CENTRE FOR PLANETARY SCIENCES AT UCL/BIRKBECK

11th Summer Meeting

Thursday 9 September 2021

Programme and Abstracts

Welcome

The Centre for Planetary Sciences at UCL/Birkbeck is delighted to welcome you to our Eleventh Summer Meeting, on Thursday 9 September 2021, which this year continues as a virtual event.

We hope you will enjoy this year's programme of talks from across our four departments, which includes research, mission updates and outreach news, from a number of our academic staff, postdocs and PhD students. We are also excited to have a talk from one of our Planetary Science MSc students, Alexandra Thompson, who will be joining the UCL Astrophysics group as an Exoplanets PhD student in October, and from summer student, Lorenzo Pia Ciamarra, about the results of his recent Exoplanets research in the Astrophysics Group at UCL.

As the virtual format allows us the opportunity to share our activities with a wider audience, feel free to forward the meeting link and this document to non-CPS colleagues who you think may be interested in attending, but **please do not share the meeting link more generally, e.g. on social media**.

This year we are using Zoom for the meeting, which hopefully most of you will be familiar with. To help the event run smoothly, please review the following section for joining instructions and best practice on the day.

Contents:

Guidance for attendees

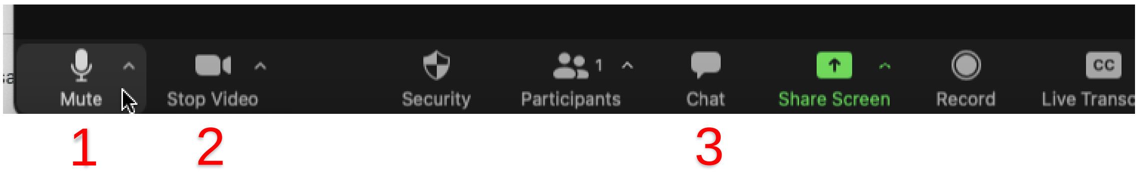
Remaining on mute

The organiser will mute all participants, apart from the speaker, at the start of the meeting. If you join the meeting late, or leave and re-join the meeting, please remember to mute your microphone. Please remain on mute while speakers are presenting their talks and posters.

You can toggle your mute status on and off by clicking the microphone icon on the left of the Zoom menu bar at the bottom of the active Zoom screen ('1' in the image below). You may need to tap or hover your cursor over the screen for the menu bar to appear.

Cameras

You can choose to have your video camera on or off for the meeting. You can start and stop your video feed using the camera icon in the menu bar ('2' in the image below).

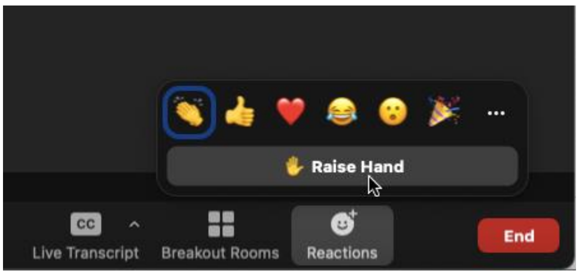


Questions for the speakers

There should be a few minutes for one or two questions from the audience after each talk and time for at least one question at the end of the poster flash-talks.

'Raise Hand' button

If you would like to ask a question to the presenter, please click the 'Raise Hand' icon via the Reactions button on the main menu bar (see image below) and wait for the session chair to request you un-mute and ask your question:



Please remember to re-mute yourself using the microphone icon in the menu bar after you have spoken, and lower your raised hand again via the Reactions button.

Chat box

You may also use the Chat function from the menu bar to post your questions for the speakers ('3' on the first image of the Zoom menu bar above). This will bring up a chat box on the right-hand side of the Zoom screen, where you can type your questions/comments. The chat will be monitored by the organisers.

We have a tight schedule, so apologies if not all questions can be asked on the day or if discussions are cut short. Please feel free to contact the speaker after the meeting if you wish to follow up on a topic.

Code of Conduct

All meetings of the Centre for Planetary Sciences at UCL/Birkbeck are committed to providing a safe, welcoming and inclusive experience for participants. Participants, including organisers, speakers, volunteers and attendees are expected to abide by our Code of Conduct.

Thank you for your participation in the CPS community, and your efforts to keep our meeting welcoming, respectful, and friendly for all participants!

