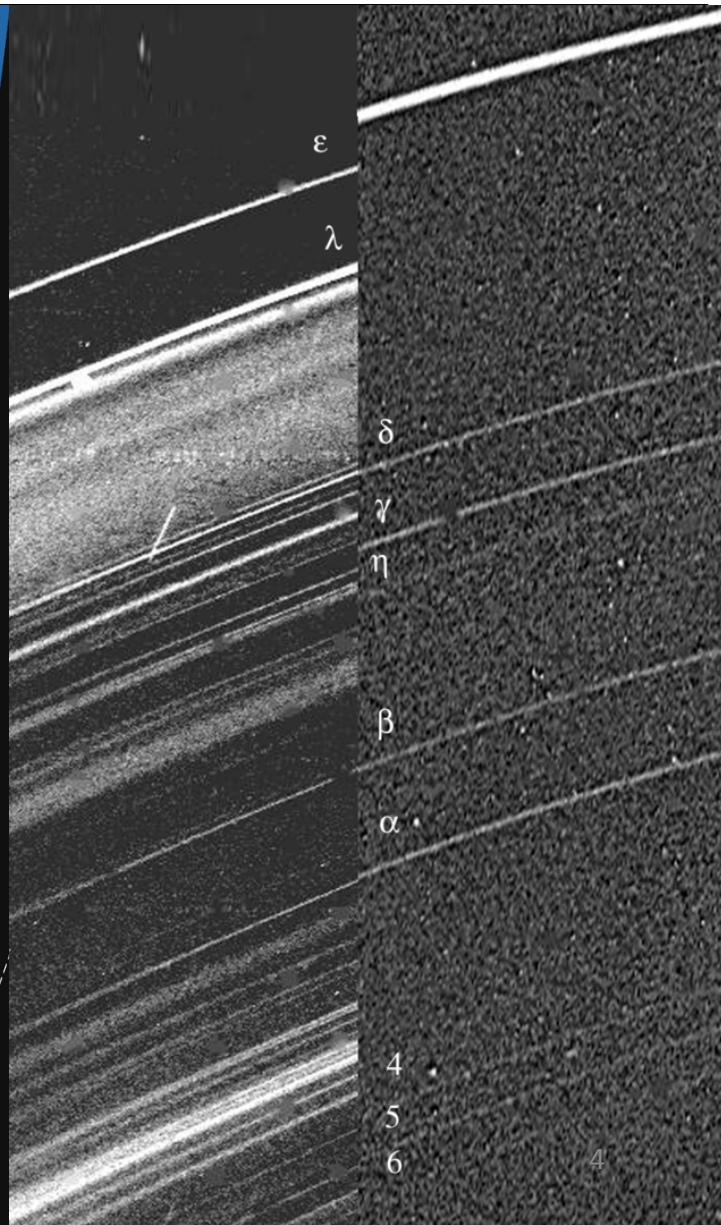
