BPSC Posters - Chondrites
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

1. Correlated Imaging & Diffraction of Bennu Particle OREX-803053-0

Ashley King (Natural History Museum, London)

Co-authors: Paul Schofield (NHM), Sara Russell (NHM), Natasha Almeida (NHM), Liam Perera (DLS), Alberto Leonardi (DLS), Sharif Ahmed (DLS), Harold Connolly Jr (RU/AMNH/LPL-UoA), Dante Lauretta (LPL-UoA)

Key points: Mineralogy and textures of a Bennu particle investigated using 3D synchrotron imaging and diffraction.

Primitive asteroids that accreted beyond the snowline likely contributed to the volatile inventory of the terrestrial planets. On 24 September 2023, NASA's Origins, Spectral Interpretation, Resource Identification, and Security Regolith Explorer (OSIRIS-REx) mission returned to Earth a pristine sample of the carbon-rich asteroid Bennu [1]. Unmodified by the terrestrial environment, the mineralogy and textures of the sample can test hypotheses about the geological history of Bennu and the extent to which its parent body was modified by metamorphism, including fluid/rock interactions, and impacts [2].

Bennu particle OREX-803053-0 is ~1 mm in size and was allocated from the bulk sample collected by the Touch-and-Go Sample Acquisition Mechanism (TAGSAM). The particle was mounted using cleaned stainless-steel tweezers onto a conductive carbon adhesive disc and imaged using an FEI Quanta 650 field emission scanning electron microscope (SEM) at the Natural History Museum (NHM), London. The particle was then investigated using Dual Imaging And Diffraction (DIAD, K11), the newest beamline at Diamond Light Source (DLS), UK, which offers unique non-destructive, spatially correlated 3D imaging and phase identification of complex samples at the micron scale.

The mineralogy of Bennu particle OREX-803053-0 is dominated by abundant fine-grained phyllosilicates, with minor Fe,Ni-sulphides, sometimes occurring as hexagons or laths up to ~5 µm in size, and clusters of magnetite framboids. Overall, the particle is relatively homogenous and appears to consist of a single lithology. The mineralogy and texture of OREX-803053-0 is comparable to highly aqueously altered chondrites and attests to fluid-rock reactions that were extensive within Bennu.

[1] Lauretta et al. (2022) Science 377:285.
[2] Lauretta et al. (2023) arXiv [astro-ph.EP] 2308.11794.

2. Distinguishing Extraterrestrial Organic Compounds from Terrestrial Contaminants in the Winchcombe CM Chondrite.

Lydia Hallis (University of Glasgow, UK)

Co-authors: Aine O'Brien (UoG), Clement Regnault (UoG), Gavin Blackburn (UoG), Phillip Whitfield (UoG), Douglas Morrison (SUERC)

Key points: Winchcombe's carbonaceous classification (CM2), in addition to its minimal terrestrial exposure, make it the ideal meteorite for the study of extraterrestrial organics [e.g., 3]. Here we present results from a targeted liquid chromatography mass spectrometry (LC-MS) study of solvent extracts from two Winchcombe samples, analysed at the University of Glasgow Polyomics facility.

The definitive identification of extraterrestrial organic compounds within meteorites and other extraterrestrial materials is highly problematic due to the ubiquitous presence of terrestrial contaminants. Even the least terrestrially exposed meteorites and the most carefully curated returned samples rapidly acquire organic contaminants from the surrounding environment. One method of identifying extraterrestrial organic molecules is to determine the molecule-specific isotopic ratios, as these ratios are known to be different on different planetary bodies. Gas-chromatography isotope ratio mass-spectrometry (GC-IRMS) is frequently used to determine the isotopic ratios of terrestrial organic molecules, but this technique requires a sample with a high abundance of organic material and/or a large sample mass. For example, previous GC-IRMS studies required several grams of relatively organic-rich carbonaceous chondrite meteorites to successfully determine compound-specific isotopic ratios [e.g., 1-2]. Such a mass is prohibitively high for precious returned samples as well as low-mass meteorites.

Winchcombe's carbonaceous classification (CM2), in addition to its minimal terrestrial exposure, make it the ideal meteorite for the study of extraterrestrial organics [e.g., 3]. Here we present results from a targeted liquid chromatography mass spectrometry (LC-MS) study of solvent extracts from two Winchcombe samples, analysed at the University of Glasgow Polyomics facility. Our data indicates that, amongst other organics, Winchcombe contains several sulfonates that are not present within the environmental control samples collected during the meteorites recovery from the field.

References: [1] Sephton and Gilmore (2004) Handbook of Stable Isotope Analytical Techniques, Volume 1. [2] Huang et al. (2015) Earth and Planetary Science Letters 426,101-108. [3] Chan et al. (2022) Meteoritics and Planetary Science doi: 10.1111/maps.139361Ó2023.

3. Leave no stone unturned: searching for a meteorite fall near Stone, UK.

Luke Daly (University of Glasgow, UK)

Co-authors: A. J. King, K. H. Joy, H. A. R. Devillepoix, D. Vida, F. Colas, J. Rowe, R. Tartèse, M. R. Lee, B. Lathrop, R. Bassom, M. Hankey, UK Fireball Alliance

Key points: A stone fell near Stone, Tried to find near Stone the stone, No Stone from Stone yet!

With the spread of fireball camera networks around the world, witnessing fireballs that drop meteorites is becoming more and more frequent. However, successfully searching for meteorites, particularly in Northern Europe's farmland remains challenging. Here we report the fireball observations, search campaign, and les-sons learned for a recent meteorite fall near the town of Stone, UK.
At 3 am UTC on Monday the 6th of May 2024 a fireball was witnessed across the UK by cameras of the UK Fireball Alliance (UKFAll). Our models predicted that 200-600g of material survived atmospheric entry and fell near the town of Stone to the south-east of Stoke-on-Trent, UK. The steep angle of entry meant the strewn field was constrained to a relatively small area 2-3 km long. Fragmentation events in the fireball implied there would be several small pieces along the strewn field. The meteoroid also had a near Earth pre-atmospheric orbit, and the fall site was largely grassland. Given these factors, alongside the possibility of finding the 'Stone' meteorite (can you imagine!), a search was organised. A team of five people arrived in the area on Wednesday 8th May to meet local landowners and get permission to search the strewn field. An international team of > 20 volunteers helped search the strewn field for two and a half days, but sadly no meteorite was found. A press release has been distributed to raise awareness about the recent meteorite fall and it is our hope that the meteorite may yet be found.

BPSC Posters – Small Bodies
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4. NEO-MIR, an ESA infrared space telescope to detect and characterise potential asteroid impactors

Marco Delbo (Observatoire de la Côte d'Azur, France)

Co-authors: Luca Conversi (ESA/ESRIN), Javier Licandro (IAC, Spain), Thomas Muller (MPE, Garching bei Munchen, Germany), Alan Fitzsimmons (QUB, UK), Marcel Popescu (AI-RA Bucharest, Romania), Paolo Tanga (Observatoire de la Côte d'Azur, Nice, France)

Key points: ESA's NEO-MIR infrared space telescope. Detection and characterisation of potential Earth-impacting asteroids.

NEOMIR is an ESA-coordinated preliminary study of an infrared space-based mission dedicated to discover and characterise the near-Earth Object (NEO) population. NEOMIR is specifically designed to detect and measure the size of potential imminent Earth-impacting asteroids, with sufficient warning time to be able to track them and possibly mitigate the impact risk. During an initial phase-0, various mission scenarios have been analysed by ESA’s Concurrent Design Facility (CDF). The outcome consisted of a mission scenario that has been further investigated via industrial contracts during the years 2022 and 2023.
NEOMIR is a wide-field telescope with medium infrared detectors operating in the 5 - 10 micron wavelength range, allowing us to detect the heat emitted by asteroids. NEOMIR is designed to observe at a solar elongation between 30 and ~40 degrees from the Earth-Sun Lagrangian point L1. This observing configuration offers the important advantage to detect potential impactors coming from a direction towards the sun. This is one of the directions from which most of the earth-impactors come, the other begin a region of the sky near opposition. While the latter can be explored with optical telescopes during the night, the former can only be observed from space. Observing in a direction close to the Sun present, however, specific challenges, such as the high background due to hot zodiacal light, high phase angle of observations, and rapid proper motion of the NEOs.

5. Broken TNOs in the main belt?

Chrysa Avdellidou (University of Leicester, UK)

Co-authors: Tom Halliday (UoL, UK), Marco Delbo (OCA, FR)

Key points: Using Gaia reflectance spectra from Data Release 3 we identified asteroid families in the asteroid main belt that show the reddest spectra.

The asteroid main belt consists of millions of asteroids. Spectroscopic observations have revealed the plethora of asteroid compositions. Linking asteroids to known meteorites can reveal their internal composition, as well as the time and place of their accretions in the solar system. It is now established that not all the asteroids accreted in their current location in the main belt, but instead they were implanted into their current orbits via several dynamical processes during the early evolutionary stages of the solar system.
In the asteroid main belt have been identified more than 110 families of asteroid fragments, which were produced by collisions among asteroids. By studying the asteroid members of the families, we can understand the internal structure of their progenitors.
Although dynamical models and spectroscopic observations showed that transneptunian objects were implanted into the main belt, however, up to know we have not detected any related asteroid family. Transneptunian objects should show dark surfaces in terms of geometric visible albedo values and red, featureless spectra in the visible and near infrared wavelength range.
The lack of such families has been an open question since spectroscopic surveys of near-earth asteroids revealed an excess of these type of objects in the near-earth space. But where did they come from the belt?
Using Gaia Data Release 3 and literature data, we identified four asteroid families having very low geometric visible albedo values and red-featureless spectra. These four families appear to be the reddest of all known dark families.

6. AI-powered twilight discovery of near-Sun asteroids and naked-eye comets at Palomar Observatory

Bryce Bolin (Goddard Space Flight Center, NASA)

Co-authors: Frank Masci, Dima Duev, Michael Coughlin

Key points: We searched the twilight sky at Palomar Observatory for comets and interior Earth asteroids. We found the first known inner Venus asteroid 593914 Aylochaxnim and naked-eye bright come C/2022 E3.

While the majority of solar system objects discovered by wide field surveys are ordinary, they also provide the opportunity to discover hidden gems such as interstellar objects, near-Sun asteroids, and bright comets. These provide opportunities to characterize extrasolar planetesimals, search for new sources of asteroids in the inner solar system, and study the composition of the protoplanetary disk. I will describe the development of AI-based techniques used to drive the discovery of these hidden gems in current and next-generation surveys such as the Zwicky Transient Facility and the Rubin Observatory Legacy Survey of Space and Time. I will describe three examples of AI-assisted solar system results: 1.) the discovery and follow-up observations of (594913) 'Ayló'chaxnim, the first known asteroid possessing an aphelion entirely within the orbit of Venus, 2.) the recovery of interstellar comet 2I/Borisov and 3.) the discovery of naked-eye comet C/2022 E3 (ZTF). I will discuss the behind-the-scenes work of using AI in these results as well as their implications for the formation of the solar system and the composition of extrasolar and solar system planetesimals.

