Prospects for a Uranus Mission

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OPAG Uranus Working Group
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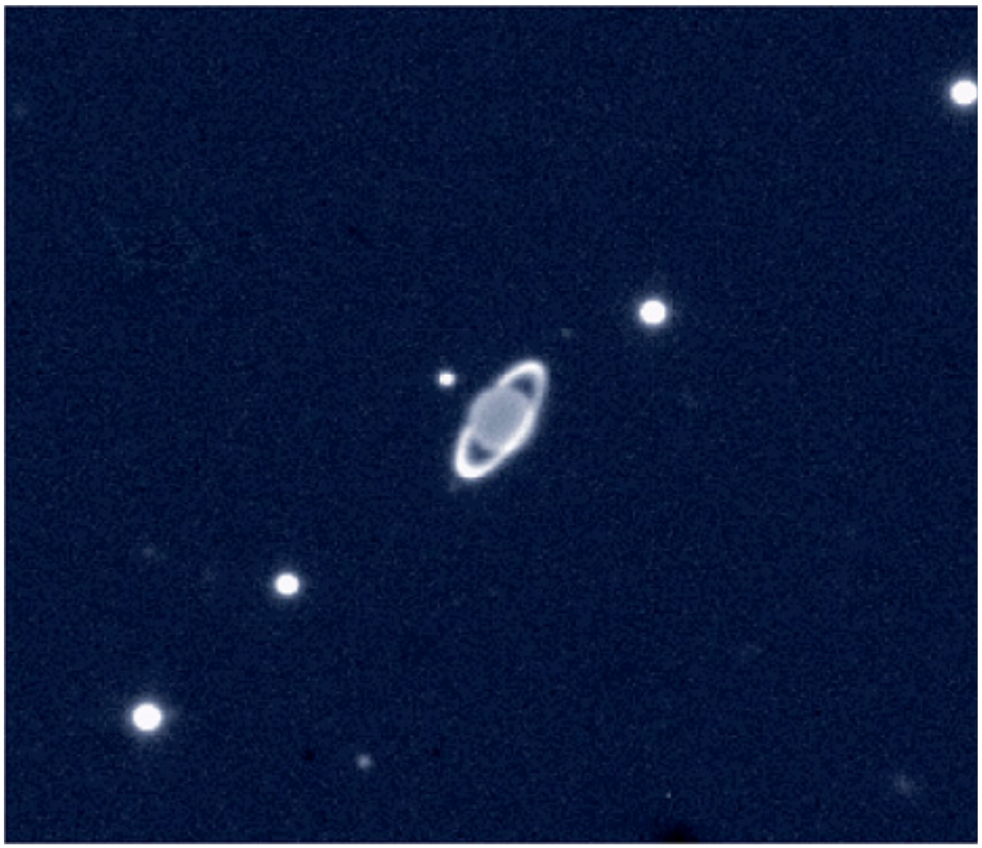
Atlanta, GA



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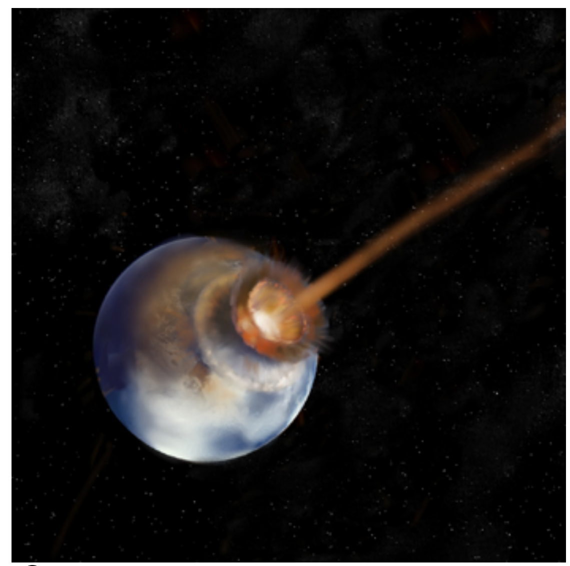