The Centre for Planetary Sciences at UCL / Birkbeck
Virtual Summer Meeting 2021

Thursday 9 September

Programme

10:00 – 10:10	Dr Dominic Papineau *CPS Director, UCL Earth Sciences / LCN*	Welcome
10:10 – 10:30	Prof Geraint Jones *Mullard Space Science Laboratory*	The Comet Interceptor Mission
10:30 – 10:50	Qasim Afghan *Mullard Space Science Laboratory*	Gaps in the dust tails of comets C/2014 Q1 (PanSTARRS) and C/2002 F1 (Utsunomiya)
10:50 – 11:10	Dr Will Dunn *MSSL / Harvard CfA*	Mostly: Orbyts – Planetary Science Research-with-Schools Projects But also: X-rays from Jupiter and Uranus Highlights
11:10 – 11:20	COFFEE BREAK (10 mins)	
11:20 – 11:40	Affelia Wibisono *Mullard Space Science Laboratory*	Jupiter's X-ray aurora during UV dawn storms and injections as observed by XMM-Newton, Hubble, and Hisaki
11:40 – 12:00	Prof Nick Achilleos *UCL Physics and Astronomy*	The Magnetodisk Regions of Jupiter and Saturn
12:00 – 12:20	Dr Dimitrios Millas *UCL Physics and Astronomy*	Compressibility of the Jovian magnetosphere
Poster Session		
12:20 – 12:25	Matthew Cheng *UCL Physics and Astronomy*	Automated bow shock and magnetopause boundary classification at Saturn using statistics of magnetic fields and particle flux
12:25 – 12:30	Zuri Gray *MSSL / Armagh Observatory*	Polarimetry of Comet 67P
12:30 – 13:30	LUNCH BREAK	
13:30 – 13:50	Dr Dominic Papineau *UCL Earth Sciences / LCN*	The search for evidence of extraterrestrial life guided by biosignatures in sedimentary rocks from the Early Earth
13:50 – 14:10	Dr Shahab Varkouhi *UCL Earth Sciences*	Biogenic silica diagenesis and anomalous compaction in deep-sea depositional systems

14:10 – 14:30	Dr Lauren McKeown *Birkbeck Earth & Planetary Sciences*	Spiders on Mars
14:30 – 14:40	COFFEE BREAK (10 mins)	
14:40 – 15:00	Richard Haythornthwaite *Mullard Space Science Laboratory*	Deriving Cassini spacecraft potentials, cross-track and along-track ion velocities in Titan's ionosphere using measurements from CAPS ELS and IBS
15:00 – 15:20	Alexandra Thompson *MSc Planetary Science student, UCL P&A*	Characterising the Effects of Active Host Stars on Exoplanet Transmission Spectra
15:20 – 15:40	Prof Andrew Coates *Mullard Space Science Laboratory*	PanCam: the 'science eyes' of the Rosalind Franklin (ExoMars 2022) rover
15:40 – 16:00	Lorenzo Pica Ciamarra *Summer student, UCL P&A*	Unified transit and eclipse atmospheric retrievals yield better-constrained chemical abundances and TP profiles
16:00	MEETING CLOSE	

ORAL ABSTRACTS

Morning session

The Comet Interceptor Mission

Geraint H. Jones

Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK

Comets are strongly deserving of in situ study as they largely preserve material formed at our Solar System's birth. In 2019, Comet Interceptor was selected by the European Space Agency, ESA, as the first in its new class of Fast (F) projects. The Japanese space agency, JAXA, is making a major contribution to the project. Here, an update is provided on the project.

The mission’s primary science goal is to characterise for the first time, a yet-to-be-discovered long-period comet, preferably dynamically new, or an interstellar object. An encounter with a comet approaching the Sun for the first time will provide valuable data to complement that from all previous comet missions, which visited more evolved short period comets. The target's surface temperature could be above its constituent ices’ sublimation points for the first time.

Following a 2029 launch, the spacecraft will be delivered to the Sun-Earth L2 Lagrange Point. This relatively stable location allows a rapid response to the appearance of a suitable target comet, which will need to cross the ecliptic plane in an annulus containing Earth’s orbit. A suitable new comet would be searched for from Earth, with short period comets serving as backup targets. Powerful facilities such as the Vera Rubin Observatory make finding a suitable comet nearing the Sun very promising. The spacecraft could encounter an interstellar object if one is found on a suitable trajectory.

The spacecraft must cope with a wide range of target activity levels, flyby speeds, and encounter geometries. This flexibility has significant impacts on its solar power input, thermal design, and dust shielding that can cope with dust impacts from 10 to 70 km/s, depending on the target comet’s orbit. Comet Interceptor comprises a main spacecraft and two probes, one provided by ESA, the other by JAXA, which will be released by the main spacecraft on approach. The main spacecraft, which would act as the primary communication point for the whole constellation, would be targeted to pass outside the hazardous inner coma, making remote and in situ observations on the comet’s sunward side.