7. Solar Radiation Pressure Effects on Dust at Small Heliocentric Distances

Jake Hanlon (MSSL/University College London)

Co-author: Geraint Jones (MSSL/UCL)

Key points: At small heliocentric distances radiation pressure force does not follow an inverse square law. Here we present an empirical relationship which can be applied to near sun dust motion simulations.

Dust grains are typically modelled using the ratio of radiation pressure and gravity. At distances greater than 1 au where the sun can be considered as a point source this is a reasonable assumption. However, at small heliocentric distances this becomes in accurate and radiation pressure does not follow an inverse square law. By considering the decrease in the visible solar area and the radial solar radiation forces we developed an empirical relationship that corrects for the breakdown of the inverse square law. This correction may be applied to near-sun dust motion studies.

8. Detectability of a possible near-surface particulate layer from near-IR spacecraft observations

Shubham Kulkarni (University of Oxford, UK)

Co-authors: Patrick GJ Irwin (University of Oxford, UK), Colin F Wilson (ESA-ESTEC, NL)

Key points: This work investigates the sensitivity of simulated near-IR spacecraft observations to the assumed variability of a hypothesised near-surface particulate layer in the atmosphere of Venus.

The Venera 13 in-situ spectrophotometric data indicates the presence of a possible near-surface particulate layer (NSPL). Such a layer could have an aeolian or volcanic origin or it could form due to volatile transport from the surface. Considering the possible formation mechanisms, it is likely that NSPL would exhibit some form of spatio-temporal variability. In this context, this work examines the possibility of detecting the NSPL through repeated near-IR spacecraft observations of the same location.
NEMESIS (Irwin et al., 2008), a radiative transfer and retrieval tool, is used to retrieve the parameters like size, abundance, and refractive index of the particles forming the NSPL while fitting the Venera 13 radiance data. Then, forward simulations of the nightside thermal emission are performed while introducing an assumed variability in the above retrieved NSPL. However, the main cloud deck (MCD) also shows a high degree of variability which proportionally attenuates the thermal emission coming from the surface. Thus, the sensitivity of the simulated spacecraft observations to an assumed variability of the NSPL while correcting for the optical thickness variations of MCD is investigated in this work.

9. An Open-Source Python-Based Model for Predicting Temperature Variations in Airless Planetary Bodies

Duncan Lyster (University of Oxford, UK)

Co-author: Dr Carly Howett (UOO, UK)

Key points: This Python-based open-source model predicts diurnal temperature variations on airless planetary bodies, improving accuracy by incorporating shadowing effects. It was built to support missions including NASA's Lucy and ESA's Comet Interceptor, with the code available on GitHub for community access & development.

Understanding the thermal properties of comets, asteroids, and icy moons is crucial for advancing our knowledge of their composition and evolution. An increasing number of missions to these bodies, including Rosetta, Osiris-Rex, Europa Clipper, and JUICE allow for thermal models that accurately consider their complex topographies.
We have developed a Python model that predicts diurnal temperature variations on airless bodies in three dimensions, factoring in their morphologies. This model significantly improves simulation accuracy by incorporating shadowing effects. The results are consistent with established models such as the one-dimensional thermal conduction model of J.R. Spencer, thermprojrs [1], and the three-dimensional surface energy balance model by Guilbert-Lepoutre & Jewitt [2].

Our tool was built to support missions such as the NASA Lucy Mission and the ESA Comet Interceptor mission. However, it is suited to a wide range of targets, including those with active surfaces. The model is user-friendly and operates quickly, requiring only a few minutes for a shape model of comet 67P with 1666 facets. Upcoming improvements include implementing radiative self-heating and energy loss through sublimation, as well as performing extensive parameter sensitivity analysis to enhance the suitability of the model to a broader range of targets.nThe code is open source and contributions are welcome: github.com/duncanLyster/comet_nucleus_model

References:
[1] Spencer, J.R., Lebofsky, L.A. and Sykes, M.V., 1989. Systematic biases in radiometric diameter determinations. Icarus, 78(2), pp.337-354.
[2] Guilbert-Lepoutre, A. and Jewitt, D., 2011. Thermal shadows and compositional structure in comet nuclei. The Astrophysical Journal, 743(1), p.31.

10. Autofluorescent PAH cosmic dust mimics in high velocity impact experiments

Jessica Wills (University of Kent, UK)

Co-authors: Jon Tandy (Kent, UK), Mark Burchell (Kent, UK), Penelope Wozniakiewicz (Kent, UK), Luke Alesbrook (Kent, UK), Derek Chan (Sheffield, UK), Steven Armes (Sheffield, UK)

Key points: Polycyclic aromatic hydrocarbon (PAH) cosmic dust mimics have been fired as projectiles, using the Kent two-stage light gas gun, into aluminium foil and aerogel targets to examine their behaviour under extreme impact conditions. These experiments have implications for the capture of intact PAH-based dust grains in future space missions.

Polycyclic aromatic hydrocarbons (PAHs) are widely distributed in the interstellar medium and can be used to track important processes, such as the evolution of galaxies, and star and planet formation. Moreover, cosmic dust particles comprising PAHs are regarded to be an important source of carbon which has implications in the search for extraterrestrial life. Such micrometeorites typically travel at speeds > 1 km/s, however studying fast-moving micron-sized particles in laboratory experiments needs a suitable mimic. Microparticles of phenanthrene, a PAH-based cosmic dust mimic, have been prepared and fired as projectiles into an aluminium foil target at 1.87 km/s using the Kent two-stage light gas gun. The autofluorescence exhibited by phenanthrene aids the analysis of the resulting craters and more specifically, it enables assessment of the spatial distribution of any surviving projectile in the proximity of each crater. These phenanthrene microparticles have also been coated with polypyrrole, a conductive polymer, and fired into an aerogel target at 2.07 km/s. These experiments allow evaluation of the extent of thermal ablation that the projectiles undergo in these extreme conditions, having implications for the capture of intact PAH-based dust grains from cometary tails or from icy satellite plumes in future space missions. A series of binary mixtures with phenanthrene and pyrene, another member of the PAH family, have also been examined to expand the PAH-based mimics into larger and more complex mixtures that typically exist more in space.

11. Searching for Intact Lunar Lava Tubes with the help of Deep Learning

Daniel Le Corre (University of Kent and ACRI-ST)

Co-authors: Nigel Mason (Uni of Kent), Jeronimo Bernard-Salas (ACRI-ST), David Mary (Observatoire de la Cote d'Azur), Nick Cox (ACRI-ST)

Key points: Sub-surface caves will be crucial for future robotic and human Lunar exploration due to their natural shelter from harmful radiation and micrometeorite impacts. We will be presenting results of training Deep Learning models to detect potential caves on the Moon in the form of lava tube collapse pits.

Sub-surface cavities are predicted to play a crucial role in future robotic and human space exploration. Lava tubes are examples of such cavities which have been extensively explored on Earth and remotely observed on other Solar System surfaces [1]. Lava tubes are underground conduits formed by the flowing of lava, which are revealed to the surface when their roofs collapse, often leaving sinuous chains of collapse pits. These chains may allow access to entire cave systems, which would provide natural shelter from harmful radiation and micrometeorite impacts on the Moon [2]. The Lunar Reconnaissance Orbiter's Narrow Angle Camera can reveal pits with great detail, although the issue is knowing where to look. A current catalogue of Lunar pits have only ~280 features - most of which are impact melt pits [3]. Therefore, automated techniques will be incredibly advantageous in surveying larger regions for the smaller lava tubes which may be more readily explored by spacecraft or humans. We will present results of a Deep Learning model trained to detect individual pits on the Moon. These detections are then assessed on a number of factors to determine if they signify the presence of lava tubes. The scales of the intact sections of any candidate lava tubes will be inferred by estimating the volumes of the collapses with the Pit Topography from Shadows (PITS) tool [4].

[1] Sauro et al. (2020). https://www.sciencedirect.com/science/article/pii/S0012825220303342
[2] Atri et al. (2022). https://arxiv.org/abs/2208.00892
[3] Wagner & Robinson (2021).
https://ui.adsabs.harvard.edu/abs/2021LPI....52.2530W/abstract
[4] Le Corre et al. (2023). https://academic.oup.com/rasti/article/2/1/492/7241547

12. A new instrument for observing meteoroid impacts on the Moon

Daniel Sheward (Institut de Physique du Globe de Paris, France)

Co-authors: Chrysa Avdellidou (UoL, UK), Philippe Lognonne (IPGP, Fr), Paul Girard (OCA, Fr), Nicolas Mauclert (OCA, Fr), Antony Cook (Aberystwyth University), Marco Delbo (OCA, UK)

Key points: Lunar Observations

We present results from a pilot project devoted to observing Lunar Impact Flashes (LIFs) in the J-band, at 1.2 micron of wavelength, in the near infrared. We show our LIFs detection(s) and the main advantages compared to visible-light LIF observations: (i) reduced day-glow photons from sunlight Rayleigh-scattering by our atmosphere, (ii) reduced number of photons from the sunlit lunar hemisphere, (iii) increased number of photons from the LIFs. We will present developments towards a dedicated observatory equipped with the Twin Lunar Impact Telescope (TILT), a double 40 cm f/D~4.25 telescope, installed on the same alt-az mount, where each optical tube will be equipped with an infrared camera. This instrument will allow us to extend the observing hour of the moon during daytime allowing us to detect the least frequent LIFs due to large impactors. This is crucial for monitoring of LIFs which can trigger seismic signals measurable by seismic stations that will be soon deployed by space missions on the Moon.

13. The Resultant Craters from Lunar Impact Flashes

Daniel Sheward (Institut de Physique du Globe de Paris, France)

Co-authors: Chrysa Avdellidou (UoL, UK), Anthony Cook (Aberystwyth University, UK), Marco Delbo (OCA, FR)

Key points: Using lunar impact flash observations, we located the resultant impact craters on the Moon. This ground truth data allows for analyses such as evaluation of the crater scaling laws, and the calculation of the luminous efficiency

Using PyNAPLE, software designed to locate fresh craters from the latitude, longitude, and epoch of an impact flash, a search was performed upon the 22 most energetic LIFs within publicly available literature. For completeness, this included the 3 LIF craters already identified within literature.

Of these 22 events, there was sufficient LROC images to locate the freshly formed craters for 6 new events, as well as the 3 already identified. For each of these events, the likely parent meteoroid stream can be obtained, thereby giving an approximate velocity, impacting angle, and projectile density. The pre-impact kinetic energy can then be obtained using the luminous efficiency, and the luminous energy of the impact flash.

The crater scaling laws, which predict crater size from kinetic energy, can be compared using the observed craters as ground truth. The scaling law of Shoemaker & Wolfe proved to be most accurate. It was found that the predicted crater diameter was consistently larger than the observed crater. While there are several factors that could contribute to this, such as the estimates for projectile density and target density, and impactor velocity and angle, the single most likely factor is the poorly constrained luminous efficiency. Under this assumption, a more accurate value for the luminous efficiency can be calculated from the observed craters. After outlier removal and meteoroid stream identification, this produces an average value of $\eta=0.017$. While this is slightly larger than the typically used values of between 10-2 and 10-4, the difference is not drastic.

