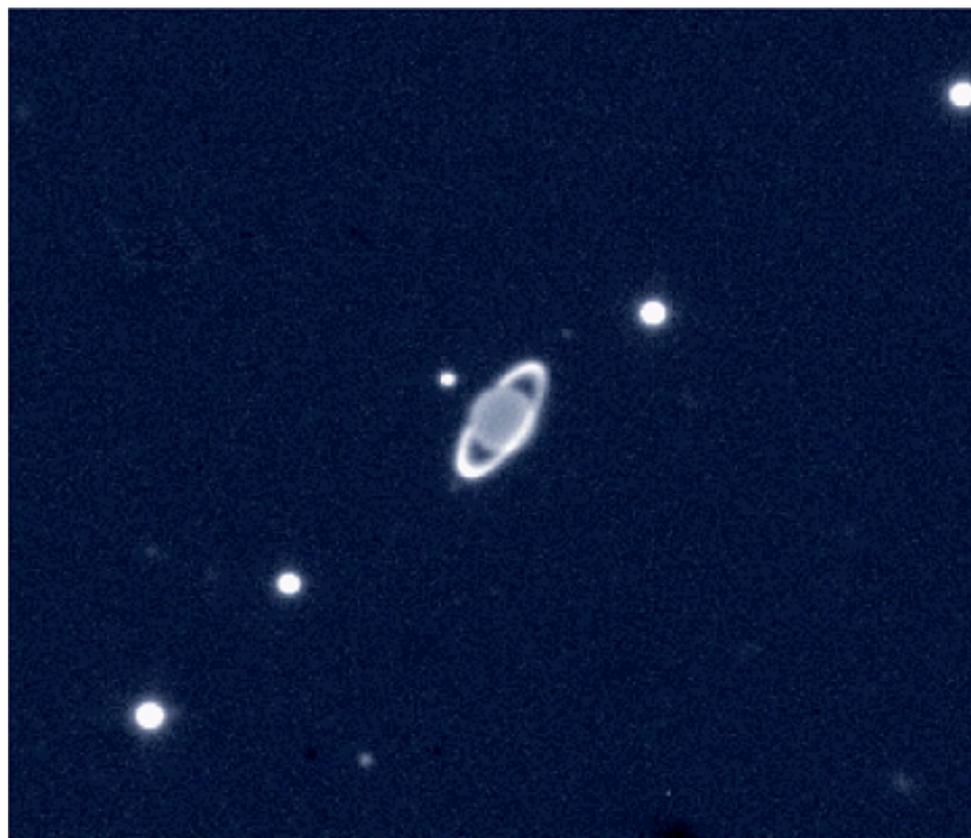


Report from the Uranus Working Group

Mark Hofstadter, JPL



Near-IR image from VLT ANTU, © ESO

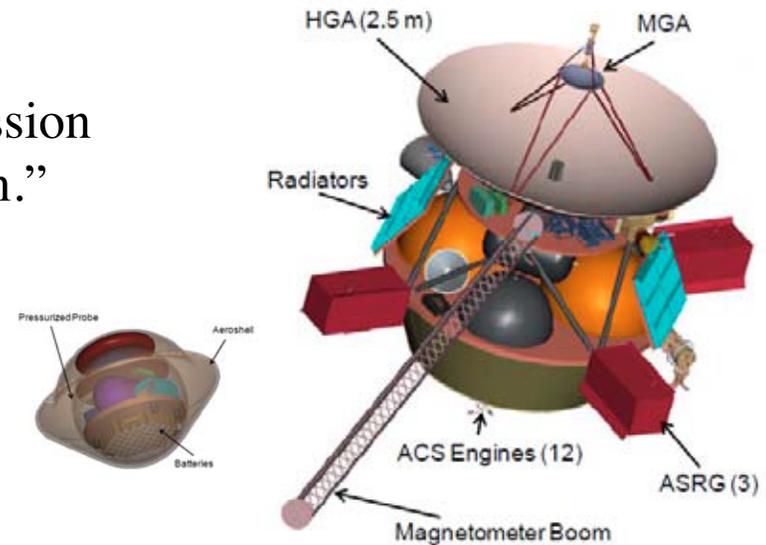
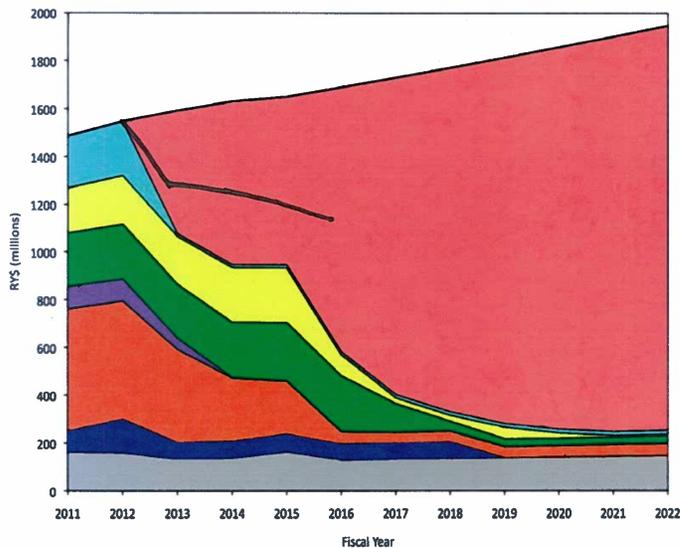
OPAG
10 January 2013
Atlanta, GA