Planned measurements of the target include its surface composition, shape, and structure, its dust environment, and the gas coma’s composition. A unique, multi-point ‘snapshot’ of the comet- solar wind interaction region will be obtained, complementing single spacecraft observations at other comets. We shall describe the science drivers, planned observations, and the mission’s instrument complement, to be provided by consortia of institutions in Europe and Japan.

Gaps in the dust tails of comets C/2014 Q1 (PanSTARRS) and C/2002 F1 (Utsunomiya)

Qasim Afghan, Geraint H. Jones and Oliver Price

Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK

We report on the discovery of unambiguous regions of low dust number density in amateur images of the dust tails of long period comets C/2014 Q1 (PanSTARRS) and C/2002 F1 (Utsunomiya). In both cases, one such gap appeared in the dust tail post-perihelion. These gaps present themselves as a wedge-shaped region devoid of dust, with dust being present on either side of it.

The dust tails were simulated using the Finson-Probstein model [1]. The simulated tails were then overlaid onto images of the dust tails for comparison. Further analysis was performed by transforming the image and plotting it in dust beta vs. ejection time coordinate space, a novel temporal mapping method developed by Price and co-workers [2]. The image dataset for C/2014 Q1 was the most extensive, covering July to September 2015. The gap was visible throughout this observation period, and its shape and structure remained constant. This also applies to the gap present in C/2002 F1, although the dataset only ranged between 27th March and 3rd April 2002.

The results of the C/2014 Q1 study show that none of the dust on either side of the gap lay along the comet's orbital path, confirming that both sections of dust were part of the main dust tail, rather than the dust trail. The edges of the gaps were bounded accurately by synchrone lines, corresponding to dust that should have been ejected between 6th -12th July 2015. Analysis of C/2002 F1 found similar results, with the edges of its dust gap bounded accurately by synchrone lines corresponding to a dust ejection time between 18th - 24th April 2002. Thus, the dust gaps in both comets correspond to dust that should have been ejected during their respective perihelion passages on 6th July 2015 (C/2014 Q1) and 22nd April 2002 (C/2002 F1).

To the authors' knowledge, this is the first time such features have been identified in cometary dust tails, and their cause(s) are still uncertain. We shall briefly present potential formation mechanisms, the respective viability of which will improve through the identification and analysis of more comets which display these intriguing features.

[1] Finson, M. and Probstein, R. (1968) The Astrophysical Journal, 154, p.327

[2] Price et al. (2019) Icarus 319: 540-557.

Mostly: Orbyts – Planetary Science Research-with-Schools Projects

But also with a slide on this year's X-rays from Jupiter and Uranus Highlights

W. Dunn

Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK

Teachers D. Fleming and W. Whyatt respectively say:

"this project has surpassed anything I could have possibly imagined - not only have our students been consistently blown away by the science of other planets, it has helped them better understand the value of their own one. Orbyts is definitely one of the coolest things I've been exposed to in my 15 year career."

"It's clear to me that the Orbyts project has been the most successful project we have been fortunate to work with and its importance cannot be overstated."

So what is Orbyts, how is it having such a profound impact on school students and what makes teachers think it's quite so cool?

Orbyts is a movement organised by space researchers and teachers that creates partnerships between scientists and schools. This provides school students with relatable science role models while empowering them to conduct their own original space research projects. This structure of regular interventions, inspirational role models and active ownership of scientific research is proving to be transformative; dispelling harmful stereotypes and profoundly shifting perceptions of science and scientists. It is proving to be particularly impactful for groups historically excluded from science. For example, our partner schools report 100% increases in girls uptake of A-level physics, following participation in an Orbyts project at GCSE. Given that Osbyts builds a symbiosis between research and schools, since 2018, it has enabled 150+ UK state school students to author publications (10s of planetary papers) - most of these student-authors are pupil premium and/or widening participation students.

In 2021, our fantastic planetary researchers partnered with school students to support research-with-schools projects on: exoplanets, aurorae, AI and machine learning, magnetospheres, Mars' atmosphere and space environment, cometary tails, space weather and X-ray observations of planets. In this talk, I'll showcase a whistle-stop tour through some of these projects, where possible letting recorded presentations by the schools do the talking. I'll overview the process of creating projects, the general structure and timeline of them and what our evaluation data shows about the value of different aspects of the programme on students, teachers and researchers. I'll also speak briefly on the best practice seminars/workshops on inclusivity, teaching, communication and management training that we offer for interested researchers and on how we pay PhD students for their time producing and delivering projects.

While through 4 years delivering over 100 research-with-schools projects, we have begun to build solid foundations of best practice, we are constantly seeking to improve the programme and to collaborate and partner with new people to improve the science experiences of everyone involved – we hugely welcome any contact about Orbyts.