BPSC Posters - Mercury
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

14. Synthetic crystalline samples of MESSENGER compositions as Mercury analogues

Tiffany Barry (University of Leicester, UK)

Co-authors: M. Battisson (UoL), A. Fox (UoL), J. Cartwright (UoL), A. Martindale (UoL), T. Yoshino (IPM, Japan), E. Bunce (UoL)

Key points: We present XRF and SEM data for synthetic samples created for 7 analogue compositions of Mercury. Results are compared to target values to assess synthesis methodologies, along with an examination of element distribution in the samples, and mineral contents.

As we know from NASA's MESSENGER data, the surface of Mercury has a chemical composition unlike anything on Earth. The planet's surface is highly reduced (IW -6) with incredibly low FeO content (<~2 wt % compared to Earth's <14 wt %), despite an Fe-core that makes up ~85% of the planet. Surface compositions of Mercury can be divided into at least 7 distinct terranes, that, although similar to mafic and ultramafic rocks on Earth, have some clear differences.

Here, we have produced synthetic glass bead and powder pellet samples of the 7 terranes, to test suitable methodologies for accurately replicating major element ratios, analogous to MESSENGER data. The glass bead samples were allowed to cool slowly and upon inspection show: 1) the presence of Mg-rich silicates that have a spinifex-like texture; 2) Fe-rich grains that, through density, appear to have settled to the bottom of the sample; and 3) more rarely, the presence of Ca-Al grains.

The samples have been analysed by XRF and SEM to quantitatively demonstrate similarities to target compositions, and this information will be used to produce further refined samples. In the future, samples will be treated in a gas-mixing furnace to generate reduced conditions, more akin to Mercury, and sample compositions will include carbon to help test hypotheses for high carbon content in Mercury's low reflectance medium.

Both oxidized and reduced synthetic samples will be used to characterise mineralogy and physical properties, to ground-test instrument operations ahead of the orbiter mission, including those using x-ray spectrometry, and shared with the instrument teams preparing for the 2025 BepiColombo mission.

15. X-ray emission from Mercury's nightside and its dependence on magnetospheric activity

Mark Sharman (University of Leicester, UK)

Co-authors: E. J. Bunce (1), S. T. Lindsay (1), A. Martindale (1), S. C. A. Toogood (1)

Key points: We have used new methods to analyse catalogues of electron-induced X-ray emission on the nightside of Mercury. By comparing these to the magnetic disturbance index, we suggest there is a higher likelihood of such X-ray emission occurring at higher levels of activity in the Mercury magnetosphere.

X-ray emission from the nightside of Mercury has previously been detected and catalogued using data from the X-ray Spectrometer onboard the MESSENGER spacecraft. Unlike on the dayside where this is caused by solar coronal X-rays, nightside emission is likely the result of precipitating energetic electrons. We have reanalysed MESSENGER-derived datasets of Si and Ca emission in the northern hemisphere, using a new map projection and a field-of-view centroiding method to plot event locations. We then filtered them against a series of parameters which may influence activity in Mercury's magnetosphere. Of these parameters, we have found a positive correlation between the frequency of emission and disturbance index, a measure of the activity level of the magnetosphere scaled from 0 to 100. 48% of all Si X-ray emission events occurred on orbits with a disturbance index of >70, and 21% with a disturbance index of >90. This suggests that there is a higher likelihood of observing X-ray emission when Mercury's magnetosphere is more disturbed, either due to an increased frequency of particle precipitation, an increase in the energy of the precipitating particles, or a combination of both. This correlation with DI is stronger in events on the dawn side of the planet, with the frequency of dusk side events showing weak or no correlation. This is consistent with previous nightside X-ray emission studies which show that the frequency of emission is significantly lower on the dusk side, and with many other studies of Mercury's magnetosphere which have observed similar dawn-dusk asymmetries.

16. A meteoroid storm on Mercury in 2025-26

Apostolos Christou (Armagh Observatory and Planetarium, UK)

Co-authors: Auriane Egal (Planétarium de Montréal, Canada), Rosemary Killen (NASA GSFC, USA), Nikos Georgakarakos (New York University Abu Dhabi, UAE)

Key points: We predict that Mercury will pass through a cloud of cm- to metre-class meteoroids from comet 2P/Encke during the arrival and early orbital phase of BepiColombo's mission.

In June & July 1975, the Apollo seismic network seismometers recorded an unusually high rate of meteoroid impacts in the 1-1,000 kg mass range. That event was later dubbed a “meteoroid storm” (Duennebier et al, Science, 1975) while the timing and distribution of the impacts suggested a link with periodic comet 2P/Encke (eg Oberst & Nakamura, JGR, 1987). A model later proposed by Asher & Clube (QJRAS, 1993; aka the Swarm model, see also Asher, PhD thesis, Univ. Oxford, 1991) reproduced the timing of the storm while also successfully predicting increased fluxes of bright fireballs observed at Earth on certain years (Asher & Izumi, MNRAS, 1998; Dubietis & Arlt, MNRAS, 2007).
Having previously demonstrated a link between the comet stream and features on Mercury’s exosphere (Killen & Hahn, Icarus 2015; Christou, Killen & Burger, GRL, 2015), here we want to determine if (and when) Mercury crosses the Swarm. We have applied the Swarm model to Mercury (Christou, Egal and Georgakarakos, MNRAS, 2024) and find that such encounters occur every 3.39 yr with the next series of crossings taking place between November 2025 and June 2026, coinciding with a critical phase in Bepicolombo operations. We futher show that circumstances in 2025-26 appear optimal for Mercury to pass through the Swarm centre, conditions very similar to those during the 1975 lunar meteoroid storm. During the talk we will present a detailed timeline of the 2025-26 Mercury-Swarm encounter and discuss potentially measurable effects on the Hermean environment.

17. Exploring the Impact of Planetary Regolith on MIXS X-ray Fluorescence Observations

Michael McKee (University of Leicester, UK)

Co-authors: Adrian Martindale (University of Leicester, UK), Antti Penttilä (University of Helsinki, Finland), Karri Muinonen (University of Helsinki, Finland), Larry Nittler (Arizona State University, USA), Graeme Hall (University of Leicester, UK), Simon Lindsay (University of Leicester, UK), Tim Yeoman (University of Leicester, UK), Emma Bunce (University of Leicester, UK), Tiffany Barry (University of Leicester, UK), Ben Clarke (University of Leicester, UK)

Key points: An empirically determined correction factor for the MIXS instrument has been derived to account for the surface roughness of Mercury's terrain. This will be used to produce more accurate elemental abundance maps of the planet's surface.

In preparation for the arrival of the BepiColombo mission to Mercury, work is underway to maximise the science return for the Mercury Imaging X-ray Spectrometer, MIXS, which will be

used to map elemental abundances across Mercury's surface. The MIXS Ground Reference Facility (GREF) at Space Park Leicester has been designed to conduct X-ray fluorescence (XRF) measurements on Mercury analogue samples using a flight-qualified model MIXS detector. The GREF may be used to simulate any viewing geometry expected to be measured by MIXS at Mercury. This is of particular importance as it allows for the characterisation of the XRF intensity as a function of phase angle due to 'regolith effects'. Several studies have shown a strong dependence between the grain size of the regolith and the XRF intensity, caused by shadowing of X-rays due to surface roughness and topographical effects, where deviations from an ideal flat surface increase with grain size and phase angle. If unaccounted for, this could lead to a mischaracterisation of the surface elemental abundances due to the energy-dependent nature of these effects.
This work presents an empirically determined correction factor derived from recent GREF measurements that will be used to acquire more accurate elemental abundance mapping of the surface terrain of Mercury. Future work will adapt this model into a universally applicable correction technique, enabling regolith effects to be resolved for any future planetary mission employing XRF. This will improve our understanding of the compositions of planetary surfaces, and therefore a better insight into their evolutions.

18. Mapping Progress Update: the Bach Quadrangle of Mercury (H15)

Annie R. Lennox (The Open University, UK)

Co-authors: David Rothery (OU, UK), Matt Balme (OU, UK), Jack Wright (ESA, ESAC, Spain), Susan Conway (Université de Nantes, France)

Key points: We present the status update on the 1:3M geomorphological quadrangle map of H15 made using MESSENGER data.

The Bach Quadrangle (H15) encompasses an area of Mercury poleward of 66° that, as of yet, has not been geologically mapped using MESSENGER data. The production of 1:3M scale quadrangle maps of Mercury is essential for understanding Mercury's geological history and provides an opportunity to identify targets for, and contextualising observations to be made by, ESA-JAXA's fast-approaching BepiColombo mission, due to begin science operations in 2026. We present a status update on the first geological map of H15 which aims to be compatible with surrounding quadrangle maps, contributing to a global map now in progress [1]. We mapped primarily using the MDIS-derived 116 m/pixel monochrome basemap. The mapping of linear features, which include craters and tectonic features, are complete and the classification of impact craters according to a 3- and 5-class system are well underway.
References: [1] Galluzzi et al., (2024). Mercury 2024 conference abstract.

BPSC Posters – Venus
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

19. Modelling the Effects of Hydrated Crust on the Density and Elevation of Tesserae on Venus

Aedan Baker (The Open University, UK)

Co-authors: Julia Semprich (OU, UK), Susanne Schwenzer (OU, UK), Richard Greenwood (OU, UK), Justin Filiberto (NASA JSC, USA)

Key points: In order to constrain the conditions needed for tesserae stability, we performed phase equilibria and isostasy modelling on a set of water-bearing rock compositions.

The composition of Venusian tesserae is still a matter of debate, but several observations suggest that they are silica-rich. The most efficient mechanism of producing these silica-rich compositions would be Earth-like tectonic activity, which requires water. However, water within the Venusian subsurface would affect the isostatic behaviour of tesserae. We present results of phase equilibria and isostasy modelling on a range of rock compositions with a varying water content and along a range of potential thermal gradients and compare them to anhydrous models with the aim to determine if any tesserae could be stable with water present.

We find that the addition of water greatly impacts the stability of all modelled compositions, significantly reducing the maximum possible crustal thickness in most cases, more so at higher water contents. This causes a significant reduction in the elevations which can be supported by all compositions, leaving most incapable of supporting more than a few kilometres and only silica-rich rock types with the lowest thermal gradient and lowest water content are able to support elevations equivalent to the tallest recorded tesserae, Maxwell Montes.

Our results suggest that under present day Venusian conditions, water is not likely to be present in the crust of tesserae. This does not imply that water has never been present on Venus as conditions during the formation of tesserae may have allowed for hydrated crust to support taller elevations. Any water bearing minerals would have undergone dehydration as Venus became hotter, leaving only anhydrous crust in the present day.

