



TMT Solar System ISDT: Report on Science Forum 2015 activities

Participants:

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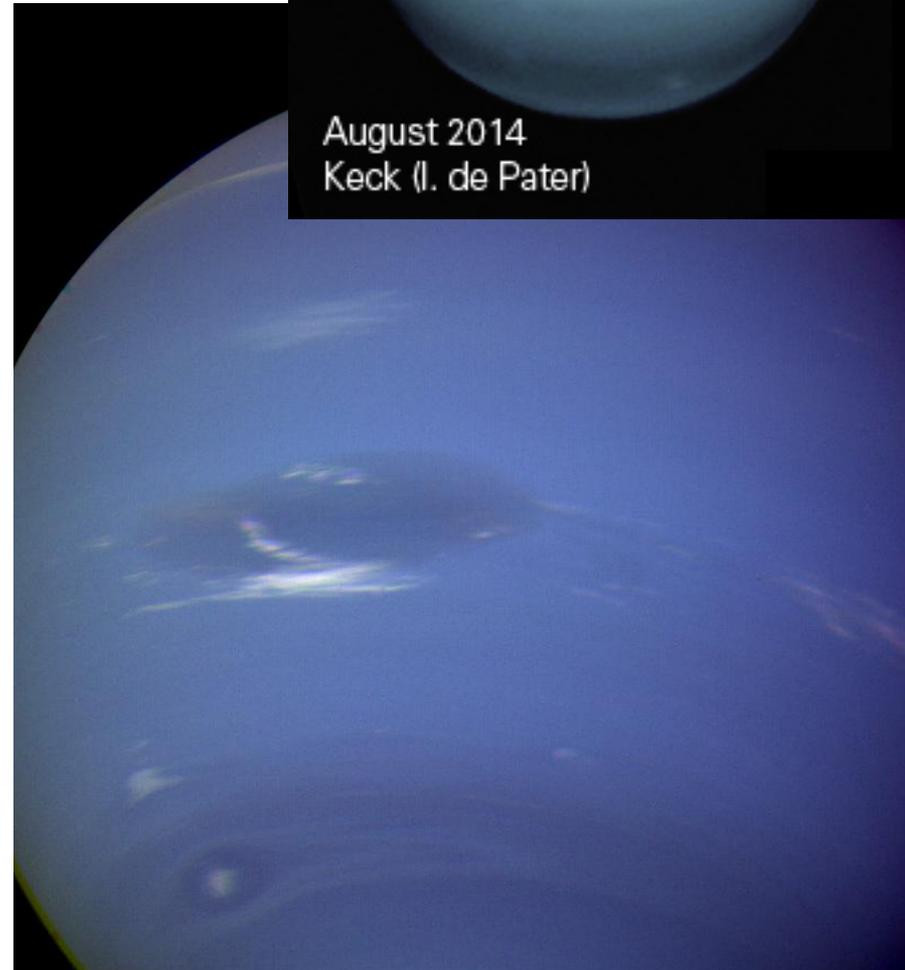
Discovery space expansion

- need plots !!
- angular resolution
 - resolve atmospheric dynamics on the distant ice giants Uranus and Neptune
 - Titan
- light-gathering
 - photometry/spectroscopy of faint small solar system bodies
 - faint spectral signatures like Europa plumes, CH₄ on Mars
- instrumentation
 - ex., high-res spectrographs

URANUS



August 2014
Keck (I. de Pater)



Solar System Key Program STM

- Started: 5 x 0 table
- Ended: 7 x 12 table
- Traces Decadal Survey-level goals to instrument/operational requirements
- Will be refined with broader community involvement