Jupiter's X-ray aurora during UV dawn storms and injections as observed by XMM-Newton, Hubble, and Hisaki

A.D. Wibisono[1,2], G. Branduardi-Raymont[1,2], W.R. Dunn[1,2], T. Kimura[3], A.J. Coates[1,2], D. Grodent[4], Z.H. Yao[5], H. Kita[6], P. Rodriguez[7], G.R. Gladstone[8], B. Bonfond[4], R.P. Haythornthwaite[1,2]

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[2] The Centre for Planetary Science at UCL/Birkbeck, Gower Street, London, UK

[3] Department of Physics, Faculty of Science, Tokyo University of Science, Japan

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[6] Department of Information and Communication Engineering, Tohoku Institute of Technology, Japan

[7] European Space Astronomy Centre, Madrid, Spain

[8] Southwest Research Institute, San Antonio, Texas, USA

Voyager 1 detected the first extra-terrestrial UV auroral emissions when it explored the Jupiter system in 1979 while the planet's X-ray aurora was discovered later that year by the Einstein Observatory. Electrons are accelerated into Jupiter's atmosphere near the poles and excite native molecular and atomic hydrogen. These then release UV photons after returning to the ground state. The same population of precipitating electrons can also emit high energy (>2 keV) X-ray photons by bremsstrahlung to produce Jupiter's hard X-ray aurora. Towards the pole, and within the oval of UV and hard X-ray emissions is where the more diffuse UV and low energy (<2 keV) soft X-ray aurorae are found. Charge exchange processes between precipitating ions and neutrals in the gas giant planet's atmosphere are responsible for the soft X-ray emissions.

Simultaneous observations of Jupiter's UV and X-ray aurorae were carried out by the Hubble Space Telescope (HST), Hisaki satellite and XMM-Newton in September 2019 to support Juno's 22nd perijove. Images of the northern far UV aurora by HST showed internally driven dawn storms and injection events occurring at least twice during the observation period. These features are thought to be caused by magnetic reconnection happening in the middle magnetosphere. This subsequently leads to the dipolarization of the field lines which injects hot magnetospheric plasma from the middle to the inner magnetosphere. Hisaki saw an impulsive brightening in the Io plasma torus on the day of the second event showing that there was indeed a large-scale injection that penetrated the central torus in the inner magnetosphere. At this time, the northern aurora brightened in both extreme UV and hard X-ray wavebands, which suggests that there was an increase in electron precipitation, or that the precipitating electrons were more energetic. There was no response from the soft X-ray aurora, and no quasi-periodic pulsations, often observed in the auroral emissions, were detected during either of the events. X-ray spectral analysis reveals that the precipitating ions were iogenic and that there may have been a second population of electrons precipitating during the dawn storms.

The Magnetodisk Regions of Jupiter and Saturn

Nick Achilleos / UCL Planetary Plasmas Group

Department of Physics and Astronomy, UCL, London, UK

The rapidly rotating magnetospheres of the gas giant planets, Jupiter and Saturn, are natural laboratories for learning about magnetized plasmas. Several spacecraft missions have provided a wealth of observations that confirm the central role of the “magnetodisk” structure in these systems. This region consists of a magnetic field generated by an extended current sheet, and the associated plasma disk. Magnetodisks continually change in response to various mechanisms – including the rotating, tilted dipole of the parent planet; the magnetopause currents; and, for Saturn in particular, rotating systems of current that communicate energy between the planet's atmosphere and the disk. In this review, we provide a summary of some of the mechanisms that determine magnetodisk structure and dynamics at both Jupiter and Saturn, and their observational signatures. We then discuss approaches to modeling the magnetic fields and currents in the middle magnetosphere regions. We discuss the influence of the magnetodisk on magnetospheric compressibility, and investigate the roles of planetary rotation and energetic particles in determining plasmadisk structure.

Compressibility of the Jovian magnetosphere

Dimitrios Millas

Department of Physics and Astronomy, UCL, London, UK

The magnetospheres of giant planets in our Solar System (Jupiter and Saturn), are a unique type of space laboratories for magnetized plasma. Their rapid rotation, composition and size result in major differences compared to the terrestrial magnetosphere, the most prominent being the presence of a disc-type magnetic structure.

A global model of the magnetosphere, including the "magnetodisc", can be constructed via an iterative scheme first presented by Caudal (1986). The model assumes an axisymmetric 2D magnetosphere and a magnetic dipole as an initial state. In addition, we implement a correction algorithm (Pontius' scheme), using the equatorial magnetic field structure to obtain an angular velocity profile consistent with the magnetodisc. This updates the angular velocity obtained from Hill's method, which is valid for a magnetic dipole.