20. New Evidence Investigated for a Global Atmospheric Electric Circuit on Venus

Blair McGinness (University of Reading, UK)

Co-authors: Giles Harrison (UoR, UK), Karen Aplin (UoB, UK), Martin Airey (UoR, UK), Keri Nicoll (UoR, UK)

Key points: The presence of a Global Circuit on Venus has been investigated, via re-analysis of Venera 13&14 data.

Many studies of Venus atmospheric electricity focused on the presence or absence of lightning in the atmosphere, with little consideration made of other aspects of the electrical environment [1]. Additionally, it has been proposed that global atmospheric electric circuits, such as the one on Earth, may be present on other planets, such as Venus [2]. We investigate new arguments for a global circuit being present in Venus' atmosphere, arising from re-analysis of data from the Venera 13&14 landers.

Among the instrumentation carried through Venus' atmosphere by the Venera landers were point discharge sensors, measuring electrical discharges from the spacecraft [3]. The recorded discharges were difficult to understand with existing understanding of Venus' atmosphere. Haze in the lower atmosphere as well as the presence of a global circuit were considered as possible explanations [3]. We have investigated the plausibility of these two factors leading to the electrical discharges measured by the spacecraft.

To investigate this, an electrical model of Venus' atmosphere was produced. This model allowed the electrical discharges from a spacecraft to be modelled for several scenarios. It was found that the best fit to the Venera data occurred when the model included both a global electric circuit, and haze layer. These findings provide supporting evidence for the presence of a global circuit on Venus.

[1] R.D. Lorenz (2018). Progress in Earth and Planetary Science, 5. [2] K.L. Aplin (2006). Surveys in Geophysics 27. 63-108. [3] R.D. Lorenz (2018). Icarus, 307. 146-149.

BPSC Posters - Mars
Main atrium and small atrium, Space Park Leicester
Copernicus Lounge for abstract **22**, Space Park Leicester
Tuesday 18th June – Friday 21st June

21. The high-resolution map of Oxia Planum, Mars; the landing site of the ExoMars Rosalind Franklin rover mission

Peter Fawdon (The Open University, UK)

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Key Points: The geological map of Oxia Planum that will be used by the Rosalind franklin rover mission. The map will aid strategic decision making and put samples analyzed by the rover in context with our regional and global understanding of Mars' geological history

This 1:30,000 scale geological map describes Oxia Planum, Mars, the landing site for the ExoMars Rosalind Franklin rover mission. The map represents our current understanding of bedrock units and their relationships prior to Rosalind Franklin’s exploration of this location. The map details 15 bedrock units organised into 6 groups and 7 textural and surficial units. The bedrock units were identified using visible and near-infrared remote sensing datasets. The objectives of this map are (i) to identify where the most astrobiologically relevant rocks are likely to be found, (ii) to show where hypotheses about their geological context (within Oxia Planum and in the wider geological history of Mars) can be tested, (iii) to inform both the long-term (hundreds of metres to ~1 km) and the short-term (tens of metres) activity planning for rover exploration, and (iv) to allow the samples analysed by the rover to be interpreted within their regional geological context.

22. Mars Sample Return (MSR) Sample Receiving Project (SRP) Measurement Definition Team (MDT-1): Overview and Status

Elliot Sefton-Nash (European Space Agency, ESTEC)

Co-authors: E. Sefton-Nash, D. Paardekooper (European Space Agency, ESTEC, The Netherlands), B. L. Carrier, M. Viotti (Jet Propulsion Laboratory, California Institute of Technology, USA), T. Haltigin (Canadian Space Agency), H. V. Graham (NASA Goddard Space Flight Center, USA), C. D. K. Herd (University of Alberta, Canada) and the Measurement Definition Team (1)

Key points: Samples returned from Mars by the planned NASA-ESA Mars Sample Return Campaign would initially be delivered to a Sample Receiving Facility (SRF). NASA and ESA have appointed the international Measurement Definition Team, Phase 1 (MDT-1) to provide inputs to design considerations for the SRF.

The planned NASA-ESA Mars Sample Return (MSR) Campaign is a multi-mission effort intended to bring scientifically selected samples of Mars rock cores, regolith, and atmosphere to Earth for the purpose of scientific investigation and discovery.

The currently envisaged high containment facility to which the samples would initially be delivered is referred to as the Sample Receiving Facility (SRF). To minimize the footprint, cost, and complexity of the SRF in handling the samples from Mars, it is crucial to define properly the minimum set of investigations, measurements, instrumentation, and operations concept required to cover the initial characterization, safety assessment, and science investigation needs. NASA and ESA appointed the international Measurement Definition Team, Phase 1 (MDT-1) to provide input to design considerations for the SRF. Future MDTs may address requirements for measurements done outside the SRF. While the overall process of the MDT-1 is like traditional Science Definition Teams (SDTs), the scope of this MDT is distinct because they must focus on the specifics of the measurement implementation plan, as well measurements needed for sample characterization and planetary protection.

MDT-1 began from the proposed MSR science objectives, from which they are deriving investigation strategies, a measurement traceability matrix, reference instruments, and preliminary concept of operations.

Twenty competitively selected, and ex-officio MDT-1 members began work in September 2023 and expect to publish their deliverables in Q4 2024. In this presentation we report on the scope and detail of MDT-1's work in the frame of preparations for receiving and analysis of returned Mars samples.

23. Status and Overview of the ExoMars/Rosalind Franklin Mission and Mars Sample Return Campaign

Elliot Sefton-Nash (European Space Agency, ESTEC)

Co-authors: E. Sefton-Nash, J. L. Vago, G. Kminek (ESA/ESTEC, Netherlands)

Key points: The Rosalind Franklin Mission is re-established with contributions from NASA and is on schedule for launch in 2028. Meanwhile, preparations for Mars Sample Return continue.

Finding signs of life elsewhere is one of the most important scientific objectives of our time. ExoMars was conceived to answer one question: Was there ever life on Mars? All project design decisions have focused and continue to centre on the achievement of this one scientific goal. This is particularly the case for the Rosalind Franklin rover. Putting the science team in the best possible condition to search for physical and chemical biosignatures has led to: 1. the need for a 2-m depth drill; 2. the choice of payload instruments; 3. the landing site requirements that led to selection of the Oxia Planum landing site, and; 4. the surface exploration strategy that guides how the Rover and instruments are used together to achieve the mission objectives. The Rosalind Franklin Mission is re-established with contributions from NASA and is on schedule for launch in 2028.

Meanwhile, preparations for Mars Sample Return continue: Following completion of the 'Three Forks Depot' containing a set of 10 carefully selected samples, Mars 2020 further pursues collection of diverse samples from Jezero crater with astounding science potential. While re-architecture of the flight segment by MSR Campaign partners NASA and ESA is underway, research and development activities on the ground continue at a sustainable level in order to build capabilities and experience for future sample receiving and analysis, and to provide further opportunities for scientific engagement.

24. Preparations for Mars Sample Return; Using Terrestrial Geological Analogue Materials to Develop a Correlative Workflow for Analysis of Mars Samples

Francesca Willcocks (Physics and Astronomy, Leicester)

Co-authors: John Bridges (Space Park Leicester, University of Leicester, UK), Sara Russell (NHM, UK), Candice Bedford (University of Purdue, USA), Susanne Schwenzer (The Open University, UK)

Key points: NASA's Perseverance rover is collecting a range of Martian samples that are due to be returned to Earth in a joint NASA-ESA mission. Initially focusing on phyllosilicate veins in an Isle of Rum peridotite, we aim to develop a correlative workflow using techniques such as CT and electron microscopy to prepare for the arrival of these Mars samples.

Throughout NASA's Mars 2020 mission, the Perseverance rover has been collecting a range of samples (including regolith, atmosphere, rock and dust) that are due to be returned to Earth in a joint NASA-ESA mission (Meyer et al., 2022). To prepare for their arrival, teams such as the MSR Planning Groups (Tait et al., 2022) are developing plans for a pipeline from curation to characterisation and analysis for these samples within a Sample Return Facility (SRF). This includes five main stages: hardware de-integrations, pre-basic characterisation (tubes sealed), basic characterisation (tubes opened in pristine containment), preliminary examination/sample safety assessment protocol (non-pristine containment) and sterilisation and release (Meyer et al., 2022; Adam et al., 2024).
For this project, terrestrial geological analogue samples for Mars (samples that are geologically relevant to those on Mars) will be used to develop a correlative workflow for data collection using techniques including X-ray Computed Tomography, Scanning Electron Microscopy, Focused Ion Beam milling, and Transmission Electron Microscopy. This correlative workflow aims to test the pipeline from pre-basic characterisation to the preliminary examination stage for Martian sample analysis after their arrival on Earth, and optimise the data we can collect for different samples. Samples include a peridotite from the Isle of Rum - an analogue for the olivine cumulate/wehrlite rocks of the Séitah formation, Jezero crater (Thiessen et al., 2024) - focusing on phyllosilicate veins present within olivine grains that appear analogous to veins found in Nakhlite Martian meteorites (Hicks et al., 2014) and alteration observed in the Séitah formation.

25. The Long Range Rover Investigation (LoRRI) mission concept

Matt Balme (The Open University, UK)

Co-author: Peter Fawdon (OU, UK)

Key points: A long-range autonomous rover could revolutionize our understanding of Mars' stratigraphy. Here we present ideas about where such a mission could be targeted, what it could accomplish, and what technology would be required to make this happen

Mars is a compelling target to study terrestrial planet surface evolution; the same variety of environments found on early Earth are likely to have also been present on early Mars (Yingst et al., 2020; MEPAG Decadal Survey White paper, https://mepag.jpl.nasa.gov/reports.cfm?expand=decadal). Furthermore, unlike the Earth, Mars has an accessible rock record that spans its entire history. Hence, if a Mars Rover mission can 'cover enough ground' Mars' environments can be studied in detail in both space and time. We propose a "Long-Range Rover Investigation" (LoRRI) concept for Mars. With high levels of autonomy, LoRRI would perform long traverses of 100s to 1000 km, determining fundamental geological characteristics of the rocks and units it encounters. LoRRI would exploit the proposed ESA Mars electric propulsion transfer stage ("EP Tug") architecture (see https://europeanspaceflight.com/esa-to-begin-work-on-mars-transfer-vehicle-mission-concept/) in the 2030s.

By documenting extents, thicknesses, lithology, structure and contacts. LoRRI will redefine our understanding of local and global stratigraphy. LoRRi would explore many locations, from the most ancient to more recent, documenting large-scale transitions from potentially habitable environments shaped by water to younger regions where the rocks were laid down in colder and/or more arid environments. environments. To build a stratigraphy, geologic contacts would be crossed and re-crossed at widely separated locations. Repeating or spatially-limited stratigraphic transitions could be targeted, to explore cyclicity or episodic variations in environment.

Here we present plausible locations for such a mission, including traverses, topographic profiles, and locations of key scientific targets, and technological/programmatic requirements. We welcome input from the BPSC attendees!