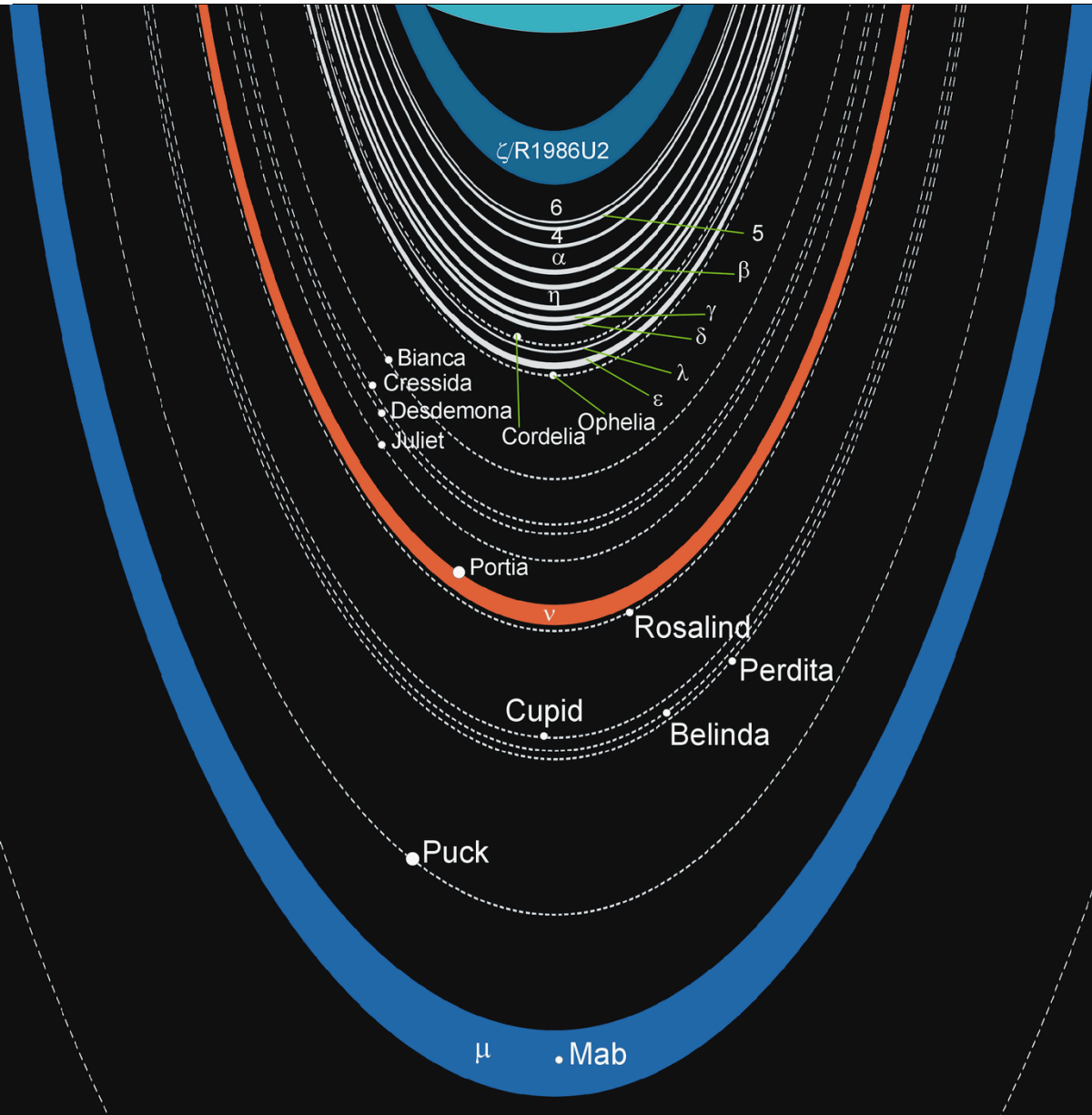