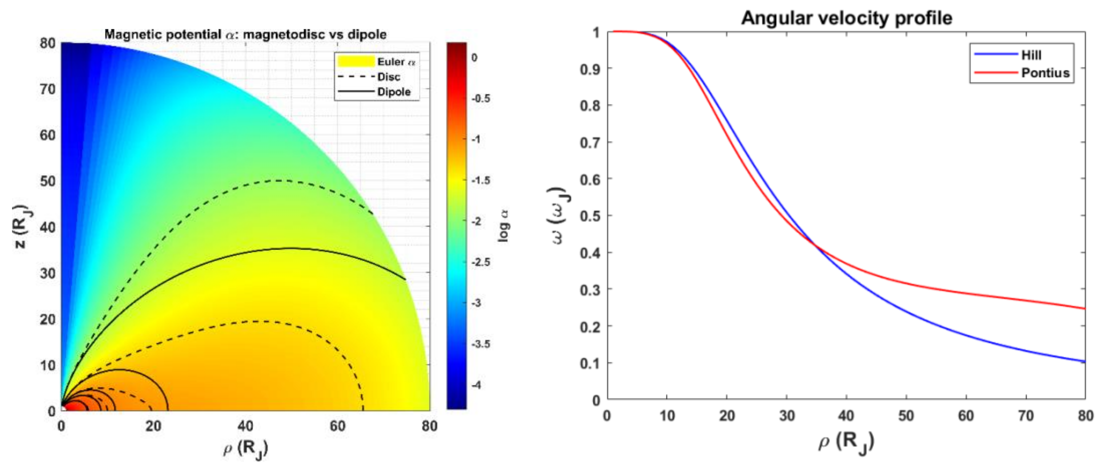

***Figure 1**. <u>Left:</u> Model of the Jovian magnetosphere, showing the magnetic potential (colour scale, normalized to the planetary value) and selected field lines. The dashed and solid lines correspond to the magnetodisc and dipolar field respectively. The stretching of the magnetic field lines compared with the dipolar case becomes evident after ~12 Jovian radii. <u>Right:</u> Equatorial angular velocity profile using Hill's method (consistent with a dipole) and Pontius' scheme (consistent with the magnetodisc structure).*

Although internal drivers are considered important in some cases, the solar activity remains the most prominent (external) driver which determines the dynamics of these magnetospheres. The response of the magnetosphere due to a change in the solar wind can be quantified by the compressibility index, calculated from the magnetopause radius as a function of the total pressure.

We present results of a numerical study of the compressibility of the Jovian magnetosphere, using the algorithms described above. First, we produce a large ensemble of models which are used as virtual observations (or "crossings"). Each model has a different system size (defined by the magnetopause distance) and hot plasma content (defined by the hot plasma index. We evaluate methods of different order to obtain the compressibility index and discuss the effects of the system size. We compare the results with observations of the Jovian magnetosphere and with similar studies focused on the magnetosphere of Saturn.

POSTER ABSTRACTS

Morning session

Automated bow shock and magnetopause boundary classification at Saturn using statistics of magnetic fields and particle flux

I Kit Cheng[1], Nicholas Achilleos[1], Patrick Guio[1,2]

[1]Department of Physics and Astronomy, UCL, London, UK

[2]Department of Physics and Technology, Arctic University of Norway, Tromsø, Norway

Statistical studies of the properties of different plasma regions, such as the magnetosheath and outer magnetosphere found near the boundaries of planetary magnetospheres, require knowledge of boundary (bow shock and magnetopause) crossings for purposes of classification. These are commonly detected by visual inspection of the magnetic field and / or particle data sampled by the relevant spacecraft. Automation of this type of activity would thus improve the efficiency of boundary and region studies, which benefit from large crossing datasets, and could also have implications for future development of onboard data-processing protocols in the pre-downlink stage.

The Cassini mission at Saturn (2004-2017) provided an invaluable dataset for testing the viability of automated boundary classification. The training dataset consists of BS and MP crossings for the time period 2004 to 2016 (Jackman et al. (2019)). We have employed a series of techniques which involve pre-processing the calibrated magnetometer data, unsupervised training of a LSTM recurrent neural network on magnetometer data to filter magnetosheath regions where crossings are most likely to be found, isolating large rotations in magnetic field using minimum variance analysis (MVA), feature engineering such as magnetic field strength ratio either side of the field rotation to form a 'feature vector' for each candidate, and finally applying a gradient-boosting decision-tree-based algorithm to predict the probability that a given interval of data contains the signature of a bow shock (BS), a magnetopause (MP), or None (not a boundary crossing).