26. Changes to Water ice cloud formation due to dust storms on Mars

Vinayak Shastri (The Open University, UK)

Co-authors: James A. Holmes (OU, UK), Stephen R. Lewis (OU, UK), Manish R. Patel (OU, UK)

Key points: Thickness of water ice clouds in polar regions increases during global dust storms on Mars.

Studying water on Mars is of importance as this benefits research on the survivability of life on Mars as well as informing future manned missions for human exploration. Most of the water on Mars is stored in the northern polar ice cap which acts as a pump for distributing water across the planet. This makes the north pole of Mars an important region for studying the annual changes to the water cycle.

Previous studies show that large-scale dust events such as global dust storm (GDS) alter the temperature structure and wind patterns in the atmosphere. It has also been demonstrated that a greater volume of water vapour breaks into the northern polar vortex during the most recent GDS occurring in 2018. This project investigates how dust storms alter the thickness of water ice cloud formation on the northern polar region of Mars using the Mars Planetary Climate Model (PCM) UK-spectral and observational data.

My preliminary model results show an increase in the altitude and thickness of water ice clouds during the GDS in the northern polar region. Simulations are underway that also assimilate observational data into the PCM by including water vapour profiles from the Nadir and

Occultation for MArs Discovery and Atmospheric Chemistry Suite instruments on board the ExoMars Trace Gas Orbiter alongside temperature profiles from the Mars Climate Sounder aboard the Mars Reconnaissance Orbiter. These observations directly impact the location and thickness of clouds formed and ensure the most realistic reconstruction of this atmospheric process.

27. Exploring the Limits of Material Discrimination with CaSSIS Multiband Imaging

Roger Stabbins (Natural History Museum, London)

Co-author: Peter Grindrod (NHM, UK)

Key points: We present ongoing investigations of the spectral sampling space of the ESA Trace Gas Orbiter CaSSIS multiband imager, using our Supervised Spectral Parameters Learning technique, that we apply to CaSSIS images of Jezero Crater, Mars, for cross-referencing of CaSSIS-derived material classes against the extensive literature on this region.

Visible-to-near-infrared multispectral images of Mars are vital for correlating compositional and morphological interpretations of the surface, but from first principles this spectral domain contains limited information for discriminating mineral species. However, a new supervised learning method for exploring multispectral dimension reductions (Supervised Spectral Parameters Learning), that considers prior knowledge of the context of an observation, implies that richer information can be extracted. The method learns linear combinations of spectral parameters, that reduce the number of spectral 'dimensions' of a multispectral image (dimension reduction), by analysing large datasets of mineral reflectance spectra obtained under laboratory conditions that are labelled by mineral type. The method leverages these labels as part of the learning process (supervised learning), providing novel multispectral dimension reduction (spectral parameter) data products applicable to a diverse range of scenes. We report on the application of this method to the dataset of 4-band multispectral images captured by the Colour and Stereo Surface Imaging System (CaSSIS) of the ExoMars Trace Gas Orbiter (TGO), and describe developments to the host software of the method, the open-source Spectral Parameters Toolkit. CaSSIS has imaged the surface of Mars extensively, including Jezero Crater, the landing site of the NASA Perseverance rover, a terrain hosting a diversity of minerals and morphologies indicative of past water activity. We assess the enhancement of contrast in CaSSIS through the application of newly learned dimension reduction data products, by comparison against the compositional units established in the literature in the context of the on-going exploration of Jezero Crater.

28. Gnaraloo Bay: Stratigraphic relationships at the apex of a Martian fluvio-deltaic system.

Robert Barnes (Imperial College London, UK)

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Key points: We present relative timing relationships between sedimentary deposits representing contrasting sub-aqueous flow types in the upper Jezero western fan, observed in an erosional window close to the fan apex.

The NASA Perseverance rover is traversing the Jezero western fan, a clastic coarsening upward succession deposited along the western rim of Jezero crater. Above an igneous succession on the crater floor, it records a transition from distal deltaic deposits to basinward prograding fluvio-deltaic and flood flow deposition in the upper fan series, bound to the west by the Margin Unit.
Gnaraloo Bay, near the Jezero western fan apex, was formed by erosion through three stratigraphic units, presenting an opportunity to constrain the relative timing relationships of the Margin Unit and upper fan stratigraphy.
Shallow crater rimwards and basinwards dipping (<10°) beds from the Margin Unit underlie an erosional boundary at eastern Gnaraloo Bay, overlain by undulose laminated and northeast and southwest inclined beds of the Tenby formation, recording a transition to a phase of upper stage flow, followed by deposition of fluvial barforms.
Sub-horizontal bedding of the Otis Peak member is exposed in hillsides in northern Gnaraloo Bay and the basal contact crosscuts the Margin Unit and Tenby formation. These units are topped by downcutting Boulder Unit deposits. The basal contact of the linear ridge of the Boulder Unit at Jurabi Point crosscuts the Margin Unit and Tenby Formation, forming an erosional unconformity in which the Otis Peak formation is absent.
We interpret the stratigraphy at Gnaraloo Bay to record distinct time gaps between key depositional events: migrating barforms over the Margin Unit deposits, followed by deposition of sheetlike sandstones and capping boulder deposits formed by late flooding events.

29. Hydrated Silica in Oxia Planum, Mars

Joe McNeil (Natural History Museum, London)

Co-authors: Peter Grindrod (NHM, UK), Livio Tornabene (UWO, Canada), Peter Fawdon, (OU, UK)

Key points: The distribution, geochemistry, and stratigraphic position of opal-bearing deposits in Oxia Planum, Mars, are investigated here, with implications for the geological history of the region and its astrobiological exploration by Rosalind Franklin.

Opal, or hydrated silica, is an important mineral in the astrobiological exploration of Mars owing to its genesis in a wide range of aqueous environments and its high preservation potential for physical and chemical biosignatures relative to other hydrated minerals. Using multi- and hyperspectral orbiter data in tandem with traditional remote sensing techniques, we have investigated putative Noachian-aged opal-bearing deposits in Oxia Planum, the future landing site of the ExoMars 'Rosalind Franklin' rover, in order to understand their distribution, position in the regional stratigraphy, and assess their astrobiological importance.

We have detected opal-bearing material in two main physiogeographic regions of Oxia Planum: firstly, stratigraphically above the clay-bearing plains and directly under the sedimentary fan, and secondly, in topographic lows (e.g. 'Pelso Chasma') south of the fan, underlying later dark infilling material. Infrared CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) spectra reveal that amorphous opal (Opal-A) is the dominant form of hydrated silica in Oxia Planum, as is the case for most detections of this mineral on Mars. However, post-depositional water-rock interactions can alter the crystallinity of opal and transform Opal-A into more crystalline varieties, such as Opal-CT, over time.

This suggests that the opal was not subject to the same prolonged aqueous alteration as the underlying clay-bearing plains. Consequently, the opal-rich horizon probably signifies sedimentary deposition following an unconformity during later phase(s) of aqueous activity associated with the fan. We also identify further potentially opal-bearing deposits within the main landing ellipse that offer exciting prospects for in situ astrobiological exploration.

30. Potential influences of impact crater morphometry on the depths to which Concentric Crater Fills (debris-covered glaciers) on Mars fill their host craters.

Ben Cornford (The University of Sheffield, UK)

Co-authors: Felix S Ng (TUOS, UK), Frances EG Butcher (TUOS, UK) and Robert Bryant(TUOS, UK)

Key points: We investigated the influence of impact crater morphometry on the degree to which debris-covered glaciers occupying impact craters in Mars' mid-latitudes ('Concentric

Crater Fills') fill their host craters. We explore the filling of Concentric Crater Fills (CCFs) on Mars, with a focus on variations in depth-diameter ratios across different latitudes.

Concentric Crater Fills (CCFs), thought to be debris-covered glaciers occupy impact craters across Mars' mid-latitude regions (~±30 and 60°). They completely cover their host crater floors, making true crater depths, and therefore CCF volume, elusive. Crater depth scales with crater diameter; hence, for a given volume of ice in a CCF, a larger crater would appear less well-filled than a smaller crater. Here we identify the systematic influences of host- crater morphometry on the degree to which CCF-hosting craters are filled. In a second study, Cornford et al. (this meeting) explore spatial variations in crater filling by CCFs (e.g., with latitude, longitude, and elevation). We generated constant volume curves (termed here: isovols) based on the existing empirical relationships of both d/D and crater cavity shape. However, d/D (depth/diameter) relationship exhibit latitudinal variations that are unaccounted for in globally-unifying equations. Pristine craters appear to become shallower poleward of ±40°. As CCFs lie within this depth transition zone, we derived d/D relationships for 10° latitude bins in the northern hemisphere based on published data (Robbins and Hynek 2012, JGR vol117) for the depths and diameters of pristine craters. This shows that a 10 km diameter crater hosting CCF at 30°N could be 1.44 km deep, whereas an identical crater at a 60°N could be 0.97 km deep. We use the derived relationships to provide an updated estimate of the ice volume content of CCFs. This is important for understanding the amount of ice mobilised by geologically-recent orbitally-forced climate changes on Mars.

31. Spatial controls on the apparent depth of glaciated Martian craters hosting Concentric Crater Fills.

Ben Cornford (University of Sheffield, UK)

Co-authors: Felix S Ng (TUOS, UK), Frances EG Butcher (TUOS, UK) and Robert Bryant (TUOS, UK)

Key points: Concentric Crater Fills (CCFs) in Mars' mid latitudes are believed to be debris-covered glaciers which formed under different climatic conditions in the past. We investigate the controls on the degree to which CCFs fill their host craters and find statistically significant influences of crater diameter, latitude and (to a lesser degree) elevation.

Concentric Crater Fills (CCFs) on Mars are believed to be debris-covered glaciers. CCFs are found ubiquitously across Mars' mid-latitudes (~±30–60°N/S), and completely cover the floors of impact craters. They provide an opportunity to understand the paleo-environmental conditions under which Mars' extensive mid-latitude ice deposits formed and evolved. We aim to identify both the systematic influences of host-crater morphometry and spatial controls on the degree of crater filling by CCFs. We analysed the apparent depths (distance between crater rim and CCF surface) of 1225 CCFs in the northern hemisphere and 1270 in the southern hemisphere. We performed regression analyses to study the relationships between apparent depth against host crater diameter and various spatial factors, such as longitude, latitude, and elevation. Our results indicate that, in both hemispheres, the apparent-depth of CCF-hosting craters increases with crater diameter (i.e., larger craters are less well-filled) and decreases with increasing latitude (i.e., poleward craters are better well-filled). Additionally, the range of apparent depth decreases poleward, which suggests a more zonally consistent glacial history at higher latitudes. Elevation, whilst having a statistically insignificant impact within a given hemisphere, is found to be significant over the large inter-hemispheric elevation range. We therefore propose that latitude-dependence of insolation had dominant influence on CCF formation and evolution. Ongoing work is investigating the causes of the observed variability in apparent-depth at lower latitudes and exploring potential influences of regional environmental variability and host crater properties not yet accounted for.

