Ion-neutral photochemistry reveals that in situ exploration of Neptune's stratosphere could give valuable constraints on the origin of CO.

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Abstract

We have developed a coupled ion-neutral 1D photochemical model of Neptune's atmosphere to study the origin and evolution of hydrocarbons and oxygen-bearing species. We have found that ionic chemistry substantially modifies the photochemistry of Neptune's atmosphere (and probably the ones of all giant planets). Two main ion layers are present in the atmosphere located above 10-5 mbar and around 10-3 mbar. In particular, the ion-neutral chemistry coupling produces aromatic species in the atmosphere of Neptune with relatively high abundances.

One other interesting result of our model is that the influx of oxygen species in the upper atmosphere of Neptune has an effect on the concentration of many ions. As a consequence, a detailed description of the composition of neutral and ionic species through the use of a mass spectrometer with a high m/z resolution could give valuable constraints on the origin of CO in the stratosphere of Neptune.

A summary of these main results will be presented in the context of in situ exploration of the Ice Giants.

Keywords: Photochemistry, Atmosphere

*Speaker

The dynamical magnetospheres of Uranus and Neptune revealed in numerical simulations

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Abstract

Based on the ratio of the planetary rotation period to the Alfvén speed relaxation time of the inner magnetosphere, Uranus and Neptune must be considered as fast-rotators. So are Saturn and Jupiter. However, in terms of impact on the global magnetospheric structure, the major difference between the two groups of planets is that, while the angle between the rotation axis and the magnetic axis is small for Saturn and Jupiter (0 and 10 degrees, respectively), it is large for both Uranus (59 degrees) and Neptune (47 degrees). The immediate consequence is that the interaction of the solar wind with the magnetospheres of Uranus and Neptune is violently modulated by rotation whereas it is quasi steady for Jupiter and Saturn (apart from sporadic reconnection events). In addition, for both Uranus and Neptune (unlike Saturn and Jupiter), the orientation of the rotation axis with respect to the solar wind flow direction varies over a large angular range during a planetary year causing considerable seasonal changes of the the global magnetospheric structure. Unfortunately, the only in situ measurements for Uranus and Neptune are those collected during the fast planetary flybys of the Voyager II spacecraft. Given the scarceness of the available data (consisting mostly of HST observations of their auroral emissions), numerical simulations constitute the only means to investigate the dynamical behavior of the de facto largely unexplored environment of Uranus and Neptune. Here we take the opportunity to present a short review of published numerical simulations of Uranus' and Neptune's magnetospheres.

Keywords: Uranus, Neptune, magnetosphere, plasma physics, numerical simulations

*Speaker

Spectroscopy of the ice giants and their moons at DLR

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Abstract

The ice giants Uranus and Neptune and their moons are among the least explored objects in the solar system. They provide however an important constraint for formation models of the solar system. Like Mercury in the inner solar system a valid formation model for our solar system has to explain the formation of these two planets. Furthermore a significant number of the recently detected extrasolar planets have mass and radius comparable to Uranus and Neptune. This makes those two planets one of the best analogs for extra solar planets in our solar system.
Based on the importance of these bodies and the dearth of information there are is now a strong push for missions to explore the Uranus and Neptune system. Such a mission would most likely consist of an orbiter and one or multiple probes. While the probes would provide detailed measurements of the atmospheric composition including depth profiles, only remote sensing techniques can provide global information. For a survey of the planets, their moons and their ring system spectral measurements over a wide wavelength range are essential.

In preparation for this exploration the Planetary Spectroscopy Laboratory (PSL) at DLR in Berlin (Germany) [1] is currently extending its capability to perform reflectance measurements in high vacuum low-temperature environments. This new setup is not only aimed at studies for the ice giants and especially their icy moons but also more genaral for the characterization of asteroid, cometary or solar system small bodies (SSSB) analogues [2, 3, 4].

Moroz et al. [5] showed pronounced spectral effects at the lowest temperature of 80K in a reflectance spectra measurement of Olivine and orthopyroxene, which are very common rock-forming minerals in the Solar System. A measure of the temperature dependence of the reflectance spectra at the primitive surface of Ceres has been addressed by Beck et al. [6] to investigate the reflectance spectrum under decreasing temperatures (down to 93K).