The resulting model performs better on bow shock events, with a precision (fraction of true events in the retrieved sample) and recall (fraction of the total true events which were retrieved) of ~86% and ~90% respectively, as compared to ~50% and ~68% for the MP. The ongoing work focuses on augmenting the feature space for improved classification of MP, based on a magnetic pressure model of MP crossings derived using a local pressure balance condition (e.g. Pilkington et al. 2015) and using the distinct energetic particle flux changes across the MP in MIMI data (e.g. Liou et al. 2021). We expect that these promising new features will help us to better constrain the retrieval of candidate events which are true MP crossings.

Polarimetry of Comet 67P

Zuri Gray

MSSL / Armagh Observatory

We have obtained polarimetric measurements using ESO's VLT of the 2016 and 2021 apparitions of Jupiter Family Comet (JFC) 67P/Churyumov-Gerasimenko, known for being the target of ESA's Rosetta mission. Polarimetry is more sensitive to changes in the scattering medium than techniques based solely on intensity measurements and can be used to set constraints on the characterisation of comets. By measuring the degree of linear polarization as a function of phase-angle, comets can be classified either as low-polarisation comets (and hence, gassy) or a high-polarisation comets (dusty). During our observing campaign, 67P will cover a wide phase angle range of ~4-45°. The polarimetric phase-curve of 67P shows that it is a dust-rich comet, uncommon for JFCs which are generally categorised as gassy comets due to their depleted dust reservoirs and space weathering. To measure spatial and temporal variation of the dust in the coma, we have also plotted polarimetric and colour maps of our data.

ORAL ABSTRACTS

Afternoon session

The search for evidence of extraterrestrial life guided by biosignatures in sedimentary rocks from the Early Earth

Dominic Papineau

London Centre for Nanotechnology, Department of Earth Sciences, University College London, UK

The Centre for Planetary Sciences at UCL/Birkbeck, London, UK

An archive of early biological evolution on the primitive Earth is preserved in siliciclastic and chemically precipitated sedimentary rocks. This archive serves the double purpose of contributing to understand the origin and early evolution of life on Earth and to establish targets to search for extraterrestrial life. In fact, if life ever arose on another planetary body, it will have gone through some early evolutionary stage that might be preserved in a similar ancient rocky context. However, biosignatures in these rocks are difficult to recognize because of the numerous abiotic processes that can mimic most known biosignatures in such rocks. Hence, 'biosignature' is a term that needs to be redefined as a '*possible* signature of life', because there are no unambiguous, smoking-gun biosignature. This contribution aims to compare the biotic and abiotic processes on the primitive Earth that can produce biosignatures. It is concluded that the multidisciplinary combination of many biosignatures observed in the geological context (inferred paleo-environment), sedimentology, petrology, mineralogy, micropalaeontology, and inorganic and organic geochemistry is essential to provide a complete understanding and reach compelling conclusions.

Keywords: Biogenic silica diagenesis; Anomalous compaction, Opal-A; Opal-CT; Ocean Drilling Program

Biogenic silica diagenesis and anomalous compaction in deep-sea depositional systems

Shahab Varkouhi

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The Centre for Planetary Sciences at UCL/Birkbeck, London, UK

The diagenesis of biogenic silica leads to dramatic petrophysical changes in the host sediment (i.e. anomalous compaction), in particular over the depth of the opal-A to opal-CT transition zones. However, although diagenetic processes associated with these variations are reasonably well understood, the kinetics of the opal-A to opal-CT reaction are not well represented by quantitative models. Constraining the rates and mechanisms that cause anomalous compaction is therefore crucial in identifying which transitions are still active, or ongoing, versus arrested. This, in turn, will improve our understanding of silica cycling and sedimentation through time. The present work documents the petrophysical-property variations in the Neogene siliceous deposits at the Ocean Drilling Program Sites 794 and 795 in the Sea of Japan, and places them in a diagenetic context to gain a process-based understanding of the physical and chemical controls on diagenesis in biogenic opaline sediments. Physical-property measurements and quantitative mineralogy show that the abrupt porosity reduction during opal-A to opal-CT transformation at Sites 794 and 795 can be attributed to chemically-induced sudden anomalous compaction phenomena that cause sediment framework to lose its strength, under fragmentation and extensive opal-A dissolution, allowing collapse of the sediment matrix. The subsequent precipitation of pore-filling opal-CT further decreases the porosity. Pore-water chemistry and thermodynamic analyses indicate that solubility equilibrium has been reached with respect to opal-CT in the transition zones at the investigated sites, implying that the precipitation of opal-CT is still an active reaction. Even though silica dissolution is triggering a reverse-weathering process, the thermochemical equilibrium reached with diagenetic opal suggests that the silica sink across the transition zones is influenced by ongoing opal-A to opal-CT transformation. The markedly low silica diffusion fluxes, the low permeability of accommodating sediment, and the considerable pore-water loss at the depth of the transition all support this conclusion that the dissolved silica has not been diffused in the sediment at rates comparable to those by interstitial-water advection.