© Karen Carr

Prospects for a Uranus Mission

It was the best of times,
“The third highest priority Flagship mission
is the Uranus Orbiter and Probe mission.”
Planetary Science Decadal Survey



It was the worst of times....

Meeting Summary (1/2)

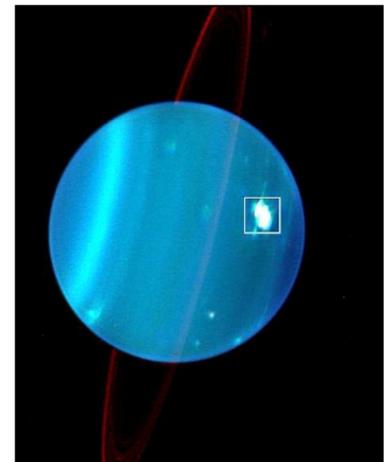
Thirty people (6 via WebEx) participated in the UWG meeting.

The main topic was how to best utilize Uranus mission opportunities to achieve Decadal Survey–recommended science.

- Long–term, a Flagship remains necessary.
- Short–term, the Discovery program can achieve some outstanding science, and specific missions were discussed.
- Medium–term, New Frontiers is an attractive option if a Flagship remains far over the horizon.

We also discussed Medium– and Large–Class ESA missions which groups in the UK and France are proposing.

- We are pleased that efforts to collaborate are being made from both sides of the Atlantic.
- We would like to start laying the groundwork for what might become (far, far in the future) a joint Flagship mission.



(Sromovsky et al. 2007, *Icarus*, 192)

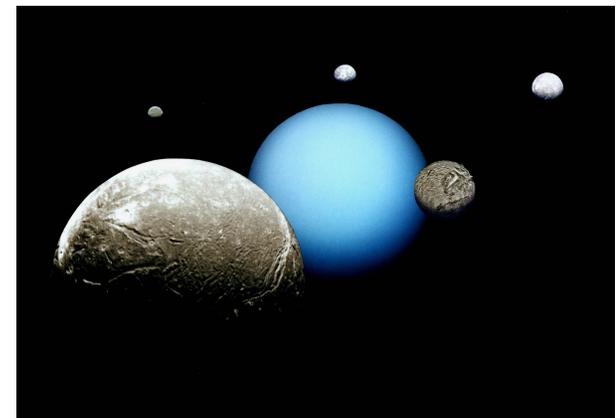
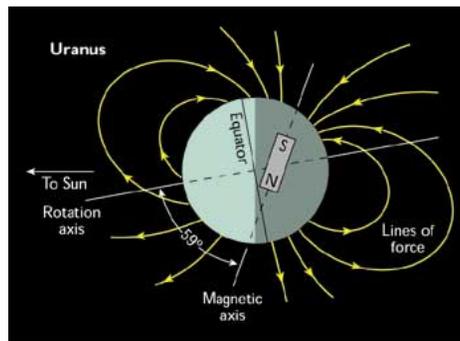
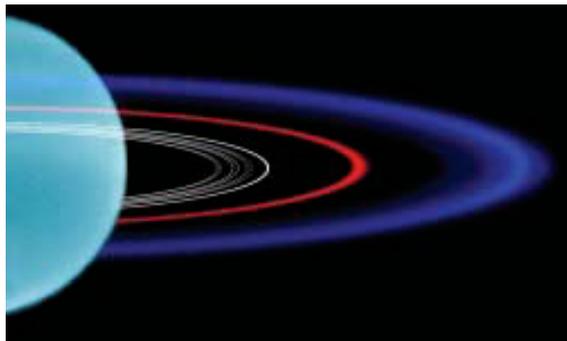
Meeting Summary (2/2)

