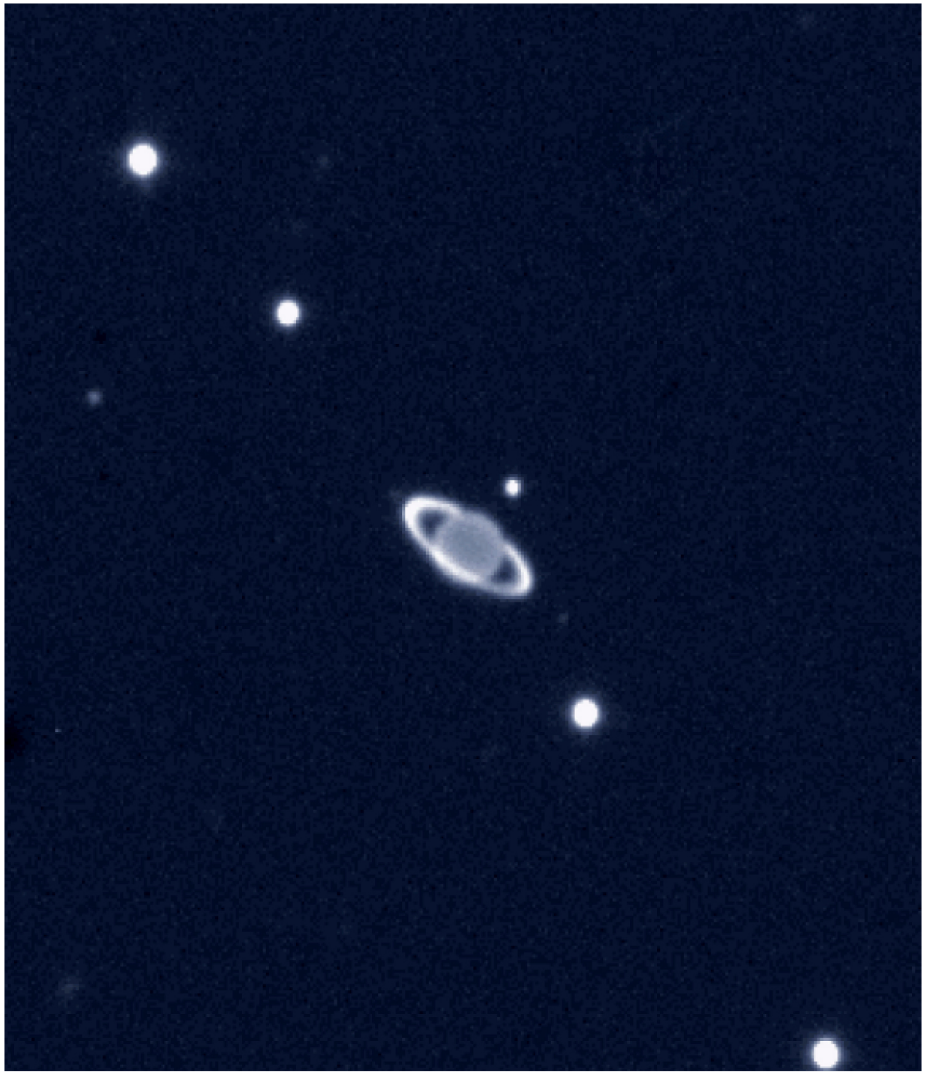
Uranus Working Group Summary Report

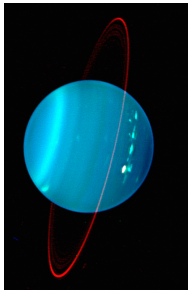
Mark Hofstadter, Chair

20 October 2011
Pasadena, CA

Discusson Facilitators:
Chris Arridge
Matthew Tiscareno
Julie Castillo-Rogez
James Norwood
Laurence Trafton



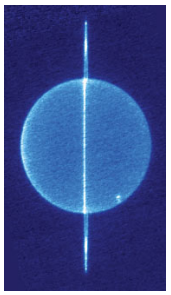
Near-IR image of the uranian system from the VLT (2002).
Credit: ESO.



Why Uranus is Important

2004
Sromovsky, Univ. Wisc./Keck

2007
de Pater, Hammel

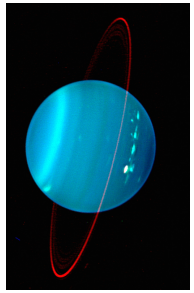


The Ice Giants, Uranus and Neptune, represent a distinct type of planet about which very little is known. Uranus is the most accessible of these, and challenges our understanding of some fundamental processes in ways that Neptune does not.

- Formation and evolution.
- Interior structure.
- Energy balance.
- Our only sampling of native Ice Giant satellites.
- Orientation of magnetic field and interactions with the Solar Wind.

Kepler results tell us that Ice Giants are much more common in our galaxy than Gas Giants.

In the Planetary Decadal Survey, both the Giant Planets Sub-Panel and the Exoplanet community White Paper identified Uranus as **the** top priority Solar System object for detailed study.