Spider on Mars

Lauren McKeown

Department of Earth and Planetary Sciences, Birkbeck, University of London, UK

The local redistribution of granular material by sublimation of the southern seasonal CO2 ice deposit is one of the most active surface shaping processes on Mars today. This unique geomorphic mechanism is hypothesised to be the cause of the dendritic, branching, spider-like araneiform terrain and associated fans and spots—features which are native to Mars and have no Earth analogues. However, there is a paucity of empirical data to test the validity of this hypothesis. Additionally, it is not clear whether some araneiform or 'spider' patterns began as radial and then grew outward, or whether troughs connected at mutual centres over time. This talk will present the results of a suite of laboratory experiments undertaken to investigate if the interaction between a sublimating CO2 ice overburden containing central vents and porous, mobile regolith under Mars pressure will mobilise grains from beneath the ice in the form of a plume to generate spider patterns.

Deriving Cassini spacecraft potentials, cross-track and along-track ion velocities in Titan's ionosphere using measurements from CAPS ELS and IBS

R. P. Haythornthwaite [1,2], A. J. Coates[1,2], G. H. Jones[1,2], A. Wellbrock[1,2]

1. Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, Dorking, UK
2. The Centre for Planetary Sciences at UCL/Birkbeck, London, UK

Introduction

Pre-Cassini models of Titan predicted thermospheric winds of up to 60 m/s, however, from Cassini-Huygens and ALMA observations there have been indications of superrotation in the thermosphere/ionosphere, with neutral wind speeds up to 390 m/s. Previous in-situ measurements have measured positive ion velocities along Cassini's trajectory (along-track), finding velocities up to 260 m/s.

The Cassini Plasma Spectrometer (CAPS) Electron Spectrometer (ELS), CAPS Ion Beam Spectrometer (IBS) and the Radio & Plasma Wave Science (RPWS) Langmuir Probe (LP) instruments on Cassini can derive values for the spacecraft potential that arises from spacecraft charging. However, there are discrepancies in the magnitude of the derived spacecraft potential between the instruments. Derived spacecraft potentials of Cassini in Titan's ionosphere are in the range between 0 and -3.5V, with ELS-derived potentials typically being more negative than the Langmuir probe, while IBS-derived potentials are more positive.

Here we derive spacecraft potentials and along-track ion velocities from the energies of the observed ions and attempt to derive cross-track ion velocities by utilising the actuation of the CAPS instrument.

Methodology

The CAPS instrument consists of three electrostatic analysers, which measure the energy/charge ratios of ions. In this study, we utilise data from CAPS ELS and IBS which observed negative and positive ions respectively. In Titan's ionosphere, ions are observed by CAPS as a supersonic beam in the instrument frame, the energies of the ions are related to the ions' mass, the spacecraft velocity, the along-track ion velocity, and the spacecraft potential.

Cross-track velocities are perpendicular to Cassini's trajectory. These velocities cause the ions to be detected from a direction which is a small angle away from Cassini's trajectory. This angle can be measured due to the actuation of CAPS across the spacecraft's velocity vector.

Results

Positive and negative ion velocities are measured both along Cassini's trajectory (along-track) and perpendicular to it (cross-track). Proportionality is observed between the positive and negative ions for the derived along-track and cross-track velocities, which agrees with the expectation of collisional coupling between the positive and negative ions and the neutrals.

The magnitudes of these velocities are up to several hundred m/s, which is higher than previously reported from *in situ* measurements, but comparable to ALMA measurements of prograde neutral winds of up to 390 m/s.