Setting up a system for reflectance spectroscopy experiments at cryogenic temperatures represents a unique opportunity for the PSL. A high vacuum low-T chamber will be coupled to the newest Fourier transform infrared (FTIR) spectroscopy instrument Bruker Vertex 80 V equipped with aluminum mirrors for high efficiency down to the UV spectral range. The optical setup will be focused on bi-directional measurements and a variety of external sources will allow covering the spectral range from UV to far-infrared. In the first concept phase various cooling systems have been evaluated. The possibility of using a closed based cycle

*Speaker

cooling by helium gas or liquid nitrogen with typical temperatures of 70-90K, to provide distributed cooling power for a cooling surface, has been studied. The nominal cooling capacity of a miniature cryocooler system currently at use at DLR is for example 65K [7]. For the first iteration of cryogenic setup a closed looped liquid nitrogen system will be use that is expected to reach a cryogenic temperature within the range of 70K – 100K. After validation of the setup this can be replaced with a closed looped helium based system to reach the temperature range of 30-40K realistic for the Uranus and Neptune system.

In the context of the proposed Outer Solar System (OSS) mission [8] DLR has already studied the concept of a thermal infrared imaging spectrometer. OPTIS (Outer Planet Thermal Imager Spectrometer) is a thermal infrared imaging spectrometer with an integrated radiometer. The scientific goal of OPTIS is to provide detailed information about the mineralogical composition of any solid surfaces in the outer solar system by measuring the spectral emittance in the spectral range from 7 to 12 μm with a high spatial and spectral resolution. Furthermore OPTIS will obtain radiometric measurements in the spectral range from 7 to 40 μm to study the thermo-physical properties.

OPTIS builds on the heritage of MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer) instrument for the ESA BepiColombo mission to Mercury, which has recently been launched successfully. At the time of the study OPTIS used a cooled MCT array detector to maximize the signal to noise ratio for the much colder surface of Triton and KBO. With the recent technological advancements for uncooled microbolometer this type of detector can also be revisited.

A highly miniaturized radiometer is integrated in the slit plane of the spectrometer. The approach of combining a spectrometer and a radiometer with the same entrance optics provides synergies benefiting the scientific analysis. The fact that the surface temperature can be obtained independently from the spectral measurements allows removing ambiguities in the retrieval of emissivity values. The radiometer will further map thermal physical properties like thermal inertia, texture and grain size.

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Keywords: spectroscopy, Uranus, Neptune, triton, extrasolar planets, Thermal infrared

A "Flight-Modified" Diamond-Anvil Cell (fm-DAC) - a novel concept for sample recovery in Giant Planet and satellite environments

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Abstract

The Diamond-Anvil Cell (DAC) has contributed significantly to the experiments in planetary interior materials research for over 4 decades, enabling the generation of pressure and temperatures under static conditions and the exploration of phase chemistry on the internal constituents of diverse planetary types - from terrestrial to simple molecular.
Its parallel adoption in many fields of materials research has been enabled by the ease of access to the sample *in situ* with visible and IR spectroscopies and more recently with micro-beam, X-ray synchrotron radiation.
What the DAC, or any opposed-anvil technology, has never been used for is a means of sample recovery from extreme environments based on its simple role as a robust, inert container. (Some early applications of the DAC may have involved its use as a forensic sample holder.)
Diamond as a confining material has many advantages for operation in extreme or reactive environments.
In this poster I outline the advantages and disadvantages of a potential sample recovery probe that makes use of a remote-controlled, flight-modified (fm) DAC.
One of the obvious criticisms might be the sample mass recovery-to-weight ratio of the total device - a figure of merit likely of prime importance for mission payload planning, and the need to bring a physical container (the fm-DAC assembly) back to Earth. (But some mission recovered sample mass ratios have been quite low e.g., Hayabusa-1, Genesis, Stardust).
A fm-DAC might therefore act only as a single element of a complete sample recovery strategy based on multiple sampling of shallow and deep planetary atmospheres, not ruling out alternative options for larger volume capture (though probably also of low mass) or *in situ* measurements. A fm-DAC array would provide point sampling physical recovery that can later be examined on return without need for complex unloading or unmixing. (A recovered sample would remain within a fm-DAC unit for distribution to Earth-based laboratory analytical instruments.) Volume of sample are of order 10ˆ5 umˆ3 / 10ˆ-{10} litre, but would not require transfer to alternative containers. Release of captured sample could be made in the entrance chambers of mass spectrometers.