OPAG Uranus Working Group

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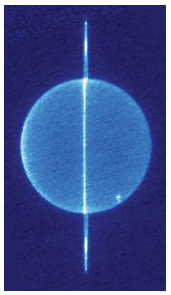


Charter: *This group will meet for two days preceding the next OPAG meeting, with the objective of assessing and coordinating Earth-based observing campaigns to best address Uranus science questions.*
("Uranus science" includes all aspects of the uranian system, including the rings, satellites, and magnetosphere.)

Goals for this meeting:

1) Identification of critical, outstanding science questions.
2) Identification of specific Earth-based measurements, efforts, and collaborations for the near future.
3) Provide a set of recommendations to OPAG (and NASA) regarding
   - Earth-based science to be done,
   - Earth-based instruments needed,
   - The future of the Uranus Working Group.
4) Provide feedback to NASA on the Uranus Equinoctial Campaign.

Attendees

Attendees:

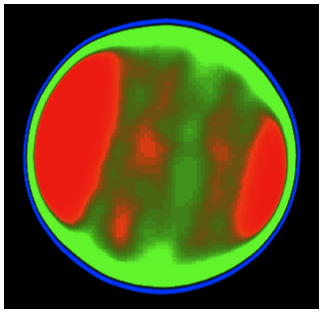
Dave Atkinson (Univ. Idaho)
Sushil Atreya (Univ. Michigan)
Chris Arridge (UCL, UK)
Kevin Baines (JPL/Univ. Wisc.)
Shawn Brooks (JPL)
Martin Burgdorf (SOFIA)
Julie Castillo (JPL)
John Cooper (GSFC)
Natalia Duxbury (George Mason Univ.)
Mark Hofstadter (JPL)
Torrence Johnson (JPL)
J.P. Kirby
Kartik Kumar (UTDelft, Netherlands)
Laurent Lamy (LESIA, France)
James Norwood (ORAU)
Glenn Orton (JPL)
Carol Paty (Georgia Tech)
Kathy Rages (SETI Inst.)
Linda Spilker (JPL)
Thomas Spilker (JPL)

Attendees:

Nathan Strange (JPL)
Matthew Tiscareno (Cornell)
Lawrence Trafton (Univ. Texas)
David Williams (ASU)

Via WebEx (incomplete list):

Nancy Chanover (NMSU)
Leigh Fletcher (Oxford, UK)
Pat Fry (Univ. Wisc.)
Patrick Irwin (Oxford, UK)
Henrik Melin (Univ. Leicester, UK)
Amy Simon-Miller (GSFC)
Larry Sromovsky (Univ. Wisc.)
Tom Stallard (Univ. Leicester, UK)
Michael Sussman (Univ. Kentucky)
Elizabeth Turtle (APL)
Anne Verbiscer (UVA)



2005, 1.3 cm
VLA, Hofstadter, Butler

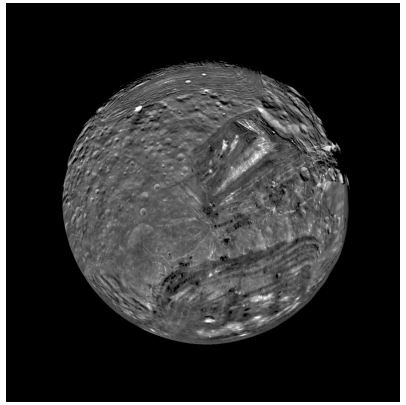
Agenda Overview

First day spent on 30-minute science presentations.

14 Presentations.

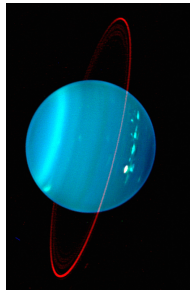
Wide range of topics including

Magnetosphere,
Aurorae,
Atmosphere,
Satellites,
Rings,
Observations from visible to radio wavelengths,
SOFIA.



Second day was primarily a discussion of science goals and measurement objectives.

- Accepted high-level science objectives of the Decadal Survey and similar existing documents.
- We did not try to prioritize among disciplines.
- Still working to distill these into a compact set of recommendations.



Results (1/4)

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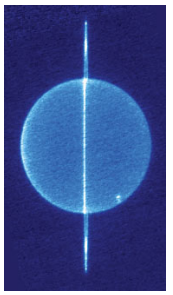
de Pater, Hammel



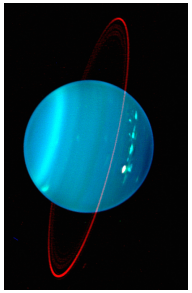
A written report will be delivered to Bill McKinnon. The content is still being distilled. A preview of our work is....

1) Identification of critical, outstanding science questions.

- High-level objectives are covered by the Decadal Surveys and related documents.