We noted the strong support in the Exoplanet and Heliophysics communities for Ice-Giant missions. Can this lead to a cross-Divisional NASA mission?

We touched briefly on the topic of technology development (e.g. probes).

Three science talks were presented:

- Comparative Planetology between the Uranian and Saturnian Satellite System - Focus on Ariel (Julie Castillo-Rogez and Elizabeth Turtle).
- Earth-based Characterization of Uranus' Aurorae (Laurant Lamy and HST team #12601, presented by Baptiste Cecconi).
- Photoelectric Photometry of Uranus and Neptune: 1950-2012 (Richard Schmude, Jr.).



Recommended OPAG “Findings”

OPAG is concerned that no action was taken on its findings last year regarding a Uranus mission study, and again urges that NASA initiate such a study responsive to Decadal Survey science goals for the ice giants.

OPAG recommends that the Discovery program adopt policies allowing outer planet missions to compete in that category. Policies might include providing Atlas-5 class launch vehicles, Radioisotope Power Systems, and NEPA approval as Government Furnished Equipment, or not counting the cost of lengthy cruise phases against the budget cap.

Discussion Topics for the Full OPAG

Wearing our “Uranus hats”, the Uranus Working Group would like to have the list of possible New Frontiers missions revisited. Wearing our larger “Outer Planet hats”, there was no clear consensus on how or even if this should be done. Open the NF program to all proposals? Limit the expansion to NF or Flagship missions recommended by the Decadal Survey? Convene a review panel to assess this? Or is the current list favorable to outer planet science?

We discussed how outer planet science and mission ideas could benefit from Earth-based observations, but that the required large-aperture telescopes are often not responsive to planetary proposals. Would it be appropriate for OPAG to state its support of observing proposals that address Decadal Survey-recommended outer planet science?

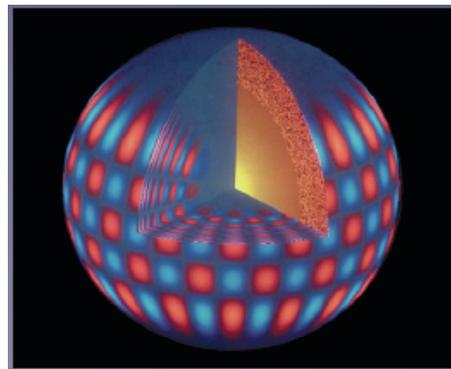
Backup Slides

Discovery Example: Doppler Imager Flyby

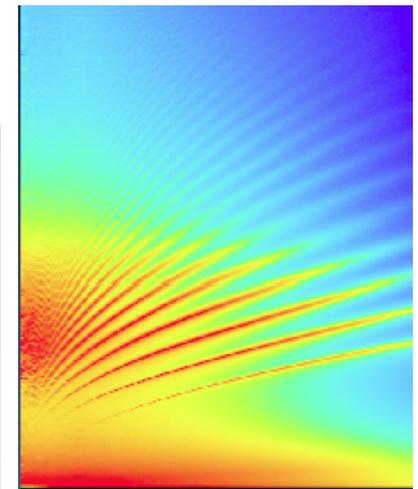
Determines the internal structure of Jupiter and Uranus. Also provides new information on the dynamics of both atmospheres.

Primary instrument is a visible-wavelength, Doppler Imager such as has been proposed for the JUICE mission.