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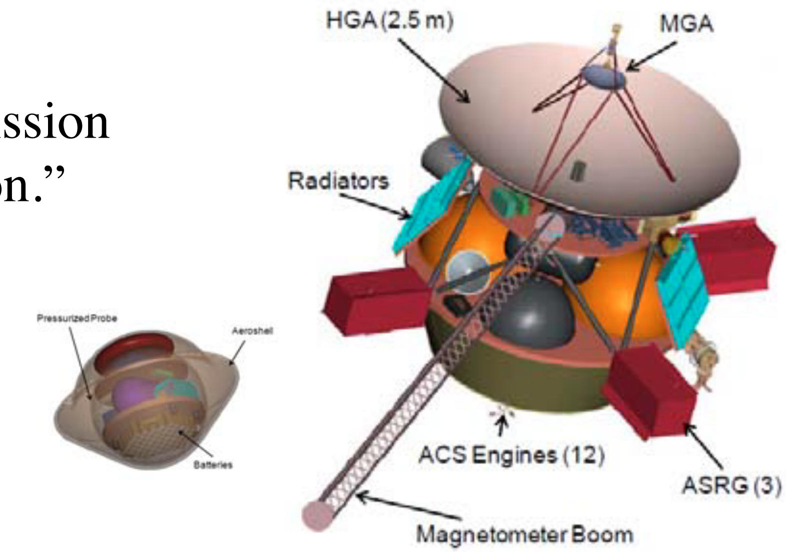
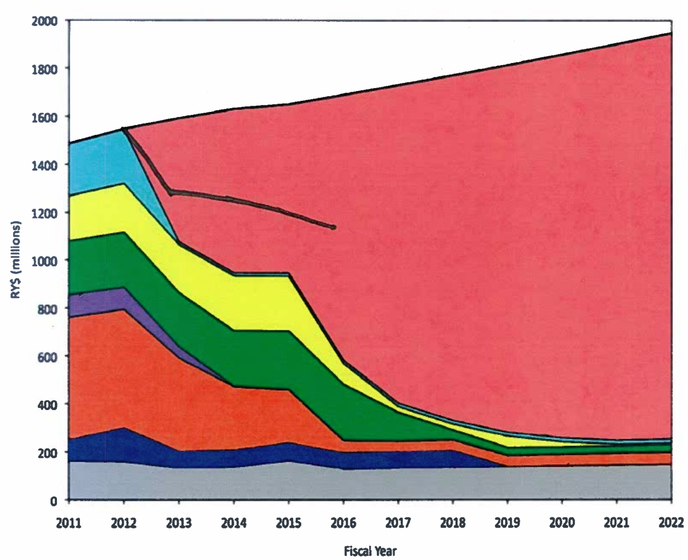
Prospects for a Uranus Mission

It was the best of times,

"The third highest priority Flagship mission is the Uranus Orbiter and Probe mission."
Planetary Scence Decadal Survey





It was the worst of times....

Outline

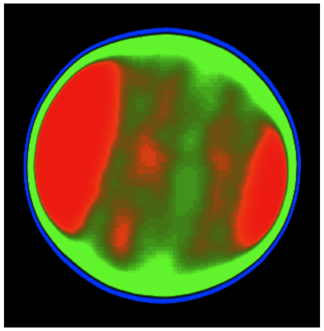
My goals are to keep the scientific community (and NASA) engaged and optimistic about possible Uranus missions, and get the mission we want flying as soon as possible.

I) Mission options.

II) Scientific goals.

III) Strategies for moving forward.

IV) Recommended "Findings" for this OPAG meeting.



NASA Mission Categories

Flagship (Cassini is a current example)
- Cost > $1 billion.
- Addresses many science objectives.
- Typically has a large suite (~10) of science instruments.

New Frontiers (e.g. Juno)
- Cost between ~$0.5 and $1.0 billion.
- Addresses several science objectives.
- Typically has a moderate number of science instruments (~5).

Discovery (e.g. InSight)
- Cost <~$0.5 billion.
- Focused on one objective.
- Small number (~1) of instruments.

All three mission categories are possible for Uranus!

Flagship to Uranus

This is the mission we want to fly. Answers questions in all relevant scientific disciplines, and is best capable of reacting to discoveries.

Launch of an Ice Giant Flagship is probably 20 years away. Europa Clipper, Mars 2020, and a Decadal Survey are between now and then.