32. Extensive Secondary Cratering from the InSight Sol 1034a Impact Event

Peter Grindrod (Natural History Museum, London)

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Key points: The InSight S1034a seismic event is shown to be the result of a new impact less than 50 km from the lander. A single 9 m diameter crater is responsible for over 900 secondary impact events, at distances of up to 7 km.

Impact cratering is one of the fundamental processes throughout the history of the Solar System. The formation of new impact craters on planetary bodies has been observed with repeat images from orbiting satellites. However, the time gap between images is often large enough to preclude detailed analysis of smaller-scale features such as secondary impact craters, which are often removed or buried over a short time period. Here we use a seismic event detected on Mars by the NASA InSight mission to investigate secondary cratering at a new impact crater. We strengthen the case that the seismic event that occurred on Sol 1034 (S1034a) is the result of a new impact cratering event. Using the exact timing of this event from InSight, we investigate the resulting new impact crater in orbital image data. The S1034a impact crater is approximately 9 m in diameter, but is responsible for over 900 secondary impact events in the form of low albedo spots up to 7 km from the primary crater. We suggest that the low albedo spots formed from relatively low energy ejecta, with individual ejecta block velocities typically between 100 and 200 m/s. Our analysis of the rate at which the low albedo spots fade over time suggests that there should be no evidence of secondary crater processes at this new impact event within 200-300 days after formation. This timescale places useful limits for future image searches attempting to identify small new impact craters on Mars.

33. Comparative analysis of Martian river morphology driven by climate.

Rebecca Warrilow (MSSL, University College London)

Co-authors: Louisa Preston (MSSL, UCL), Andrew Coates (MSSL, UCL)

Key points: On Earth, the morphology of river networks can provide valuable insights into the environmental conditions in which they form. This remote sensing research applies this concept to analyse Martian rivers, aiming to enhance our understanding of the hydrological processes and climatic conditions responsible for shaping the surface of ancient Mars.

On Earth, river channels can offer clues about the environments in which they form. For example, fluid and sediment flux values reflect the amount of precipitation that produced the water flow and the upstream erosion that generated the sediment. In addition, drainage basins show different morphological characteristics depending on the climate in which they form, yielding valuable quantitative parameters that distinguish polar and equatorial river networks.
Extensive evidence supports the hypothesis that liquid water played a pivotal role in shaping the Martian surface during the planet's early geological history and indicates that Mars was once warmer and had a thicker atmosphere. However, the intensity and duration of events driving river formation remain poorly constrained, necessitating a deeper understanding of the paleoclimatic conditions responsible for precipitation events. Therefore, it is important to utilise the similarities between hydrologic systems on Earth and Mars to recognise how the Martian climate has transitioned into the dry, frozen environment we see today.
This project will use satellite data to remotely measure, map, and model river networks across Mars, with the aim of comparatively investigating fluvial systems across various climatic environments. This research will contribute to our understanding of global climate change and through this can track how potentially habitable environments for life as we know it have consequently changed over time.

34. Dipping Layers on Mars give insights into the planet’s glacial history

Evan Blanc (Nantes University, France)

Co-authors: Susan J. Conway, Frances E. G. Butcher, Axel Noblet, Anna Grau Galofre

Key points: Mapping of dipping layers in the mid-latitudes of Mars, revealing insights into its glacial history.

We report the widespread occurrence of layered outcrops intimately associated with ice deposits in the mid-latitudes. For the first time we map the global extent of these deposits previously only reported in patches. We explore the relationship between these layered outcrops, debris covered glaciers and more recent ice deposits by exploiting images and elevation data from the HiRISE at 25 cm/pixel, Context camera at 6 m/pixel. We use topographic data from HiRISE stereo-images to study their detailed geometry. We find that these layered outcrops are extremely widespread in the martian mid-latitudes and have similar morphology in both the northern and the southern hemisphere pointing to a globally relevant process. We find these layered outcrops are conformal to topography and on low slopes. We hypothesise that they are patchy remnants of the basal layers of past ice (or ice-rich) deposits. In Hellas Basin the layered outcrops are continuous with layers expressed in the hosting icy units, whereas elsewhere on Mars they are surrounded by younger icy deposits. We infer that in Hellas Basin we are seeing a snapshot of how these outcrops were formed elsewhere on Mars, but due to Hellas' unusual setting/climate, it is only here that the outcrops are preserved within their host ice. We hypothesise that these layered deposits inform us about the former extent of mid-latitude ice caps or ice sheets on Mars. Therefore, these Dipping Layers could give information of Mars climate beyond that obtainable by studying the polar caps and other well-studied mid-latitude ice deposits.

35. The Martian seismic dataset from InSight

Anna Horleston (University of Bristol, UK)

Co-authors: John Clinton (ETHZ, Switzerland), Savas Ceylan (ETHZ, Switzerland), Taichi Kawamura (IPGP, France), Simon Stähler (ETHZ, Switzerland), Constantinos Charalambous (ICL, UK), Nikolai Dahmen (ETHZ, Switzerland), Cecilia Duran (ETHZ, Switzerland), Fabian Euchner (ETHZ, Switzerland), Doyeon Kim (ICL, UK), Géraldine Zenhäusern (ETHZ, Switzerland), Domenico Giardini (ETHZ, Switzerland) and the InSight Science and Operations teams

Key points: A description of the catalogued marsquakes and contaminating operational signals within the continuous Martian seismic dataset from InSight.

Over the course of the 1445 days of active operations on Mars InSight collected a near continuous dataset from the SEIS instrument, which was deployed onto the surface of Mars in late 2018. A catalogue of Marsquakes was produced by the Marsquake Service and released with a 3-month

cadence, the final standard release (v.14) being in April 2023. Since then, the catalogue has been studied and revised using deep-learning techniques and our greater understanding of the red planet. The continuous seismic dataset is also publicly available but contains many signatures of non-tectonic origin including those from the operation of the heat flow probe and the many activities performed by the robotic arm, including tether burial, solar array cleaning and soil elastic properties testing. In this presentation I will start by giving an overview of the updates to the catalogued seismicity and an outline of the products that will be released in a reference catalogue later this year. I will also share the typical seismic signatures created by the various operational procedures carried out and outline the catalogue of non-tectonic signals that is in preparation.
The combination of the marsquake catalogue and the operational catalogue will enable researchers in the future to fully utilise this unique dataset.

36. Identifying and Evaluating Dust Devil Signals in InSight Data

David Reid (University of Bristol, UK)

Co-authors: Karen Aplin (FSE, UoB), Nick Teanby (FSE, UoB)

Key points: This presentation presents an overview of trends observed in the pressure magnitude, magnetic field and size in the statistical analysis of nearly 2800 dust devil events. – the first study of this magnitude.

NASA's InSight mission launched in May 2018 and landed on the surface of Mars in November of the same year. With a final mission duration of 1440 Sols, this spacecraft provided a wealth of scientific data, its payload suite measuring pressure, temperature, seismic velocities, and magnetic field from the surface of Mars.
On Mars, atmospheric dust is more prevalent that on Earth due to the lower gravity, dry atmosphere and surface, and presents challenges for solar power generation on the surface of the planet. Dust is key to the Martian climate, absorbing sunlight and accentuating the airflow. There is also speculation of electrostatic discharge and a global electric circuit on Mars. This study focuses on dust devils specifically, distinct from the broader discussion on Martian dust. Dust devils, driven by localized heating and convective activity, pose unique challenges and opportunities for exploration. Understanding their dynamics is essential for future missions to Mars.
By combining the datasets from pressure, wind-speed, seismic and magnetic sensors on InSight, dust devils can be studied. This presentation presents an overview of trends observed in the pressure magnitude, magnetic field and size in the statistical analysis of nearly 2800 dust devil events. – the first study of this magnitude.

37. Martian Meteoric Mg+ ions: an intercomparison of LMD Mars PCM simulations and MAVEN observations.

Caitlin Gough (University of Leeds, UK)

Co-authors: Daniel Marsh, Wuhu Feng, John Plane (University of Leeds, UK), Diego Janches (NASA Goddard, USA), Matteo Crismani (CSU San Bernardino, USA), Jean-Yves Chaufray (IPSL, France), and Nicholas Schneider (LASP, USA).

Key points: The LMD Mars PCM with Mg chemistry successfully captures aspects of the diurnal, latitudinal, and seasonal variability of Mg+ as observed by the MAVEN satellite. Analysis of the model output has allowed potential drivers of this variability to be identified, for example the reduction of Mg+ observed during the southern hemisphere summer is likely due to a greater evaporation of surface water ice.

The MAVEN (Mars Atmosphere and Volatile Evolution) satellite began its orbit around Mars in September 2014 and has since been measuring many atmospheric phenomena. Before MAVEN, Earth was the only planet at which metallic species could be directly measured. The MAVEN satellite has observed a continuous layer of Mg+ that exhibits significant diurnal, seasonal, and latitudinal variability. The Laboratoire de Météorologie Dynamique (LMD) Mars Planetary Climate Model (PCM) is a 3D numerical model that simulates the Martian atmosphere from the surface to the exobase and includes a detailed network of both neutral and ion-molecule chemical reactions and photochemistry, dust, winds, and temperature. An intercomparison of LMD Mars PCM simulations with Mg chemistry and MAVEN observations is integral to understanding the forces driving the Mg+ variability.

Both the MAVEN observations and LMD Mars PCM simulations show a dawn-side maximum Mg+ density at ~6:00 that is likely due to tidal descent during the night. Both the PCM simulations and MAVEN observations show that the density of Mg+ is significantly reduced during the southern hemisphere summer; analysis of the LMD model shows that this is likely due to an increased rate of MgCO3(H2O)6 complex formation due to an increased evaporation of surface water ice. The latitudinal variability of Mg+ is influenced by meridional winds, where the long lifetime of the atomic ion allows it to be used as an effective tracer of upper atmosphere dynamics.

38. Automatic Digitisation of Transverse Aeolian Ridges on Mars using Deep Learning with Mask-RCNN.

Alexander Barrett (The Open University, UK)

Co-authors: Matthew Balme (The Open University, SPS), Elena Favaro (European Space Agency, ESTEC) Mark Woods (Centre For Modelling and Simulation, Robotics, Autonomous Systems and AI Group.) Mateusz Malinowski (CFMS, Robotics, Autonomous Systems and AI Group)

Key points: Deep Learning was used to measure the orientation of Transverse Aeolian Ridges in ~20 HiRISE images of Mars. This allows us to infer formative wind direction for these features.