Characterising the Effects of Active Host Stars on Exoplanet Transmission Spectra

Alexandra Thompson

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With over 4000 exoplanets currently confirmed and this number rapidly increasing as a result of the numerous exoplanet-sensitive and dedicated missions in operation, exoplanetary science is arguably one of the fastest growing fields in astrophysics. Excluding the small number of planets that are favourable to direct imaging, the host star and any exoplanets orbiting it are observed as a blended / unresolved source. This means that the stellar and planetary signals are intrinsically entangled and we cannot treat exoplanets as isolated objects. Knowledge of the stellar properties is therefore essential towards accurately constraining properties of the planetary atmosphere. One of the largest effects the host star can potentially have on exoplanet transmission spectra is stellar contamination. This is introduced by active regions on the stellar photosphere in the form of colder spots and hotter faculae that may result in the transit chord, the true light source for the transmission spectrum, deviating from the disk-integrated spectrum of the host star. Contamination features due to the star have the potential to mask genuine planetary signals or mimic them, resulting in spurious detections. This research focuses on the effects of unocculted active regions, with unocculted spots increasing the transit depth at shorter, optical / near-IR wavelengths where the contamination is strongest, and unocculted faculae decreasing it. To complicate matters further, there is no one-size-fits-all stellar contamination correction for exoplanetary systems. The covering fractions of spots and faculae increase substantially towards later spectral types e.g. K and M dwarfs which typically show high variability amplitudes indicative of very heterogeneous photospheres. On top of this, we also have to account for temporal variations in stellar activity, particularly on the timescales of stellar rotation and the evolution and decay of spots and faculae. This means that observations of the same exoplanet system taken at different epochs may be contaminated by different levels of stellar activity and may need to be treated separately.

Since recognising this problem, multiple ways of correcting for stellar contamination have recently been pioneered by the exoplanet community, ranging from simply masking datapoints associated with occulted active regions to combined stellar and planetary retrievals. In alignment with this wider goal, I have introduced a stellar activity plugin to the UCL Exoplanet Group's retrieval code TauREx3 that introduces 4 additional fitting parameters related to the heterogeneity of the host star. These parameters are the spot covering fraction (Fspot), the spot temperature (Tspot), the facular covering fraction (Ffac) and the facular temperature (Tfac). Firstly, I test the retrievability of these parameters on simulated observations of 4 spectral types (F5V, G5V, K5V and M5V) each displaying a typical level of activity for their class. I also conduct a second, simpler retrieval on the same simulated observations which does not account for stellar heterogeneity. I compute the Bayesian evidences for the two retrievals and use this to discuss whether the additional complexity of a retrieval constraining stellar activity is warranted for each spectral type. Finally, I demonstrate the use of the plugin with real observations by re-analysing the observations of LHS 1140b (Edwards et al. 2020) for which stellar activity was considered in forward modelling but not in retrieval. The results of my retrieval analysis reinforce the conclusions of Edwards et al. in which they infer the presence of faculae on LHS 1140. The plugin has also been used extensively to analyse HST STIS spectra for WASP-17b (Saba et al. in prep).

PanCam: the 'science eyes' of the Rosalind Franklin (ExoMars 2022) rover

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The scientific objectives of the ExoMars Rosalind Franklin rover [1] are designed to answer several key questions in the search for life on Mars. In particular, the unique subsurface drill will address some of these questions for the first time, such as the possible existence and stability of sub-surface organics. PanCam [2] will establish the surface geological and morphological context for the mission, working in collaboration with other context instruments. Here, we give an update on this exciting mission, and describe the PanCam scientific objectives in geology, atmospheric science and 3D vision. We discuss the design of PanCam, which includes a stereo pair of Wide Angle Cameras (WACs), each of which has an 11 position filter wheel, and a High Resolution Camera (HRC) for high resolution investigations of rock texture at a distance. The cameras and electronics are housed in an optical bench that provides the mechanical interface to the rover mast and a planetary protection barrier. The electronic interface is via the PanCam Interface Unit (PIU), and power conditioning is via a DC-DC converter. PanCam also includes a calibration target mounted on the rover deck for radiometric calibration, fiducial markers for geometric calibration and a rover inspection mirror. Recent simulations [3] show the view from PanCam, the 'science eyes' of the Rosalind Franklin rover. We will show Summer 2021 images from the PanCam Engineering Model on the Ground Test Model rover in the Mars Terrain Simulator at ALTEC, Turin, the ultimate operations centre for Rosalind Franklin.

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Unified transit and eclipse atmospheric retrievals yield better-constrained chemical abundances and TP profiles

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Most often, atmospheric retrievals are run on single observations of an exoplanet, either a transit or an eclipse, analysing respectively the terminator region and the dayside as completely separate, non-interacting regions, in what is evidently a reductive approach. During the summer, I investigated – under the supervision of Prof Tinetti and Dr Changeat, within a Brian Duff Studentship – the potential benefits of performing unified retrievals on transits and eclipses, under the assumption that atmospheric chemistry can be coupled between the terminator region and the dayside. Such unified retrievals on simulated ARIEL data for Hot Jupiter HD 209458b resulted in significantly better and more accurate constraints on both the atmospheric chemistry and the dayside and terminator's T-P profiles than traditional transit-only or eclipse-only retrievals.