One simple practical observation is that, for the many high pressure studies on the properties of molecular hydrogen (and other simple elemental molecules or their mixtures) in the 100 GPa pressure range in the last 3 decades, the DAC was usually "gas-loaded" at 200MPa (2 kbar) and room temperature in laboratory vessels. These conditions are well above critical points of the gases involved and provide dense fluid atmospheres of the sample mixtures of interest that are trapped by the immersed DAC sample assembly (gasket). In this sense,

*Speaker

the pressure environment (and with right materials, temperature environment) should have minor effect on the operation of a fm-DAC. Diamond graphitisation would take place near 1000C perhaps in an oxygen atmosphere and remains a serious constraint below ~20 GPa total pressure.
Materials engineering for the body of the DAC might be migrated from modern space system composites to provide light weight, high-load-bearing structures, stable in both compression and tension, as the seating platform for large (of order 2mm) diamond-anvil culets.

A severe challenge is posed by recovery. Atmosphere models (Ref. 1) suggest that a pressure of 200MPa in Jupiter's outer atmosphere would correspond to a depth of perhaps 500km below 1 bar and temperatures exceeding 1000K. The Galileo probe stopped transmission at 132 km below 1 bar (Ref. 2). Clearly a recovery system would require an escape vehicle or a floating platform and winch, that seems unlikely to be readily achieved above a Giant planet, even with the current, imaginative mission technologies.

Nonetheless, perhaps the icy moons of the Giant planets offer a more beneficial environment for such deep, direct sampling and recovery, with a viable fixed surface to operate from. The satellites may also provide the possibility for greater chemical understanding of the accretional molecular chemistry of ice-giant systems. For deep ocean sampling on icy satellites, for example, a fm-DAC would lend itself extremely well to capture and containment of the local fluid environment. In the context of searching for biosignatures or extant microbial life, the fm-DAC concept would be ideal for excluding terrestrial contamination both in the recovery and the analysis phases.

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Keywords: Diamond, anvil cell, sample capture, high pressure, high temperature, hydrogen, helium, dense fluids

Uranus spin : toward an updated rotation period and SIII longitude system

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Abstract

The official inner rotation period of Uranus of 17.24+/-0.01h was determined from unique remote radio auroral observations and in situ magnetic observations obtained during the flyby of the planet by Voyager 2 in Jan. 1986. The poor uncertainty on the rotation period yielded the associated SIII Uranian Longitude System (ULS) defined at that time to be valid only for a couple of months aside the flyby.
25 years later, the Earth-based re-detection of Uranus ultraviolet aurora with the Hubble Space Telescope provided a new mean to remotely track the magnetic poles. By fitting the bright southern auroral features observed late 2014 with model auroral ovals, we could determine the longitude of the southern magnetic pole with a 26○ uncertainty and reference again the longitude system. The observational campaign was however too short to sample the rotation period with an improved accuracy.

In this work, we apply the same method to the other auroral features detected between 2011 and 2017 to attempt to update the inner rotation period and determine a SIII longitude system valid over an extended time interval.
While a more accurate rotation period better characterises the planetary core, an updated SIII longitude system is essential to design any future exploration of the Uranian magnetosphere.

*Speaker

Prospects for Ice Giant Seismology

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Abstract

Understanding the composition and differentiation of the Ice Giants' interiors is a primary goal of a flagship mission. Experience on Earth and the sun have demonstrated the preeminance of seismology as a tool for probing interior properties. More recent observations of Saturn and Jupiter have demonstrated that these giant planets have long-lived non-radial seismic normal modes which can be used to understand their interiors. In this poster we explore what we may stand to learn from Ice Giant seismology. We comment on possible excitation sources and the feasibility of detection, as well as differences between the Ice Giant and Gas Giant seismology. We also discuss possible detection methods, including Doppler imaging and gravity field measurements, and their relative merits.