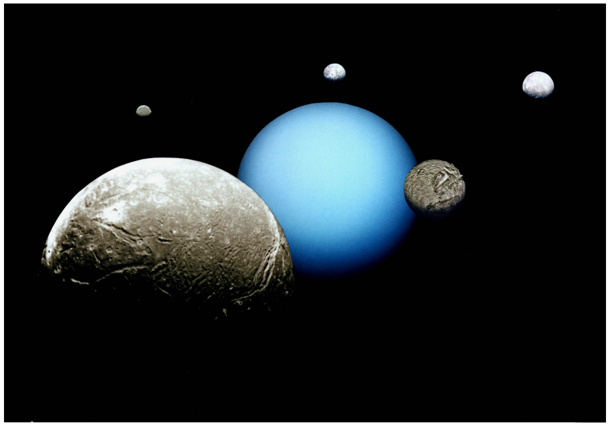
PRO: The science!

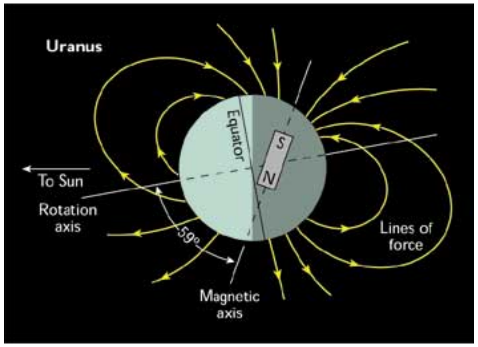
CON: Time to science and uncertainty.

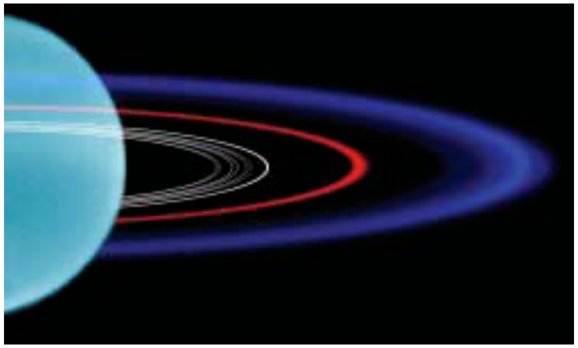
Wildcard: An L-Class ESA mission to Uranus may be proposed.

To make the Flagship a reality, we need:

- Mission studies.
- Community interest.
- Earth-based science and technology development.
- To be ready to create/respond to opportunities.







New Frontiers to Uranus

A New Frontiers mission could do excellent science in several areas. (Can have a 2-year orbital mission with a 91 kg science payload. For reference, Cassini orbiter has a ~350 kg payload.)

Launch of a Uranus New Frontiers would be 10 years away. The Decadal Survey does not allow such a mission, but the mid-term review in ~2018 is an opportunity to modify this, and Curt is open to "The Community" requesting a modification before then.

PRO: Does good science sooner than a Flagship.

CON: May push a Flagship mission beyond the 30-year horizon.

- Meeting multiple science objectives may cause some to feel the Flagship is unnecessary, and allows the argument of waiting for NF science results before designing a Flagship.
- Possible budget issues with simultaneous development of NF and Flagship missions.

Will it be counter-productive for Outer Planet science to alter the current NF mission list?

Recommendation: Decide soon if we want to argue for opening up the next NF call.

Discovery to Uranus

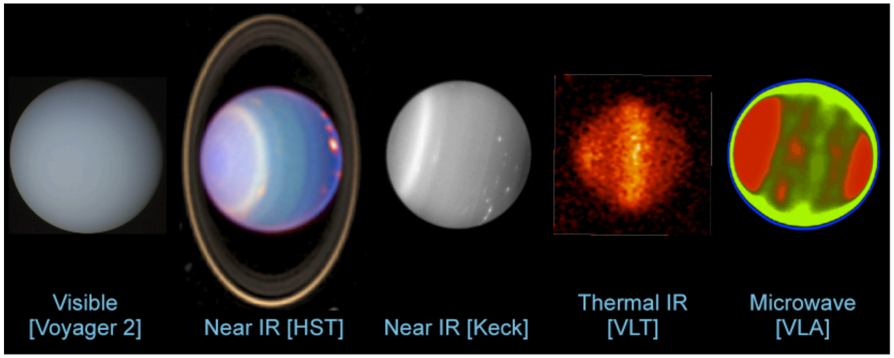
A narrowly focused Uranus mission is do-able at the Discovery level!