- Examples of topics highlighted in discussion are
  - Interior structure and bulk composition.
  - Atmospheric abundances: noble gases, elemental and isotopic ratios (e.g. S/N, H/D), and trace species (e.g. H_2S, PH_3).
  - Spatial and temporal variability of temperature, composition.
  - Location, composition, and microphysical properties of clouds.
  - Thermospheric heating.
  - Auroral observations as a probe of the magnetosphere.
  - Composition, dynamics, and evolution of rings and satellites.
  - Comparison with other giant planet ring and satellite systems.
  - The need for models (e.g. dynamics, magnetosphere).
  - The need for laboratory work.

Results (2/4)



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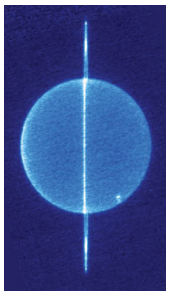


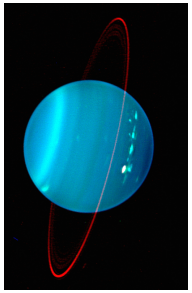
2) *Identification of specific Earth-based measurements, efforts, and collaborations for the near future.*

Many observations identified. They involve ground-based observatories (e.g. Keck, Gemini, IRTF, ALMA, EVLA), aircraft (SOFIA), and space-based observatories (Hubble, Spitzer, Herschel).

Some common themes are

- The importance of temporal sampling and spatial resolution. Features evolve on time-scales of hours (storms, aurorae) to decades (seasons, solar wind geometry). Vertical and horizontal variations in composition and temperature have been identified throughout the atmosphere.
- Getting our first look at the Northern Hemisphere of the satellites and the planet. It will be 40 years before we again see a pole emerging from night (early Spring).
- Many goals require in-situ, close-range, or high phase-angle observations.

Results (3/4)



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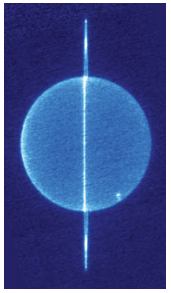
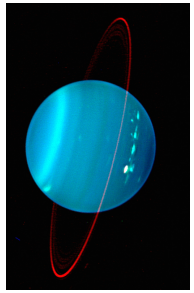


3) Provide a set of recommendations to OPAG (and NASA).

See last slide.

Results (4/4)



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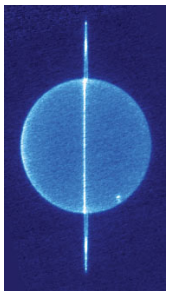


4) Provide feedback to NASA on the Uranus Equinoctial Campaign.

The 2007 ROSES language ("this program is accepting proposals that take advantage of this rare opportunity to investigate equinoctial phenomena such as ring-plane crossings and atmospheric changes driven by varying insolation") supported many exciting discoveries:

- New rings and satellites.
- Intriguing ring/satellite interactions.
- Seasonal variations in upper-tropospheric cloud and storm patterns, with the hemispheres "swapping" appearances.
- Unexplained vertical structure in the liquid-water cloud region.
- Evidence for circulation patterns yet to be explained by dynamics.
- Observing time on ground and space-based telescopes.

This has been a tremendous success!

Conclusions

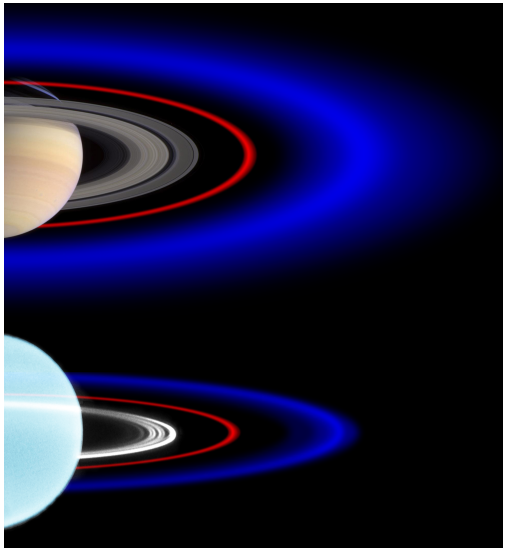
There are many important Earth-based observations to be done in the near future.

- Needed to advance our understanding of Ice Giants as a unique class of planet.
- Needed to advance our understanding of the formation and evolution of our solar system and exo-planetary systems.
- Needed to support mission studies in the coming years.

There are many critical observations that can only be made by a dedicated space mission.

The “Uranus Equinoctial Campaign”---supported by wording in the ROSES call---led to exciting discoveries.

We have three requests of OPAG, the details of which still need to be approved by the collective....



de Pater et al. 2006

We will ask that OPAG

1) Amend the Uranus Working Group charter to continue the group as a forum for ongoing uranian science and future exploration.

- Given the scientific importance of the uranian system, we need to have a group with some official standing.

2) Endorse a statement that can be used with Time Allocation Committees to support Uranus observing proposals.

3) Ask that NASA insert language into the ROSES call that encourages uranian-system proposals. Ideas under consideration are

- Important Uranus observations related to the current season,
- Relevant lab and theoretical work,
- Comparative planetology with Saturn (Cassini, Voyager) and Jupiter (Juno).