Keywords: seismology, normal modes, Doppler

*Speaker

Photochemistry of stratospheric ices in Titan's atmosphere

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Cassini-Huygens mission has revealed the chemical complexity of the atmosphere of Titan, the largest moon of Saturn. Mainly composed of N_2 and CH_4, electrons coming from the magnetosphere of Saturn, energetic ions and solar UV photons induce their photo-dissociation in the upper part of the atmosphere [1]. This result in the formation of complex organic molecules (hydrocarbons and nitriles) and aerosols by mechanisms still poorly known. Considering Titan's temperature profile combined to large atmospheric seasonal variations, some gaseous molecules can condense in the stratosphere leading to the formation of icy particles or clouds, submitted to long UV photons (λ>230nm) at such altitudes. Besides several molecules have been pointed out to be responsible for clouds observed either at the North pole or the South pole, by comparison with experiments carried out in laboratories [2].

The last cloud observed by the space mission, also called "High Altitude South Polar" cloud, may be the result of the simultaneous condensation of benzene, C_6H_6, and hydrogen cyanide, HCN [2]. To better understand these observations, we have chosen to simulate the condensation and the photochemistry of these two molecules, first isolated and then condensed simultaneously. The experimental setup used in our laboratory allows us to monitor the solid phase by FT-IR. These results may help later in the interpretation of space mission data.

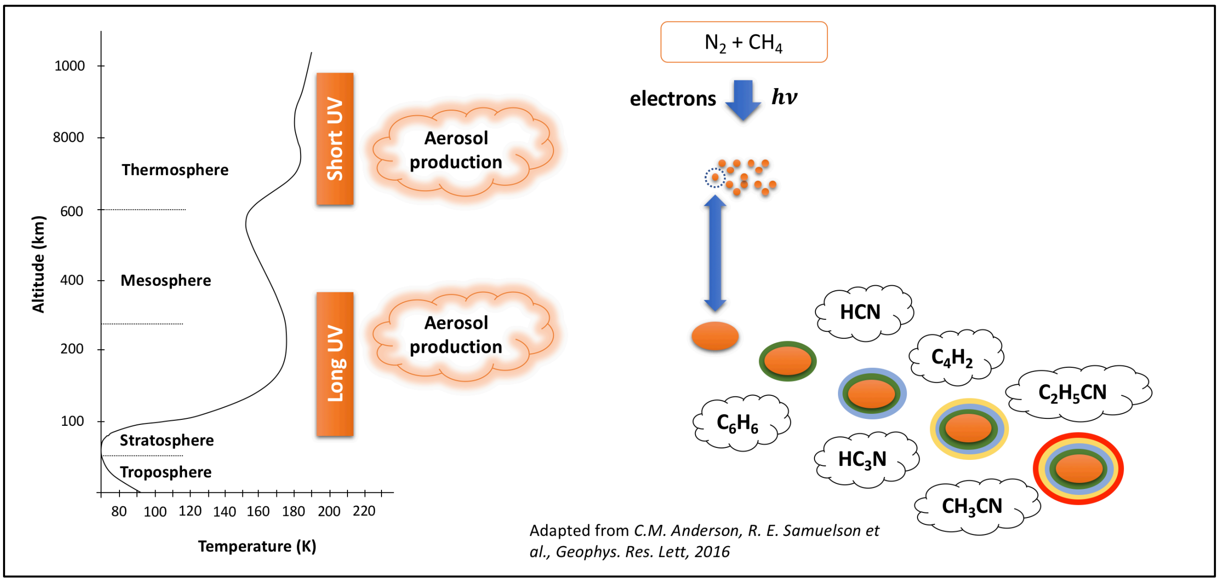

Figure 1: Sedimentation aerosol's process occurring in Titan's atmosphere

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The plethora of Uranus and Neptune heat flux predictions from evolution models

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Abstract

The low heat flux out of Uranus in conjunction with the 10 times stronger heat flux from Neptune remains an unexplained puzzle and limits our understanding of how a typical ice giant interior might look like. Here we discuss new and established adiabatic and non-adiabatic evolution tracks of Uranus and Neptune. We show how uncertainties in the adiabats of ices and H-He reflect in largely different calculated present heat flows. Allowing for non-adiabatic evolution can significantly shorten or prolong
their cooling time, depending on the assumed temporal behavior of thermal boundary layers. We suggest observables that could help us to gain more insight in the interior of Uranus and Neptune.