Mission could launch within 10 years. The next Discovery call is expected in the 2015 timeframe.

PROS:
- Fastest way to do important, space-based Uranus science.
- May compliment rather than compete with the Uranus Flagship. Advances mission studies, maintains community interest, encourages Earth-based science, but will not do enough science to satisfy the Decadal Survey's requirements for a Flagship.

CONS:
- Limited number of scientific disciplines addressed.
- We do not want to fracture the Uranus community.

Recommendation:
Explore the Discovery option aggressively. Do any ideas have broad community support?



Science Objectives at Uranus

Goal: Understand Ice Giant formation, evolution, and their current state in our solar system, and the implications for exoplanets.

Objectives based on the Decadal Survey and various reviews since its release.
Is each of them, by itself, worth a Discovery mission?

•Determine the internal structure: bulk composition and density profile.

•Determine the noble gas abundances.

•Determine the isotopic ratios of H, C, N, and O.

•Determine atmospheric zonal winds, dynamics, composition and structure.

•Understand the structure of the magnetosphere and interior dynamo.

•Determine the planet's heat budget (absorbed solar vs. emitted IR).

•Determine atmospheric thermal emission, structure and variability.

•Measure the magnetic field, plasma, and currents to study the tilted/offset/rotating magnetosphere's interactions with the solar wind and atmosphere.

•Determine the geology, geophysics, surface composition, and interior structure of large satellites.

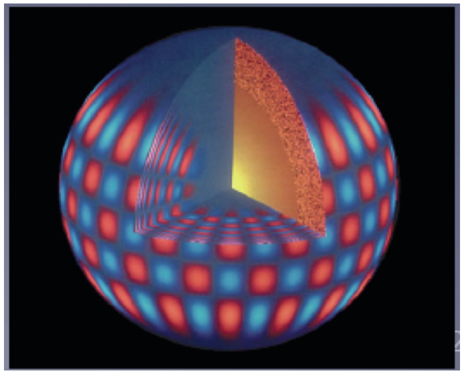
•Determine the physical and dynamical state of the rings and small satellites, and the source of Uranus' outer, dusty ring.

Discovery Example: Doppler Imager Flyby

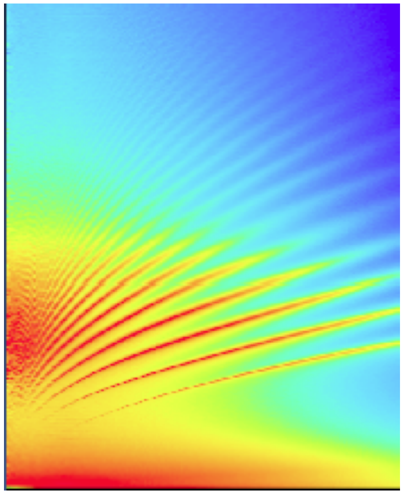
Determines the internal structure of Jupiter and Uranus. Also provides new information on the dynamics of both atmospheres.

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



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Strategies for Moving Forward

Push NASA to use money (some of it already allocated by Congress!) for a Uranus Flagship mission study.

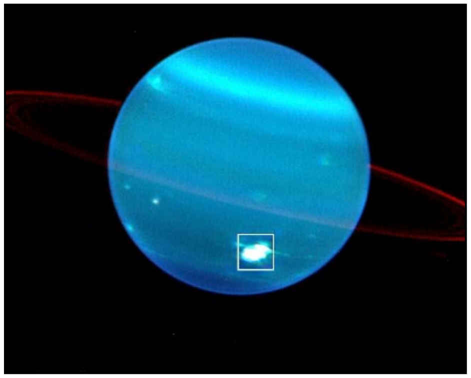
Continue doing good, Earth-based science. This maintains both our own and the broader community's interest in Ice Giants.

Support outer-planet technology development efforts (e.g. probes).

Be ready to respond to and create opportunities. Example, how to turn an ESA L-Class Uranus mission into a joint NASA-ESA Flagship?

Assess the pros and cons of pursuing a Uranus New Frontiers mission. Consider specific missions?

Aggressively pursue Discovery mission ideas and gauge their support within the Uranus community.