# Rings of Saturn

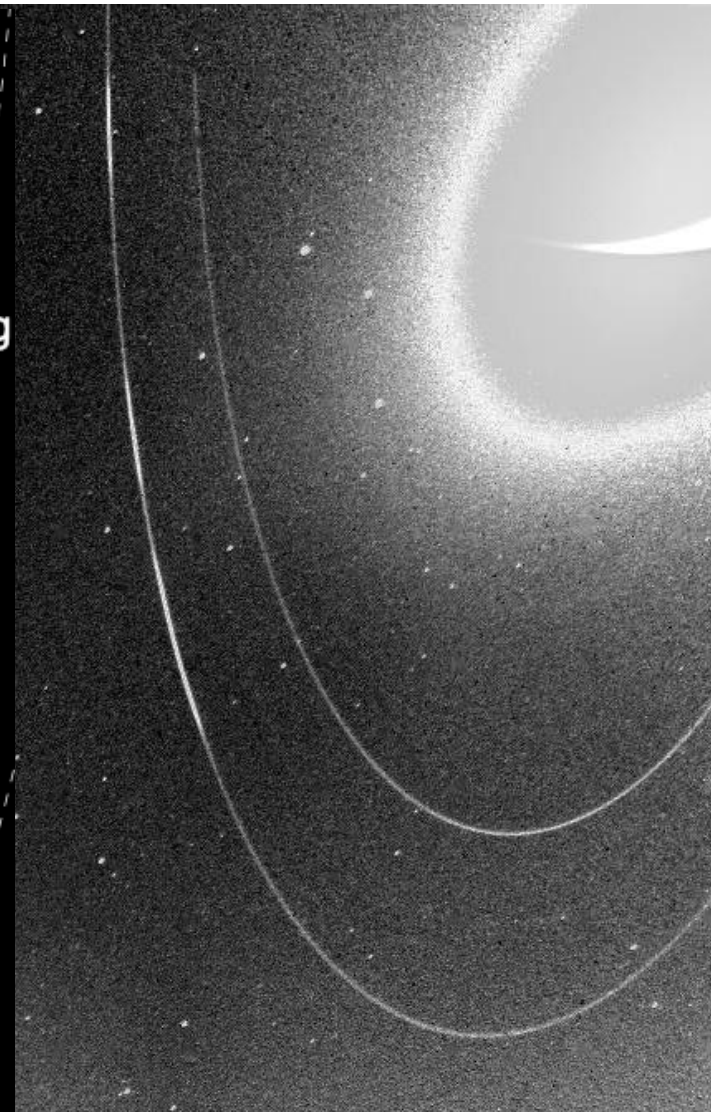
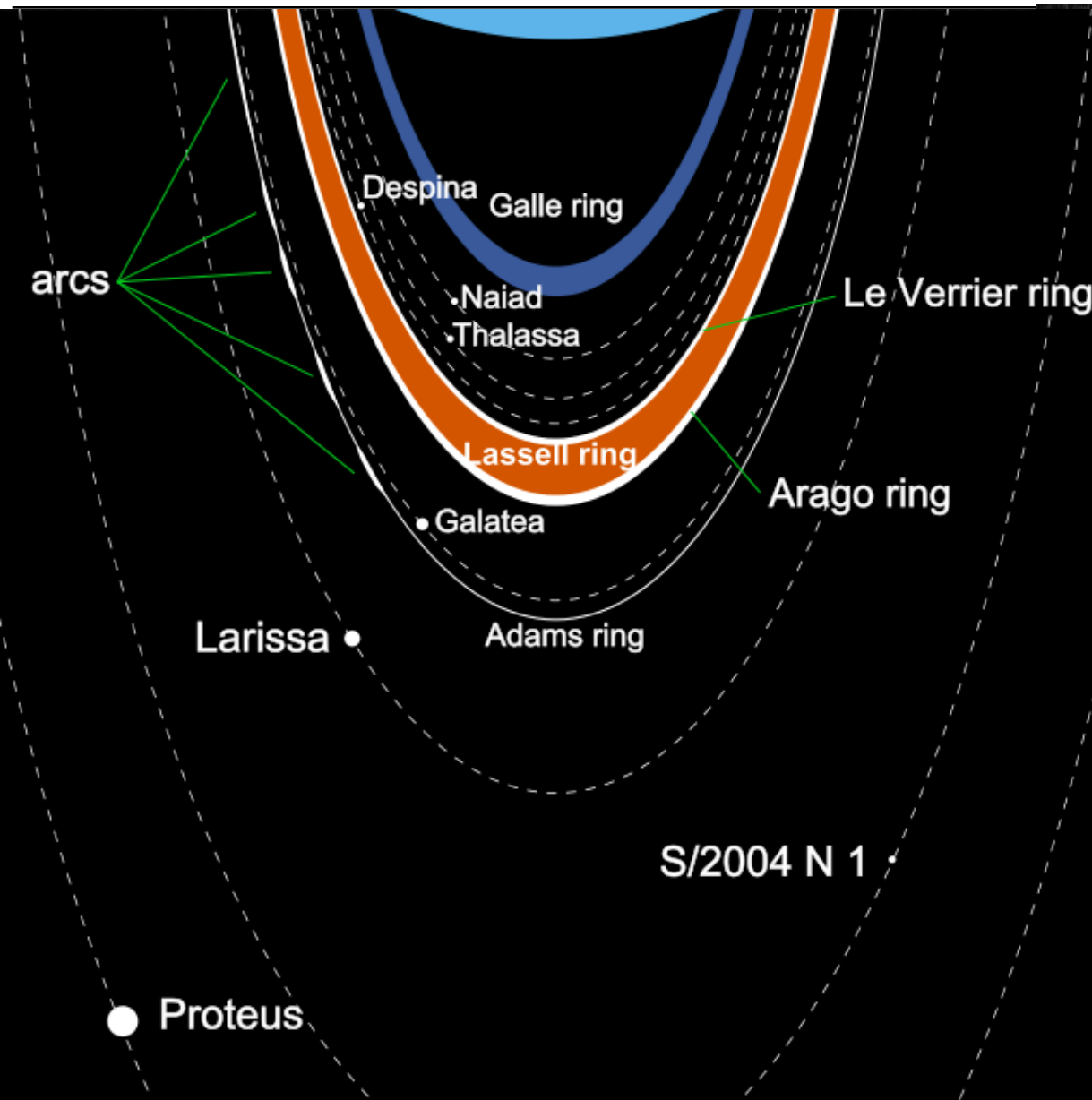