Keywords: thermal evolution, Uranus, Neptune

*Speaker

Atmospheric D/H as a constraint on the origin and evolution of the ice giants

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Abstract

Hydrogen is a major element in giant planets and understanding its history yields insight into the origin and evolution of these bodies. The deuterium-to-hydrogen (D/H) ratio varies strongly among Solar System reservoirs, ranging from ˜25 ppm in the nebular gas [1] to > 150 ppm in solid-body (e.g. cometary) reservoirs [e.g. 2]. In contrast to the gas giants where captured nebular gas dominates the hydrogen budget, in the ice giants the solid-body hydride ("ice") component may contribute hydrogen comparable to the nebular gas. Indeed, the currently inferred D/H ratio in ice giant atmospheres is intermediate between that of the nebula and the icy planetesimal reservoir [e.g. 3]. D/H is therefore a unique tracer for understanding the origin and evolution of ice giant source reservoirs, interior processes (e.g. convective mixing via core-dredging [4]), and integrated history. However, precisely because the ice component contributes comparable hydrogen as the nebular gas, inferring the bulk D/H of ice giant atmospheres requires special considerations. In this presentation, I review the observations currently used to characterize the D/H in ice giant atmospheres, identify the fractionation processes that currently produce D/H variability in these atmospheres, and assess the assumptions made in translating the observations to a bulk composition for the atmospheric reservoir. I describe the conditions under which the D/H of the upper atmosphere is representative of the ice giants' deep atmospheres. Finally, I describe how in-situ atmospheric measurements can refine our understanding not only of the upper atmospheric D/H but its interpretation as a constraint for ice giant evolution.

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Keywords: atmosphere, hydrogen, isotopes, components, mixing, fractionation

*Speaker

Trident: Discovery Mission to Neptune's moon, Triton

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Abstract

Neptune's large moon Triton is one of a rare class of solar system bodies with a substantial atmosphere and active geology. Primarily composed of N2, H2O, CO2, CH4, and CO, Triton is subject to the tidal, radiolytic, and collisional environment of an icy satellite, however, its starting point and initial composition is that of a KBO Dwarf Planet. Capture into Neptunian orbit would have resulted in substantial heating early in Triton's history. Triton's high inclination results in significant obliquity, possibly sufficient to maintain an internal ocean. Confirmation of the presence of an ocean would establish Triton as an exotic and probably the most distant ocean world in the solar system, potentially expanding the habitable zone to 30 AU.
Triton's typical surface age from cratering is probably < 10 Ma, with an upper limit of < 50 Ma, probably the youngest surface age of any planetary body in the solar system except Io. Candidate endogenic features include tectonic structures, cryovolcanic landforms, "cantaloupe terrain", and several particulate plumes and associated deposits. Post-Voyager, the preferred mechanism for Triton's plumes was an exogenic solar-driven solid-state greenhouse effect. However, this paradigm is being questioned in the context of plume observations on much smaller Enceladus and possibly Europa. Triton's atmosphere is thin (_~1 Pa), but sufficiently substantial to be a major sink for volatiles, and sufficiently dynamic to play a role in movement of surface materials.

Much like Pluto, Triton experiences dynamic surface-atmosphere volatile interchange and potentially dramatic climate change happening over obliquity and/or seasonal timescales. The presence of volatile methane, together with its unique, intense ionosphere that may be driven primarily by energy from Neptune, makes possible a wide range of "hot atom" chemistry allowing higher order organic materials to be produced in a similar manner to Titan and Pluto. Such materials are of potential importance to habitability, especially if conditions exist where they come into contact with liquid water.

We have identified an optimized solution for a New Horizons-like flyby of Triton in 2038 which appears compatible with the NASA Discovery-class 2019 opportunity.

The science goals are: (1) Investigate Triton as a potentially habitable world, by studying its water, energy and organic matter; (2) Investigate contemporary organic synthesis on

*Speaker

Triton; and (3) Investigate Triton in the context of other worlds. Trident's science objectives are achieved by an instrument suite selected for high performance and complementary science value, while avoiding new development. An active-redundant flyby sequence ensures unique observations during an eclipse of Triton – and another of Neptune itself – and includes redundant data collection throughout the flyby. High-resolution remote sensing and high-capacity onboard storage enable near-full-body mapping over the course of one Triton orbit. Trident will pass within 500 km of Triton, inside its atmosphere, sampling its ionosphere, and getting sufficiently close as to permit highly detailed magnetic induction measurements. Finally, passage through a total eclipse makes possible atmospheric occultations.