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

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.

To allow Outer Planet missions to successfully compete in the Discovery and New Frontiers programs, OPAG encourages NASA to provide Atlas-class launch vehicles and Radioisotope Power Systems as Government Furnished Equipment in those programs.

Backup Slides

The Ice Giants

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

Definitions

- Gas: H_2 and He.
- Ice: Things which could be solid or gas in the solar nebula, such as H_2O, CH_4, NH_3. (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

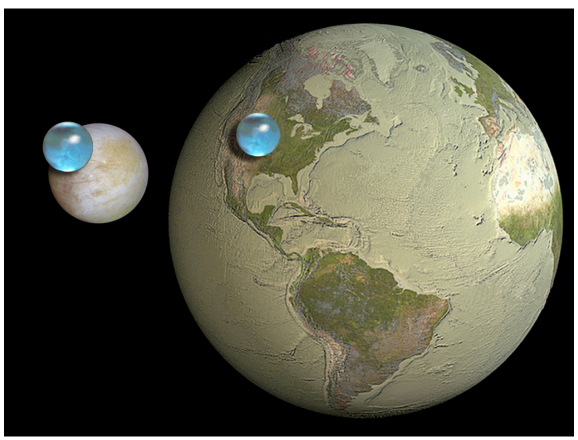
Planet	Gas	Ice	Rock	Total Mass (M_{Earth})
Earth	0%	0%	100%	1
Jupiter/Saturn	95%	4%	1%	~200
Uranus/Neptune	10%	65%	25%	~15

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).



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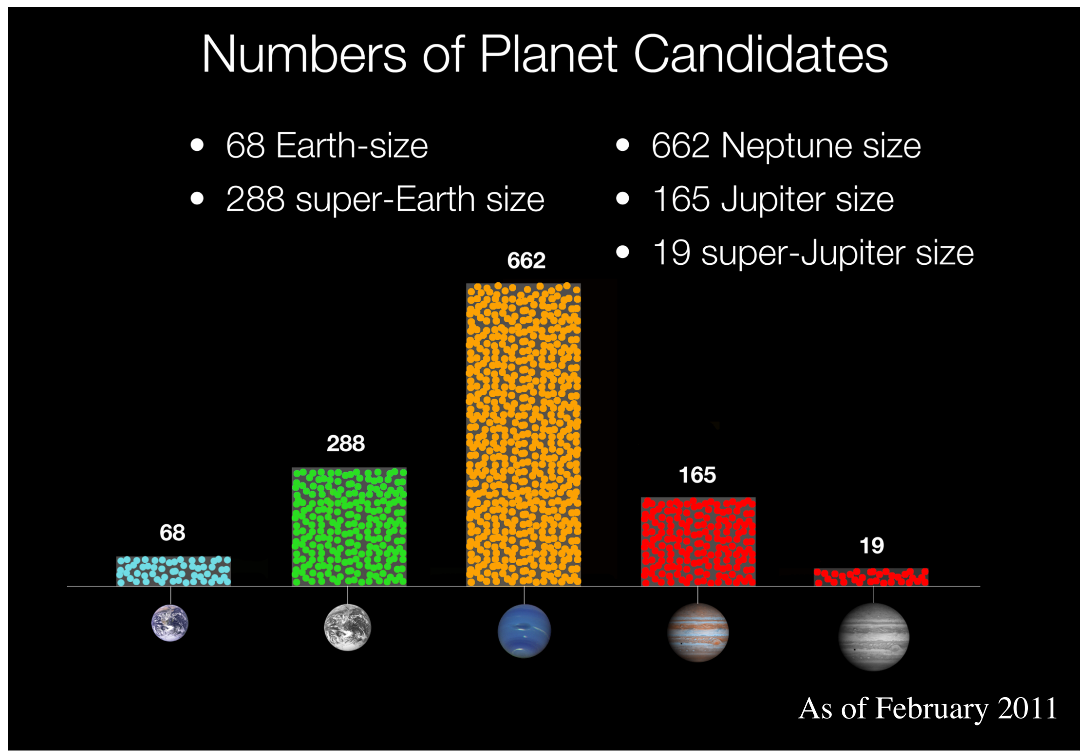