# Rings of Uranus



# Rings of Neptune



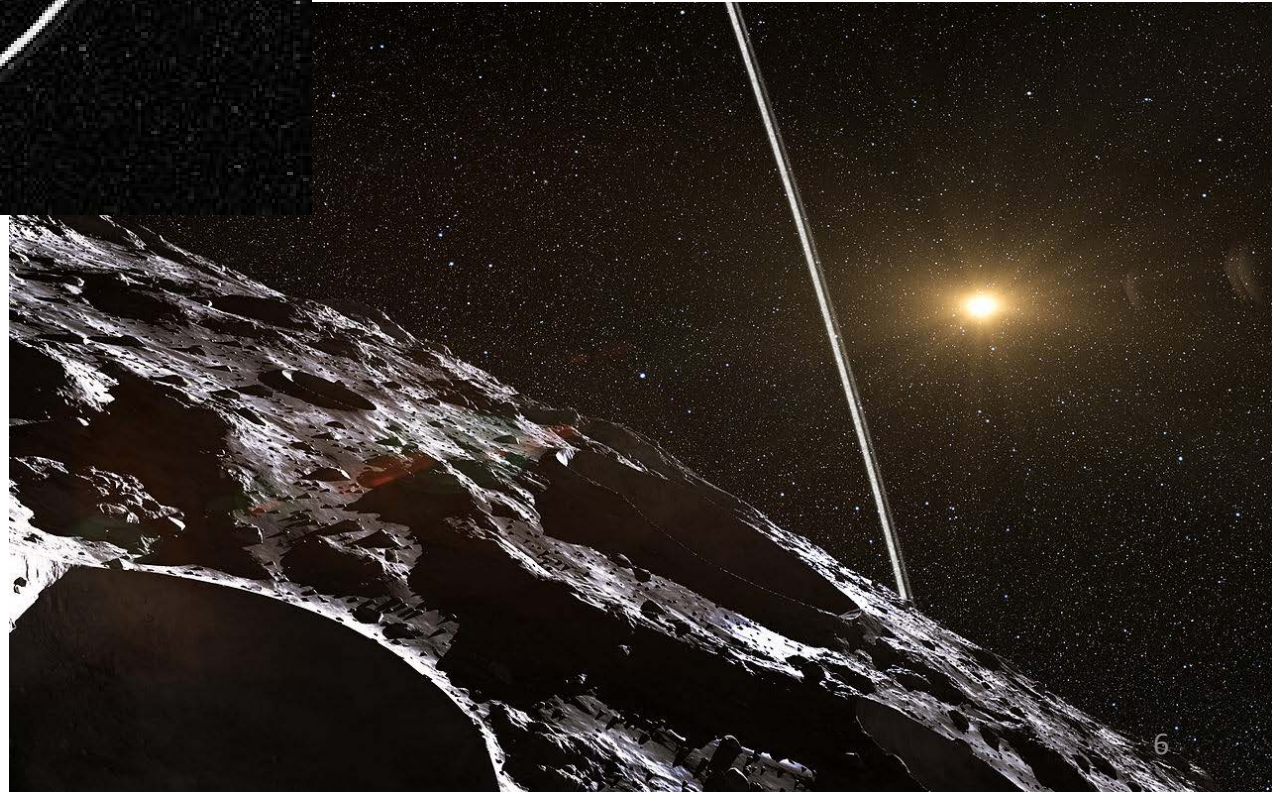


# 10199 Chariklo: 2 Rings



- 2013 stellar occultation revealed 2 rings,  $\sim 7$  km and  $\sim 2$  km wide and about 9 km apart
- Water ice detected in rings