- Measures the velocity of the cloud-tops reflecting sunlight.
- Can use spatial and temporal frequency information to identify trapped normal-mode oscillations of the interior, which are diagnostic of structure. Builds upon the mature fields of helio- and stellar-seismology.
- Also obtains detailed maps of the instantaneous velocity of the scatterers in the atmosphere, as well as allowing traditional feature tracking.
- Flyby mission. Collects data for ~4 months around closest approach to each planet.
- 8-year flight time to Uranus.
- Limited resources for other instrument(s).



Courtesy P. Gaulme



Courtesy F.-X. Schmider

The Ice Giants

Uranus and Neptune represent a distinct class of planet, commonly referred to as “Ice Giants.”

Definitions

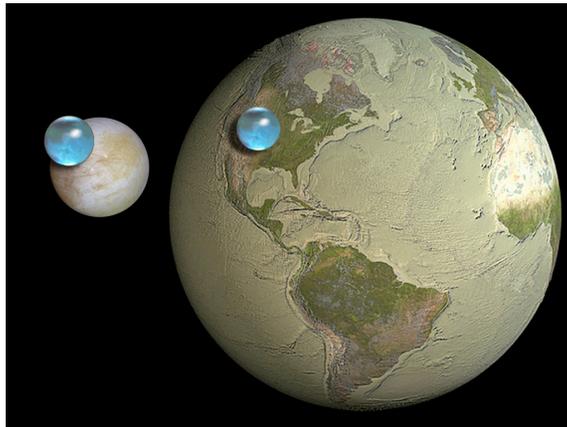
- Gas: H₂ and He.
- Ice: Things which could be solid or gas in the solar nebula, such as H₂O, CH₄, NH₃. (We do not believe these species are present as solid ice in Uranus and Neptune today.)
- Rock: Things that were solid almost everywhere in the solar nebula.

Approximate Composition as a Percentage of Mass

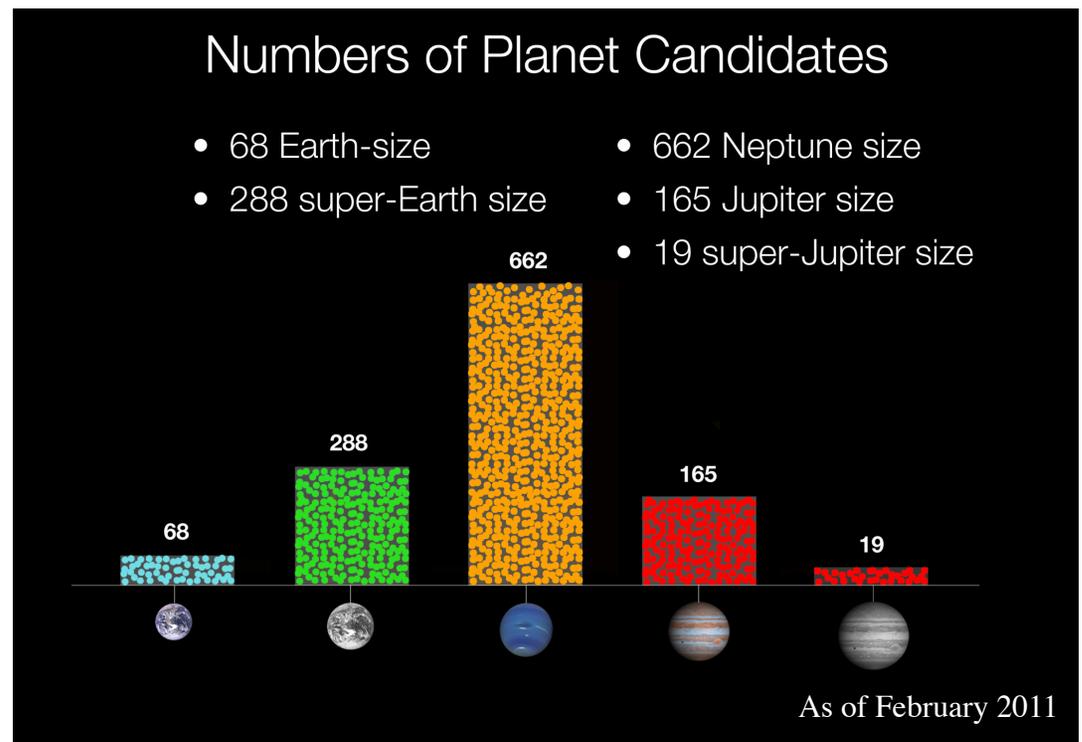
Planet	Gas	Ice	Rock	Total Mass (M _{Earth})
Earth	0%	0%	100%	1
Jupiter/Saturn	95%	4%	1%	~200
Uranus/Neptune	10%	65%	25%	~15