	A	B	C	D	E	F	G
1	Science goals	Science objectives	Observables	Instrument requirements	Suitable instrument	Scheduling/operational requirements	High-level products
2	search for life in solar system "icy ocean worlds"	measure organic pre-biotic compounds	hi spatial/spectral resolution synoptic observations of icy surfaces, including Ceres, Europa, Enceladus (timescale TBD)	wavelengths: NIR (1–5 μm for D/H in methanol). spectral resolution: R~7000? (high to distinguish different organics, measure isotopes). spatial resolution: diffraction limited. low geometric distortion.	NIRES	timing to cover 360 deg longitude. AO WFS operation near bright host planet. short observation (queue mode).	L2: geometrically-corrected images, in I/F photometric units. L3: lat/lon maps of reflectance. L4: lat/lon maps of chemical species.
3		measure chirality in organics	plume spectra	hi-resolution spectral polarimetry. NIR range. very high sensitivity. (maybe synoptic coronagraphic imaging of extended source to trigger spectroscopic follow-up)	newI	intense polarimetric calibration. observation triggering on timescales of plume lifetime (currently unknown).	L2: calibrated to I/F photometric units.
4	search for life on Mars	quantify CH4 on Mars: spatial and temporal variability	high resolution, spatially-resolved, multi-band spectra of Mars	NIR spectra at R~100,000. SNR: ??.	NIRES	high doppler shift, but close to opposition for spatial resolution. short observation (queue mode).	L4: lat/lon maps of CH4 column abundance
5	determine origin/evolution of water in the inner solar system	measure isotopic tracers of solar system formation in a statistically significant number of comets	hi-res spectra in specific wavelength regions	Optical spectra at ~50,000 and NIR spectra at R~100,000. SNR: ??. spatial resolution: seeing limited.	NIRES, HROS	queue scheduling due to complex, short visibility windows, twilight observing and high airmass pointing may be required for some targets. guiding at fast non-sidereal rates (?"/hr).	L4: catalogs of objects, observing/orbital geometry, isotope ratios (D/H, 15/14N, 16,17,18O), production rates
6	determine origin/evolution of water in the outer solar system	compositionally classify oort cloud comets	low-res spectra or multiband photometry, including hydration features	R~20 from 0.4–2.5 μm. unresolved.	IRIS	rapid O/IR/O instrument switching compared to object rotation periods. short observation (queue mode).	L3: calibrated (I/F) spectra L4: catalogs of objects, observing/orbital geometry, band centers/depths
7	determine organic parent molecule abundances across all planets and moons	hi-res spectra	hi-res spectra	NIR spectra at R~100,000. SNR: ??. unresolved.	NIRES	short observation (queue mode).	L3: calibrated (I/F) spectra L4: catalogs of objects, observing/orbital geometry, molecular abundances
8	determine the origin/evolution of water in the inner solar system	low-res spectra of KBOs, LPCs, MBCs, including hydration features	low resolution spectra of KBOs, LPCs, MBCs, including hydration features	R~1000?, 0.6–2.5 μm. SNR:??. unresolved.	IRIS		L3: calibrated (I/F) spectra L4: catalogs of objects, observing/orbital geometry, model-derived band identifications/centers/depths
9	determine the origin/evolution of water in the outer solar system	time series of cloud formation on Uranus/Neptune on timescales of minutes, days, months	time series of cloud formation on Uranus/Neptune on timescales of minutes, days, months	diffraction limited spatially. 0.8–2.5 μm range. R~500+?. low geometric distortion.	IRIS/IFU	short observations with multiple timing intervals of hours, days, months (queue mode).	L2: calibrated (I/F) data cubes L3: lat/lon mapped spectra
10	determine the origin/evolution of water in the outer solar system	time series of cloud formation on Uranus/Neptune on timescales of hours and their variability on Uranus/Neptune	time series of cloud formation on Uranus/Neptune on timescales of hours and their variability on Uranus/Neptune	diffraction-limited imaging in NIR, range of ~5 narrow-band filters sampling different gas opacities. low geometric distortion.	IRIS/cam	short observations with multiple timing intervals of hours, days, months (queue mode).	L2: calibrated (I/F) distortion-corrected images L3: lat/lon maps
11	determine the origin/evolution of water in the outer solar system	cloud/haze distributions on year/decadal timescales	cloud/haze distributions on year/decadal timescales	diffraction-limited imaging in NIR, range of ~5 narrow-band filters sampling different gas opacities. low geometric distortion.	IRIS/cam	short observations with multiple timing intervals of hours, days, months (queue mode).	L2: calibrated (I/F) distortion-corrected images L3: lat/lon maps
12	understand the hydrological cycle and seasonal variation on Titan	determine the spatial and temporal variation of haze layers and methane clouds	multispectral time series of cloud and haze distribution on Titan on timescales of days, to months to years	diffraction limited spatially. 0.8–2.5 μm range. R~500+?. low geometric distortion.	IRIS/IFU	short observations with multiple timing intervals of hours, days, months (queue mode).	L2: calibrated (I/F) data cubes L3: lat/lon mapped spectra
13	determine the impact hazard to Earth [8]	characterize physical properties of the NEO population	low-res spectra, optical and thermal imaging	R~1000 NIR spectra. optical and MIR (10 μm) photometry.	IRIS/IFU, WFOS, MIREX	guiding at fast non-sidereal rates (?"/hr). rapid O/IR/O instrument switching compared to object rotation periods.	L4: catalogs of objects, observing/orbital geometry, size, albedo, asteroid spectral class

Key Program Example: Determine the origin/delivery of water and organics to Habitable Worlds