Trident's focus on the internal structure, surface geology, organic processes, and atmospheric characteristics of Triton closely align with key priorities established in the NRC 2013 Planetary Decadal Survey and the NASA 2018 Roadmaps to Ocean Worlds white paper.
JPL contributions was carried out at Caltech-JPL under a contract from NASA. Pre-decisional, for planning and discussion only.

Keywords: Triton, mission, Discovery, NASA

Retrieval of haze and cloud profile from simple analysis of reflection spectra.

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Abstract

The main objective of this work is to use approaches related to the use of radiative transfer and the use of gas absorption to retrieve, without radiative tranfer, the vertical properties of hazy and cloudy atmosphere. We use Titan as test case because it is a very well documented case, and then we use our model for other planets and Neptune and Uranus.
In this work, we assess the possibility to retrieve information about the scatterer layers with the minimum of information on the planet, but with a good knowledge on gas spectroscopy. We use a model of Titan atmosphere to generate synthetic spectra at various spectral resolution between R=60 to 60000. From this synthetic spectra, we try to retrieve information on the haze layer assuming very few information about the atmosphere.

We are able to retrieve the vertical profile of the haze opacity, with a vertical scale given according to the opacity of the gas or an equivalent altitude built on a proxy (eg, z _˜ -H × log (
*tau*_gas) with
*tau*_gas the integrated opacity of the gas and H the scale height of the atmosphere). After using synthetic spectra, we also use a real observation of Titan made by VIMS on board Cassini (R=120- 180), which is also compared to the expectated profile.

In a second part we use spectra of other planet to assess the ability of our model to clearly differenciate hazy and cloudy planets and to retrieve with a good accuracy the vertical structure of the particles.

*Speaker

Characterization of ocean worlds around ice giants : Uranus vs. Neptune

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Abstract

Uranus' and Neptune's systems harbor several moons which are of interest for ocean world exploration. However, the two systems have very different characteristics, opening different perspectives for ocean world characterization. The five largest moons of Uranus (Miranda, Ariel, Umbriel, Titanian and Oberon) are comparable in sizes and orbital configurations to the medium-sized moons of Saturn. The observations performed during the flyby of Voyager 2 revealed signs of endogenic resurfacing associated with tectonic stress, possibly involving cryovolcanic processes, especially on the moons Ariel and Miranda with the youngest surfaces. The late resurfacing of Ariel may have been triggered by tidally induced melting events similar to Saturn's moon Enceladus, offering a unique opportunity to better understand how such small moons may become active. The largest moons, Titania and Oberon, with diameters exceeding 1500 km, may still habor liquid water oceans at depth, remnants of past melting events. The comparative study of Uranian and Saturnian moons will provide constraints on the formation of such moons as well as on the likelihood and duration of internal melting events, essential to characterize their astrobiological potential. In contrast, the large moon Triton, one of a rare class of solar system bodies with a substantial atmosphere and active geology, offer a unique opportunity to study a body comparable to the Dwarf planet Pluto, orbiting a giant ice planet. Its orbital configuration indicate that it was captured into Neptunian orbit, which resulted in substantial heating early in Triton's history and potentially in relatively prolonged hydrothermal activities. From this point of view, Triton may be intermediate between Enceladus and Europa, offering opportunity to better understand the role of hydrothermal activities on the habitability of ice-covered oceans. Uranus has the advantages to have several moons of interest, however their orbital configuration due to the large axial tilt of Uranus makes a multiple flyby mission of these moons technically more challenging than on Neptune. Neptune with a single moon of interest makes the programming of the scientific investigations simpler, requiring only a limited set of dedicated flybys. Even with a single flyby mission comparable to New Horizons at Pluto (see Prockter et al. *this workshop*), some of the main science questions about Triton may be addressed. The exploration of these two satellite systems would be compatible with an in-situ probe into the ice giant planet.