Why are Ice Giants Important?

- I) The Ice Giants are a distinct and important type of planet about which very little is known.
- II) Ice Giants may be the most abundant type of planet in our galaxy.
- III) The Ice Giants are a laboratory for understanding fundamental processes (e.g. atmospheric energy balance; magnetosphere-atmosphere interactions; icy moon geology).

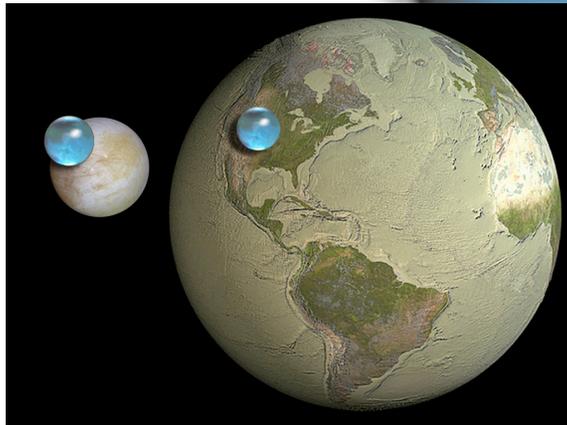


© Woods Whole Oceanographic Institute & Kevin Hand



Why are Ice Giants Important?

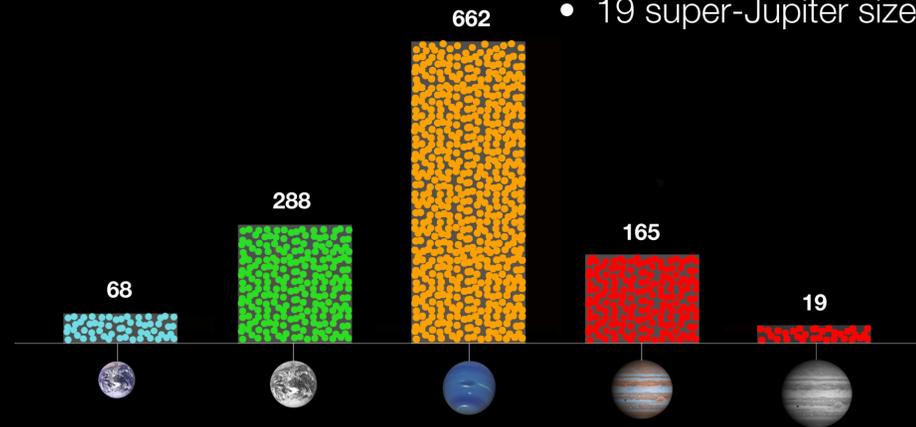
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- II) Ice Giants may be the most abundant type of planet in our galaxy.
- III) The Ice Giants are a laboratory for understanding fundamental processes (e.g. atmospheric energy balance; magnetosphere-atmosphere interactions; icy moon geology).
- IV) Follow the water!



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Numbers of Planet Candidates

- 68 Earth-size
- 288 super-Earth size
- 662 Neptune size
- 165 Jupiter size
- 19 super-Jupiter size