- Smallest known object ( $\sim 250$  km) to have rings
- Unexpected, rings thought to be stable only around more massive bodies





# Decadal V&V questions relevant to Ring systems

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- **A. Building new worlds:**
- *Q1. What were the initial stages, conditions and processes of solar system formation and the nature of the interstellar matter that was incorporated?*
- *Q2. How did the giant planets and their satellite systems accrete, and is there evidence that they migrated to new orbital positions?*
  
- **C. Workings of solar systems:**
- *Q7. How do the giant planets serve as laboratories to understand Earth, the solar system, and extrasolar planetary systems?*
- *Q10. How have the myriad chemical and physical processes that shaped the solar system operated, interacted, and evolved over time?*
  
- *Another source: Ring White Paper*



# 1. What is currently causing ring structures to change or evolve?

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- Jupiter's rings: changes observed in diffuse rings
- Saturn's rings
  - Significant changes in D and F rings over decadal and shorter timescales
- Neptune's and possibly Uranus' rings
  - Similarly fast changes
  - Neptune ring arcs evolving, one might be disappearing
- Monitor rings to better understand changes
- Detect and monitor orbital migration for both embedded "propeller" moons or moons interacting with rings
  - Reflects processes in protoplanetary disks
- Past and present condition of ring disks help us understand how ring and satellite systems evolve
- Q1, Q2, Q7, Q10





## 2. What is the composition of ring systems, and how does that composition vary with time and space?

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- Saturn's rings
  - Composition and thermal properties of particles and their regolith characteristics vary over different ring regions
  - Meteoroid pollution rates for rings important for understanding ring origin
- Jupiter's, Neptune's and Uranus' rings
  - Chemical and physical properties are almost completely unknown
  - Characterize them for comparative study
- Chariklo rings: water-ice detected, anything else?
- Determine composition and particle physical characteristics
  - Will lead to better understanding of solar system in the past
- Q1, Q2, Q7, Q10



### 3. How old are the known ring systems, and how did they originate?

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- Jupiter's rings: Diffuse, gossamer rings
- Saturn's rings: Massive, dense ring disk
- Uranus' rings: Narrow, dense rings surrounded by broad sheets of tenuous dust
- Neptune's rings: Ring arcs in one ring, diffuse rings
- Chariklo rings: Largest Centaur has two rings
  - What other bodies might have rings and how might they originate?
- Differing origins, histories and current states of these systems
- Bring knowledge of other ring systems up to same level as knowledge of Saturn system
- Past and present condition of ring disks help us understand how rings originate and evolve
- Q1, Q7, Q10

## 4. What can rings tell us about their planetary surroundings?

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- Ring systems function as useful detectors of their surrounding environment
- Population of meteoroids in outer solar system illuminated by ring phenomena
- Present condition of ring disks help us understand how rings interact with planetary surroundings
- Q1, Q2, Q7, Q10



## 5. What can rings tell us about exoplanets or about protoplanetary disks?

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- Planetary rings: accessible natural laboratories for disk processes
- Inter-particle and disk-mass interactions key
  - Windows into the origins and operations of exoplanet systems and of our own solar system in its early stages
- Rings could be observed around transiting exoplanets possibly yielding constraints on planet's spin and interior structure
- Q1, Q2, Q7, Q10



# Summary of Ring Questions

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1. What is currently causing ring structures to change or evolve?
2. What is the composition of ring systems, and how does that composition vary with time and space?
3. How old are the known ring systems, and how did they originate?
4. What can rings tell us about their planetary surroundings?
5. What can rings tell us about exoplanets or about protoplanetary disks?