- Measure isotopic tracers of solar system formation (NIRES, HROS)
- Composition of asteroids from the Oort cloud (IRIS)
- Organic parent molecule abundances in comets (NIRES)
- Understand chemistry of outer SS small bodies (IRIS)

TMT Enables

- Tracing water outgassing today beyond the asteroid belt
- Composition class for “Oort Asteroids” – Constrain dynamical models
- Isotope and organic volatile measurement in typical comets
- Chemistry of Kuiper belt objects
- Understanding of chemistry in outer disk

Synergy TMT with LSST & ALMA – placing missions in context

- Resolved disk chemical observations can be tied to dynamics
- Origin of volatiles for habitable worlds

TMT Requirements

- Flexible scheduling (queue, short partial nights, synoptic)
- Non sidereal guiding
- UV sensitivity
- High resolution near IR spectroscopy

Major science goals

- Determine origin/delivery of water and organics for habitable worlds
- Understand the heat transport, circulation and climate of giant planets, and its relation to exoplanets and Earth
- Determine the impact hazard to Earth
- Search for life in solar system "icy ocean worlds"
- Search for life on Mars
- Understand the hydrological cycle and seasonal variation on Titan
- Goals are traced to "Priority Questions" of the Decadal Survey



Instrument preferences and requirements

- NIR spectroscopy and imaging, low/medium resolution
 - IRIS/IFU and imager
 - ice giant cloud properties
 - small body classification
- NIR and optical high-resolution spectroscopy
 - organic composition
 - isotope ratios
 - seeing-limited (unresolved bodies) or diffraction-limited (Mars CH₄)
- additional wish lists
 - mid-IR range
 - polarimetry
 - coronagraphy of extended targets like Europa



Operational constraints

- Scheduling: Queue mode
 - faint targets with complex visibility windows
 - short observations with complex timing constraints,
 - usually: longitudinal coverage of rotating s
- Telescope
 - targets at low elevation
 - fast non-sidereal rates ($\leq 800''/\text{hr}$ for most Near-Earth Objects at closest approach, up to $5000''/\text{hr}$ in exceptional cases)
 - fast instrument switches
 - twilight?
- Adaptive optics
 - differential tracking of targets and guide stars
 - using extended objects as guide stars
 - dynamic AO backgrounds near bright objects
 - faint NGS



Upcoming meetings:

THE SOLAR SYSTEM AS SEEN BY THE ELTS

ESO GARCHING

30 November - 4 December 2015

Registration Deadline: October 30 2015

Goals of the workshop

The objective of this workshop is to prepare the planetology community for making the best use of the Extremely Large Telescopes. In complement to many successful space planetary missions, ground-based observations are still essential for understanding physico-chemical properties of solar system objects. In addition, the observation of solar system objects, as fast-moving objects, raises specific constraints that must be addressed by the ELTs and must be planned well in advance. The workshop will help defining these constraints.

Invited speakers (preliminary list)

A. Barucci (Paris Observatory)
N. Biver (Paris Observatory)
B. Brandl (Leiden University)
H. Boehnhardt (MPS, Göttingen)
A. Caustanis (Paris Observatory)
R. Davies (MPE, Garching)
T. Greathouse (SwRI, San Antonio)
A. Moullet (NRAO, Charlottesville)
T. Müller (MPE, Garching)
G. Orton (JPL, Pasadena)
B. Sicardy (Paris Observatory)
D. Sonnborn (GSFC, Greenbelt)
A. Stern (SwRI)
P. Tanga (OCA, Nice)
L. Testi (ESO, Garching)
N. Thieffry (Oxford University)
G. Villanueva (GSFC, Greenbelt)

SOC:

C. Dumas (ESO/Santiago)
T. Encrenaz (LESIA, Paris Obs., co-Chair)
E. Jehin (IAG, U. Liège)
U. Käuff (ESO, Garching, Chair)
G. Orton (JPL, Pasadena)
J. Spyromilio (ESO, Garching)
G.-P. Tozzi (Arcetri Observatory)

LOC:

S.M. Chastolis-Klingner (ESO, Garching)
T. Encrenaz (LESIA, Paris Observatory)
U. Käuff (ESO, Garching, Chair)
M.K. McClure (ESO, Garching)
G. Orton (JPL, USA)
J. Spyromilio (ESO, Garching)
G.-P. Tozzi (Arcetri Observatory)





47th Annual Meeting

Division for Planetary Sciences

Washington, DC | 8-13 November 2015

DPS workshop:

TMT Solar System Science Town Hall

- goals: broaden community participation in Key Program brainstorming, update planetary scientists on TMT status
 - >700 attendees at DPS
 - complimentary lunch enticement
 - was due yesterday