Transverse Aeolian Ridges (TARs) are decametre-scale aeolian bedforms observed on Mars. TARs form perpendicular to prevailing winds, so formative wind direction can be derived from their orientations. In this investigation, TARs were segmented in 25-100 cm/pixel High Resolution Imaging Science Experiment (HiRISE) images using Mask R-CNN (Region-based Convolutional Neural Network). 5587 TARs were manually digitised In six HiRISE images from across Mars. The manually digitised TARs were used as training data for the Deep Learning model, which was then used to classify 21 further HiRISE images, distributed across Mars, to derive formative wind directions.
The model performed well, capturing a representative sample of TARs. However, not every feature is detected. False negatives occur where features at new sites appear dramatically different to those found in the training dataset. Nevertheless, visual inspection confirmed that a representative sample had been recorded. Furthermore, when overlapping or closely adjacent images were tested, very similar direction signals were found for a given area. Some false positives were observed, but these were infrequent enough that the true direction signal was generally 1-2 orders of magnitude higher than the “noise” produced by false positives. By expanding the training dataset to cover a more diverse set of examples from sites in many locations around Mars, we can reduce false negatives to improve the recall of the model and reduce false positives to further improve the signal to noise ratio. This will allow deployment of the model across thousands of images.

39. Open question in Mars atmosphere research: the noble gas perspective

Susanne Schwenzer (The Open University, UK)

Co-authors: Tim Swindle (U of Arizona, US), Uli Ott (MPI, Germany)

Key points: Noble gases in the Martian atmosphere and trapped in Martian rocks track many processes, including changes in atmospheric conditions and reactions.

Noble gases provided the fingerprint to link the SNC meteorites – now firmly known as Martian meteorites – to Mars for the first time. They have since provided key insights into the Martian atmosphere within them, and into many other processes. With their 5 elements (He, Ne, Ar, Kr, and Xe) and 23 isotopes that record a wide variety of processes over the entire history of the planet, noble gases can trace atmospheric loss, inhomogeneity of Martian interior reservoirs, atmosphere rock interactions and many more. They are also influenced by cosmic and solar radiation, further complicating the picture. Terrestrial research has shown that surface-atmosphere-water interactions have complex influence on the different noble gas species, with different levels of loss and incorporation during exposure of minerals and rocks to processes such as temperature changes, weathering and mineral formation. In this presentation, we will recap the history of linking Mars to the SNC meteorites, and consider the contributions that landed spacecraft made to our understanding of the Martian atmosphere. We will also re-emphasize the importance of future investigations of the Martian atmosphere to understand Mars' climate change and how a once water-rich planet came to be a dry, inhospitable desert.

40. Heterogeneous chlorine chemistry in the modern martian atmosphere

Paul Streeter (The Open University, UK)

Co-authors: Kylash Rajendran (Open University, UK), Stephen Lewis (Open University, UK), , Manish Patel (Open University, UK), Kevin Olsen (Oxford, UK), Manish Patel (Open University, UK)

Key points: Hetorogeneous chlorine chemistry improves representation of atmospheric hydrogen chloride (HCl) in a 4D martian climate model. A dust and ice scheme for producing recently detected HCl is able to capture broad aspects of observed seasonal, latitudinal, and vertical HCl structure.

The recent discovery of hydrogen chloride (HCl) in the martian atmosphere has spurred investigation into the nature of Mars' contemporary chlorine cycle. Observations from the ExoMars Trace Gas Orbiter (TGO) show strong seasonal variability in HCl, over shorter timescales than would occur under solely gas-phase photochemical processes. One possible explanation for this observed behaviour is the presence of heterogeneous chlorine chemistry on atmospheric aerosols, specifically dust and/or water ice. To explore this, we implemented a heterogeneous chlorine chemistry scheme into the Open University's Mars Global Climate Model (MGCM). Under this scheme, HCl is released from dust aerosol via interaction with atmospheric hydrogen (source) and is adsorbed onto water ice (sink). This scheme was implemented alongside dozens of existing gas-phase chlorine reactions in the MGCM. We compared our simulation to both a simulation with solely gas-phase chemistry, and to HCl retrievals from the Atmospheric Chemistry Suite (ACS) spectrometer on TGO.
We found that only the heterogeneous chemistry simulation was able to reproduce the strong seasonal HCl cycle seen in observations, via HCl enhancement during Mars' dusty season. The

heterogeneous scheme was also able to improve the latitudinal and vertical distribution of modelled HCl relative to observations. The HCl sink of water ice appears to be able to reproduce observed sharp gradients in HCl near the polar regions and in the vertical distribution. While further work is needed to understand the exact reactions in play, our results suggest that heterogeneous chemistry plays a key role in the contemporary martian chlorine cycle.

41. The variability of the Mars topside ionosphere over strong crustal magnetic field regions using Mars Express/MARSIS data

Dikshita Meggi (University of Leicester, UK)

Co-authors: Beatriz Sánchez-Cano (UOL, UK), Mark Lester (UOL, UK), Katerina Stergiopoulou (UOL, UK), Simon Joyce (UOL, UK), Catherine Regan (MSSL, UK), David Andrews (IRF, SE), Shaosui Xu (SSL, USA), Xiaohua Fang (LASP, USA), Olivier Witasse (ESA ESTEC, NL)

Key points: Electron density profiles from MARSIS onboard Mars Express are analysed by computing the deviation from a Chapman layer and quantifying the topside total electron content. We find that topside layers above the photochemical region tend to be formed over horizontal fields and are stable over a larger latitudinal range over un-magnetised regions than magnetised regions of Mars.

Mars, without a global dipole magnetic field, has its atmosphere directly exposed to the impinging solar wind, which is a complex interaction due to the remnant crustal magnetic fields, with spatially varying strengths and inclinations, especially in the southern hemisphere. “Hybrid magnetospheres” generated over the strong crustal field regions, coupled with the planet’s rotation, increases the complexity of ionosphere dynamics. This study analyses 28 Mars Express orbits spanning 12 years of observations from the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) instrument to characterise the variability of topside electron density profiles both over strong crustal field anomalies in the southern hemisphere and far away from them. Variations are quantified by evaluating electron density departures from Chapman layer fits (ΔN_e), and electron contents of topside profiles normalised with respect to the solar zenith angle (TEC_n). A solar cycle dependence is perceived, with topside layers predominantly occurring during low solar activity in both strong and weak crustal field regions. We find that topside layers are mostly confined to regions where crustal fields either have horizontal to moderate inclinations or undergo drastic changes in orientation from vertical to horizontal. Moreover, the most horizontally extensive transient topside layers, spanning up to ~33.2° latitude, are observed over unmagnetized regions where draped horizontal magnetic fields dominate, showing little correlation with space weather events or solar wind disturbances. It is found that TEC_n may be elevated by a factor of ~1.5 over closed magnetic field apexes compared to nearby regions where field lines are vertical.

42. Sporadic E-like Event Driven by Wind Shear in the Martian Ionosphere

Rong Tian (Wuhan University, UK)

Co-authors: Chunhua Jiang (WHU China), Christopher Fowler (WVU, USA), Beatriz Sánchez-Cano (UOL,UK), Glyn Collinson (NASA,USA), David Andrews (IRF,Swedish), Wenjie Yin (WHU, China), Guobin Yang (WHU, China), Tongxin Liu (WHU, China), Chongzhe Lao (WHU, China) , Yaogai Hu (WHU, China)

Key points: 1.An Es-like event with both layer and rift was observed in the Martian ionosphere, accompanied by significant wind and magnetic shear. 2. Statistical analysis indicates that 9 Es-like events are found to be associated with wind shear in 305 orbits with wind measurements.

Sporadic E layers (Es) are characterized by thin, high-density layer structures in the E region in the terrestrial ionosphere. Recent studies show that Es-like events on Mars can also be observed and driven by magnetic shear. We report a new observation of a wind-shear-related Es-like event with both layer and rift in the Martian ionosphere, observed by NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft. Statistical analysis indicates that 9 Es-like events are found to be associated with wind shear in 305 orbits with available wind measurements and most occurred in the strong magnetic field region. Simulations suggest that the observed event can be explained by the sole effect of wind shear and the combined effect of wind and magnetic shear. This study provides new observations of Es-like events on Mars and serves as a credible candidate for demonstrating the contribution of wind shear to the formation of Es-like events.

BPSC Posters – Giant planets
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

43. Modelling Cosmic Ray Ionization of the Ice Giants' Atmospheres with CORSIKA 8

Ola Al-Khuraybi (University of Bristol, UK)

Co-authors: Karen Aplin (UoB, UK), Alberto Gambaruto (UoB, UK)

Key points: A Monte Carlo simulation has been performed for the propagation of the Galactic Cosmic Rays through customized atmospheres and magnetic fields of Uranus and Neptune. Initial results show peak of ionization occurring in the upper Troposphere (Tropospheric haze region).

Galactic cosmic rays (GCR) are high-energy particles that ionize atmospheres as they propagate in an air shower cascade. Understanding the ionization profile of the Ice Giants can help better interpret Voyager 2 data from over three decades ago, as well as propose the requirements of a future mission. Moreover, it adds a further piece to our holistic understanding of the Ice Giants. The GCR dose is higher at the Ice Giants as the solar wind modulation decreases with distance from the Sun, making GCR ionization more significant. The GCR ionization contributes to the conductivity profile of the atmosphere and may assist with chemical processes such as nucleation and cloud formation.
CORSIKA 8 (C8), a Monte Carlo extensive air shower modelling tool, is promising for modelling planetary cosmic rays. C8 utilizes a Sternheimer-corrected Bethe-Bloch equation to calculate the energy deposition due to ionization at various pressures in customizable atmospheric compositions. This energy is then used to calculate the ionization yield function. While C8 models have demonstrated alignment with Earth and Mars data, we have verified the consistency of C8 results for the Ice Giants against other models available in literature. C8 routines for low and high hadronic cascades, as well as electromagnetic and muonic cascades, have allowed us to model the Ice Giants to unprecedented detail. The maximum ionization due to GCR is found in the upper troposphere at pressures ≈ 104 Pa, agreeing with most existing models.

44. Investigating Saturn’s Ultraviolet Aurorae Using Hisaki Spectroscopic Data

Leah Clare (Lancaster University, UK)

Co-authors: Sarah V. Badman (Lancaster University, UK), Tomoki Kimura (Tokyo University of Science, Japan), Hiroyasu Tadokoro (Japan)

Key points: We analyse extreme/far ultraviolet spectroscopic data of Saturn's aurorae recorded by Hisaki. We constrain the temporal variability of the aurorae by investigating the emitted power over two-week timescales.

The aurorae of Saturn offer valuable insight into the plasma dynamics of its magnetosphere. Utilising data from JAXA’s space telescope Hisaki, acquired during two observing campaigns in 2014 and 2015 from low Earth orbit, we conducted spectroscopic analysis in the extreme/far ultraviolet wavelengths. Our study involves removing foreground geocoronal emission from the spectroscopic data to isolate Saturn's auroral emissions, particularly the hydrogen Lyman lines and Werner bands. This processing step is crucial due to overlapping features in the geocoronal and auroral emissions. By calculating daily auroral powers throughout both campaigns, we aim to constrain the temporal variability of Saturn's aurorae and further compare with Cassini observations of the aurorae and magnetosphere.