As of February 2011

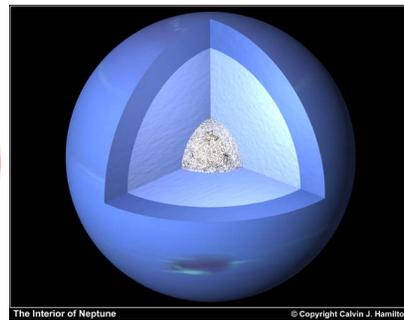
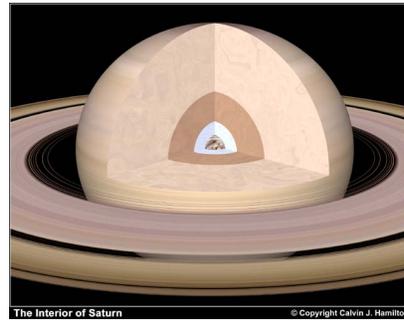
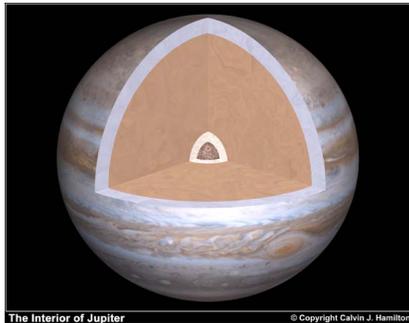
Why Uranus instead of Neptune?

- I) Uranus is the most challenging to our understanding of planetary interiors, energy balance, formation, and evolution.
- II) Uranus is the most accessible ice giant, enabling less-expensive missions.
- III) The uranian system contains our Solar System's only samples of Ice Giant native satellites.

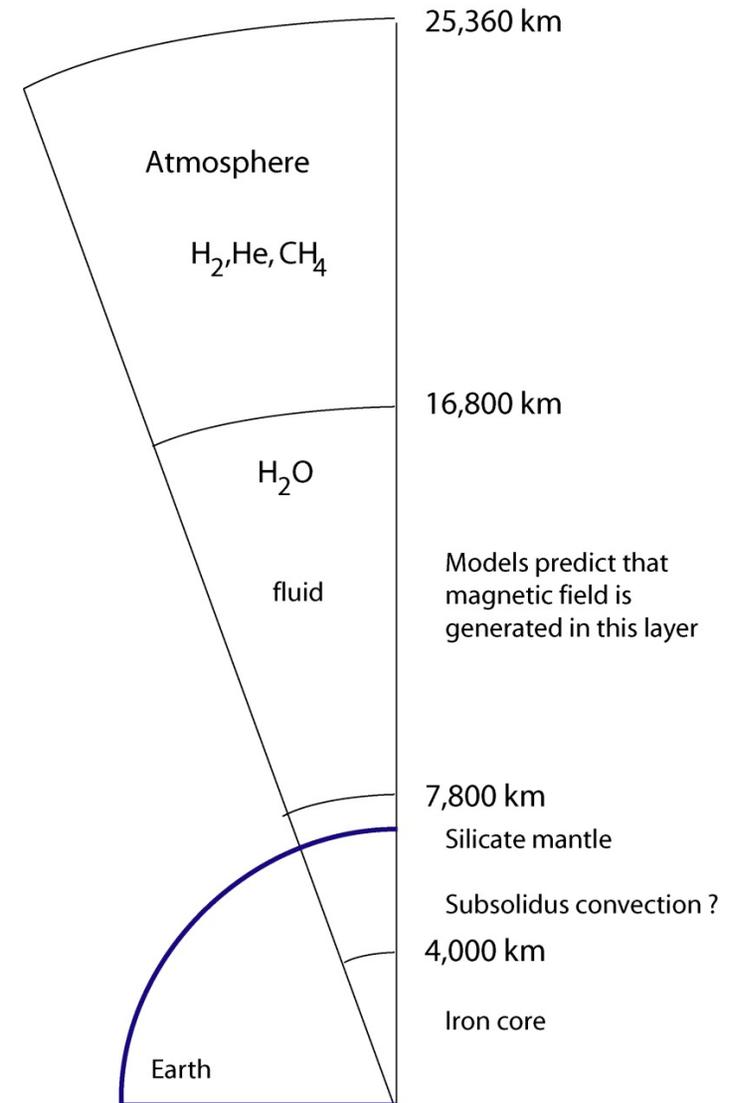


Why is the Uranus Interior of Interest?

Uranus is the only giant planet whose gravity field cannot be explained with a simple three component model (rock core, ice layer, gas layer). Is this related to its anomalous, low release of internal heat?



Images © C.J. Hamilton



Courtesy C. Sotin.