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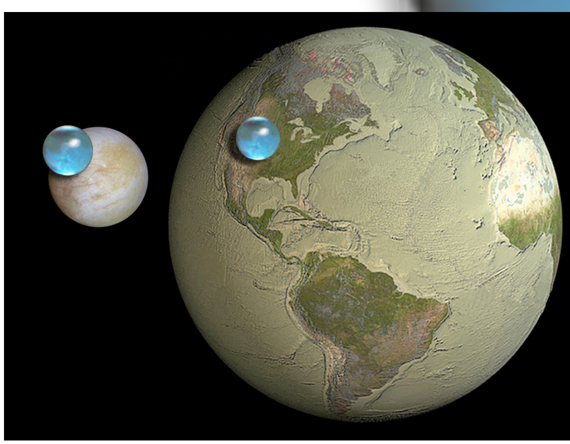
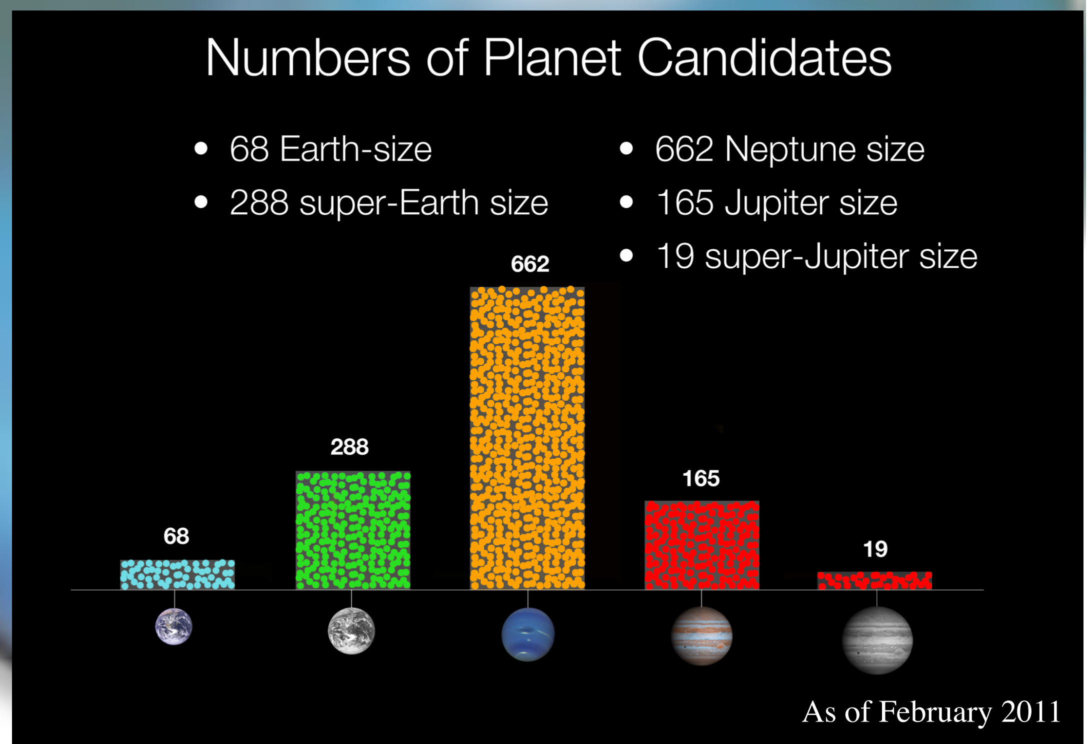
IV) Follow the water!





Why Uranus instead of Neptune?