Keywords: Ocean Worlds

*Speaker

Probing Ice Giants' Gravity Fields and Atmospheres through Radio Tracking from Earth

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Abstract

Several mission concepts were proposed in the last few years for the in-situ exploration of the Ice Giants, both by NASA and ESA. In most cases, an orbiter was dedicated to the study of the giant planet(s) and its largest moons. In previous studies, an initial high inclination orbital phase with a very low pericenter distance (as for Juno and Cassini proximal orbits) was foreseen, to enable a detailed mapping of the planet gravity field. In addition, the orbiting mission scenario usually required multiple close flybys of the Ice Giants' major satellites to determine their gravity fields, search for satellite atmospheres, sound the interiors, and image their surfaces at high resolution. Moreover, while the spacecraft would be probing the planetary system(s) it would be occulted by the planet atmosphere as seen from the Earth. Such a configuration offers a unique opportunity to study remotely the physical properties of the occulting atmosphere (probing both its neutral and charged components) using radio links as the spacecraft is being occulted. Indeed, non-null refractivity causes the radio signal to depart from the path which would be expected in vacuum. Additionally, atmospheric occultations also affect the phase velocity of the radio waves. Both changes modify the wave frequency and conversely, from the time variation of the Doppler measurements, the refractivity profile can be retrieved. This talk will give an overview of the achievable gravity and atmospheric science objectives in potential Ice Giants mission concepts, through a careful design of the spacecraft radio frequency system and the analysis of the tracking data acquired both on the ground and on-board.

Keywords: Radioscience, Gravity science, radio occultations, atmospheres, ionospheres, interiors

*Speaker

The Icy Giants & Triton's Ionospheres – lessons learned from Cassini observations within Saturn's and Titan's ionospheres

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Abstract

We discuss the importance to determine the structure and composition of the upper atmospheres and ionospheres of the Icy Giants (Uranus & Neptune) as well as Triton's ionosphere in the light of numerous recently obtained Cassini results. The ionizing radiation and charging environment within the upper atmospheres of Saturn and Titan creates a very complex organic chemistry leading to charged sub-nm-sized to 100 nm-sized aerosols. The charged dust has a profound effect on the ionospheric structure and related chemistry, enhancing the ion number density well above photochemical equilibrium levels, while the electrons tend to become attached to the dust population. The organic chemistry leads to compounds reaching above 50,000 amu diffusing downward and possibly creating a pre-biotic chemistry. This process, involving nitrogen, methane and water may very well be a more general process, also applicable for the cases of Uranus, Neptune and Triton, were all have these starting species abundant in their upper atmospheres. We therefore propose that a future mission to the Ice Giants and the moon Triton has Langmuir probe, electron spectrometer, dust, ion- and neutral mass spectrometers onboard to make detailed in-situ measurements on both the orbiter and atmospheric probe in order to investigate this fundamental chemistry and aerosol formation.

Keywords: upper atmosphere structure & chemistry

*Speaker

HIGH ENERGY ENTRY PROBES FOR ICE GIANT EXPLORATION. THE ARIANEGROUP CAPABILITIES

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Abstract

High entry velocity in the thick atmosphere of the Ice Giant Planets would present considerable peak heat flux and
heat load. It is worth keeping in mind for reference with the only past existing mission on giant planet Jupiter with
the Galileo values: 170MW/m^2, 2000 MJ/m^2.

Due to this very demanding environment, heatshield is a critical element, for which a very robust solution is
mandatory and carbon/phenolic or Carbon/carbon are most relevant candidates.
The presentation will address ArianeGroup heritage in the field of heatshield for European entry missions and will
introduce options Europe can consider for heat shield design in adequate shape and dimensions on the basis of
available materials such as carbon-phenolic or carbon-carbon. Particular attention will be paid on material and
technologies which are mastered at industrial level for ArianeGroup rocket propulsion core business.
It will also present an overview of ArianeGroup capabilities for entry probes (trajectory and aerothermodynamics
analyses, probe design, material qualification in a relevant environment, elaboration of a reliable thermal and
ablation model...)

Keywords: entry technologies, heat shield, carbon, phenolic, carbon, carbon, trajectory, aerodynamics, probe design, testing, thermal model, ablation model

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