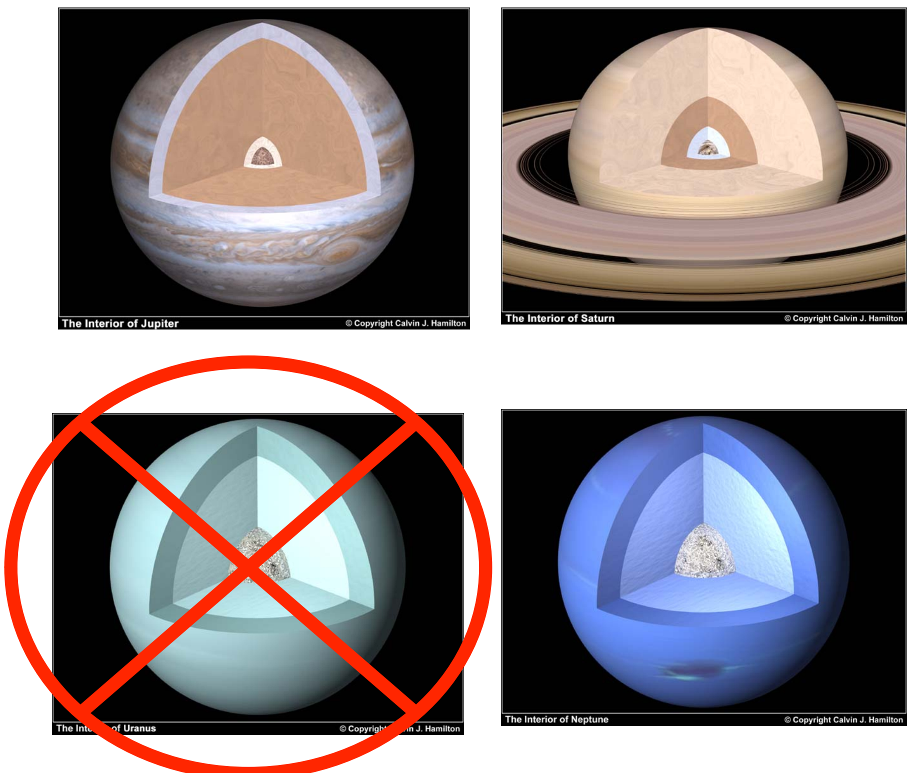
I) Uranus is the most challenging to our understanding of planetary interiors, energy balance, formation, and evolution.

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?



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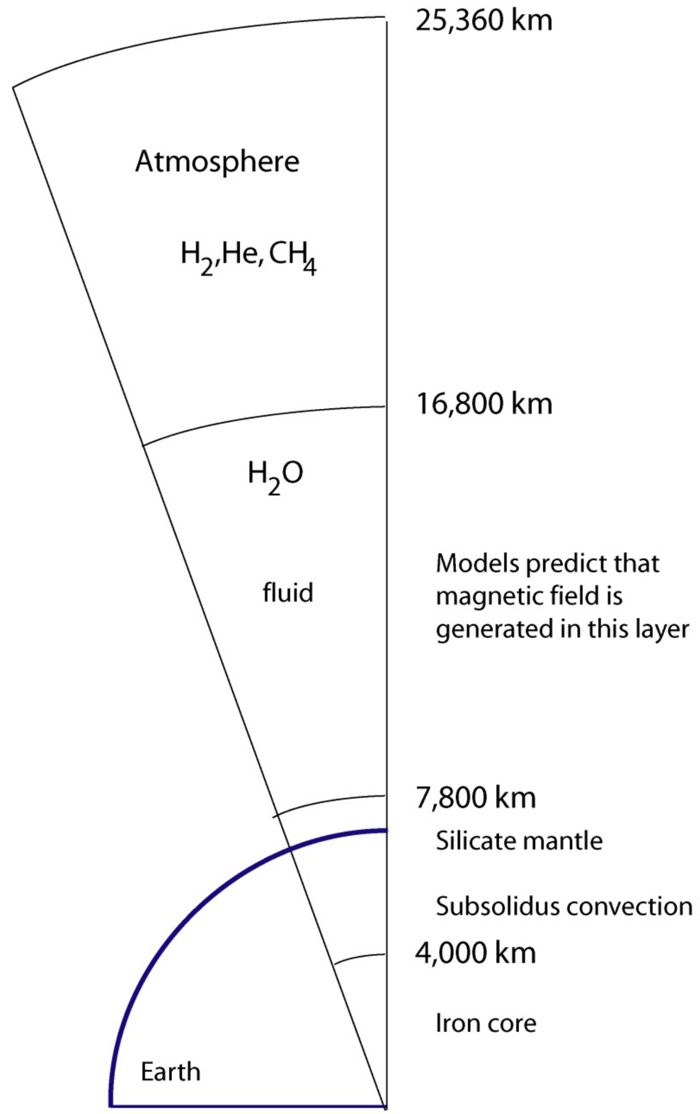

Courtesy C. Sotin.