45. Curious Currents of the Ringed Giant: Investigating Saturn’s low-altitude field-aligned currents during Cassini’s final orbits

Samuel Farr (Lancaster University, UK)

Co-authors: Dr. Gabrielle Provan (LEI, UK), Dr. Sarah Badman (LAN, UK), Prof. Stanley Cowley (LEI, UK)

Key points: Using magnetic field measurements taken during Cassini’s ‘Grand Finale’ we investigate the field aligned currents over Saturn’s southern auroral region. We aim to develop understanding of FAC dynamics, structure, and implications of seasonal influences and magnetospheric dynamics.

Saturn's aurorae are driven by a system of field-aligned currents, coupling the magnetosphere and the ionosphere. We use magnetic field measurements collected during Cassini’s final 22 orbits, known as the ‘Grand Finale’, to investigate field-aligned currents flowing in Saturn's southern polar region. These measurements were made post-noon during northern summer, when differences in ionospheric conductivity between the two hemispheres will be significant.

Following previous studies, we separate the planetary period oscillation (PPO) currents from the PPO-independent currents. We compare the magnitude and latitude of both sets of currents to measurements made in the northern hemisphere, also during the Grand Finale, and at other local times to identify possible seasonal influences and effects driven by magnetospheric dynamics such as tail injections.

46. Jupiter's dawnside magnetodisc: the force-balance context to Juno observations

Gabrielle Provan (University of Leicester, UK)

Co-authors: J. D. Nichols (UoL, UK) and S. W. H. Cowley (UoL, UK)

Key points: It is the hot magnetospheric plasma which predominantly governs variations in the total azimuthal current in the magnetodisc.

We employ an iterative vector potential model of force balance in Jupiter's dawnside magnetodisc in order to examine the physics behind variations in the total azimuthal current previously observed by Juno. Specifically, we vary three key parameters that govern the force balance: a hot plasma parameter (=pV), the iogenic plasma mass outflow rate,and the ionospheric conductivity. We consider data obtained by Juno on orbits 1-12 as the spacecraft travelled inbound towards Jupiter and crossed the Jovian magnetodisc in Jupiter's middle magnetosphere. We fit the model to the residual component of the magnetic field and the density of the plasma sheet ions, finding the best-fit parameters for each orbit. We find orbit-by-orbit variations in the best-fit parameters, demonstrating a dynamic plasma sheet. We find a relation between the total azimuthal current in the magnetodisc and the hot plasma parameter, demonstrating that it is the hot plasma which predominantly governs variations in the total azimuthal current in the magnetodisc.

47. Seasonal, Diurnal and Solar Wind Driven Variability in Model-Predicted Reconnection Voltages Applied to Uranus' Dayside Magnetosphere

Sophia Zomerdijk-Russell (Imperial College London, UK)

Co-authors: Jamie M. Jasinski (JPL, USA) & Adam Masters (Imperial, UK)

Key points: Understanding the role of global magnetic reconnection in the solar wind-driven dynamics of Uranus' magnetosphere is important for the science definition of a new mission.

Analytical modelling determined that the reconnection voltage applied to Uranus' dayside magnetosphere under different magnetospheric configurations is lower than that determined at other planets in the solar system.

Uranus provides a key missing piece for fundamental comparative planetary magnetospheres and solar wind-magnetospheric interactions due to its location in the outer solar system and its 'vacuum' magnetosphere with weak plasma sources. Currently, we do not know whether a viscous-like interaction will overtake global magnetic reconnection as the dominant process in solar wind-magnetospheric interactions at the outer planets, or if global magnetic reconnection will remain dominant as it does at the Earth. A link to resolve this paradigm with a Uranus mission would be to provide a step change in our understanding of one of these two processes at Uranus. It is possible to assess the effectiveness of magnetic reconnection between the interplanetary and planetary magnetic fields in driving Uranus' magnetosphere by quantifying the voltage that is applied to the magnetospheric system due to reconnection processes. Through analytical modelling, we present predictions of the dayside reconnection voltage at Uranus under different magnetospheric configurations. We find that the typical reconnection voltage applied at Uranus' dayside magnetosphere is ~10 kV, lower than that determined at Earth and other planets within the solar system. We will also explore whether the reconnection voltage exhibits dependence on diurnal, seasonal, or solar wind variabilities. This will allow us to investigate the role of reconnection processes in solar wind-driven magnetospheric dynamics and whether reconnection is driven in cycles at Uranus, helping us to better understand the 'open-closed' magnetospheric dynamics that have been observed in magnetospheric models of Uranus.

48. Interplanetary Dust Flux at Uranus and Neptune

Nicholas Teanby (University of Bristol, UK)

Co-authors: Patrick Irwin (Oxford, UK), Conor Nixon (GSFC, USA), Martin Cordiner (GSFC/CUoA, USA), Lucy Wright (Bristol, UK), Joshua Ford (Bristol, UK)

Key points: Stratospheric water vapour was measured on Neptune and Uranus with the Herschel Space Telescope. This can be used to infer interplanetary dust fluxes into these planets, which can be compared to model predictions and other observations.

Interplanetary dust is a key component of the Outer Solar System space environment. It acts as an external source of material, seeding the upper atmospheres of giant planets and moons with trace species and impacting onto moon surfaces. It can be the dominant source of stratospheric oxygen for these very cold atmospheres, supplied mostly in the form of water ice. This external source can have significant effects on atmospheric chemistry, where photochemical reactions

can form more complex atmospheric molecules. Understanding interplanetary dust abundance is also important for future mission design as impacts with dust particles are a potential risk for spacecraft.
Here we use observations of stratospheric water emission lines by the Herschel Space Telescope to constrain interplanetary dust flux into the atmospheres of Uranus and Neptune. These fluxes will be compared to direct measurements from the New Horizons Student Dust Counter instrument and dynamical model predictions. We find the fluxes of external water at Uranus and Neptune are very similar, ~8 and ~13 x 10^4 molecules/cm2/s respectively, suggesting dynamical models may need revision, especially at Neptune's orbital distance where this flux is around 5-10 times less than current dynamical model predictions.

49. Saturn's Quasiperiodic Auroral Flashes in the Equinoctial Campaign

Tianshu Qin (The University of Hong Kong, Hong Kong SAR, China)

Co-authors: Sarah V. Badman (LU, UK), Zhonghua Yao (HKU, China)

Key points: We closely analyse of the development of quasiperiodic auroral structures and the plasma environment.

The ~1 hour periodicity is a well-established phenomenon at Saturn, which can be observed through energetic particle and magnetic field measurements, as well as radio wave and auroral observations. Saturn's 2009 equinoctial campaign undertaken by the HST coordinated with the continuous orbital operation of Cassini provided an unprecedented opportunity to observe both polar regions and investigate how aurora responds to the dynamics in Saturn's magnetosphere. Quasiperiodic auroral flashes, typically present for a few minutes in the duskside, are previously found to be hourly recurrent and captured in consecutive orbits of HST exposure. Previous studies have established a strong correlation between transient aurorae and magnetic field perturbations as well as plasma injections exhibiting strikingly similar periodicities, thereby suggesting their occurrence on closed field lines. However, in HST's dual-hemispheric observations, the duskside transients are identified only in the southern hemisphere. This strict lack of interhemispheric conjugacy indicates, rather unexpectedly, that the transients can be frequently present in open field orientation. In a multi-instrument case study, we found that Cassini was magnetically mapped to spatial locations virtually overlapping the transient aurorae but in the opposite hemisphere a few hours before auroral observations. Simultaneously, we identified multiple magnetosheath and boundary layer crossings accompanied by encounters with plasma structures that are more likely spatial variations. The lack of direct evidence of particle acceleration in closed regions of the outer magnetosphere (e.g., magnetopause reconnection) provides consistency to the non-conjugate transient auroral distribution, which contributes to further explain the mechanisms of Saturn's auroral dynamics.

50. From Earth to Europa: An Exploration into Sulphur-Ice Environments

Jessica Caughtry (University College London, UK)

Co-authors: Louisa Preston (UCL, UK), James Bradley (QMUL, UK), Anne Jungblut (NHM, UK)

Key points: Jupiter's moon Europa hosts a sub-surface ocean beneath a thick, dynamic ice shell, through which potential biosignatures must traverse before detection. This research investigates the impact of polymorphic ice transitions induced by low temperatures and high pressures on microbial cells and biosignatures.

Many water worlds have been discovered throughout the solar system, each hiding a liquid, sub-surface ocean beneath a thick shell of ice and rock. Jupiter's moon Europa may be the most astrobiologically promising of these; the confluence of hydrothermal activity on its seafloor and radiolytic sulfur and oxygen production at its surface creates a source of chemical energy for potential life to utilize. Chaos terrains criss-crossing Europa's exterior suggest possible communication with the underlying ocean, therefore investigating these alongside possible plumes will be critical for upcoming life-detection missions such as NASA's Europa Clipper and ESA's JUICE.

Induced by the high pressures and low temperatures expected to exist within the shells of icy moons, the impact of polymorphic ice transitions on microbial cells and biosignatures remains poorly understood. Focussed specifically on interior ice-shell dynamics and the ocean-ice interface, this research aims to further our understanding of not only Europa, exploring the physio-chemistry of different ices, biosignature modification and detection methods under different conditions and planetary-scale redox systems, but also of vulnerable Arctic environments present on Earth along with their associated microbiological communities. This will be achieved through laboratory experimentation, fieldwork and modelling, including: FT-IR spectroscopy, ice polymorph transition equipment, cell limitation and microbial community analyses, and ion/elemental environmental compositional investigation. Knowledge gained may subsequently be used in modelling similar exoplanet super-Earths where the ocean and atmosphere are not in contact. Ultimately, results will enhance our knowledge of habitability and life in extreme environments, both on Earth, and beyond.

51. Seasonal variation of Titan's stratospheric tilt

Lucy Wright (University of Bristol, UK)

Co-authors: Nicholas A. Teanby (Uo Bristol, UK), Patrick G. J. Irwin (Uo Oxford, UK), Conor A. Nixon (PSL, NASA Goddard, US), Joshua S. Ford (Uo Bristol, UK)

Key points: Titan's stratosphere rotates about an axis that is tilted with respect to the solid-body rotation axis. We determine the magnitude and direction of this tilt and investigate its evolution over half a Titan year.

Titan, the largest moon of Saturn, is the only moon in our Solar System with a substantial atmosphere. Titan's stratosphere is in superrotation, a phenomenon also exhibited in in the atmospheres of Venus, Jupiter, and Saturn. The symmetry axis of the rotating stratosphere appears to be offset from Titan's geographic pole by approximately 4 degrees [1]. The offset of this stratospheric tilt axis has been determined consistently through temperature retrievals [1, 2], composition retrievals [3, 4], and by analysis of images of stratospheric haze [5, 6, 7] and polar clouds [8]. However, the mechanism causing the tilt is not yet understood. We independently determine the magnitude and direction of the stratospheric tilt axis, from temperature and composition maps with a higher spatial resolution than in previous studies. This is achieved by inverting low-spectral-resolution (FWHM~14.5 cm-1) mid-infrared spectra (580—1500 cm-1) acquired by Cassini's Composite Infrared Spectrometer (CIRS) [9, 10]. In addition to determining an average stratospheric tilt, we investigate the seasonal evolution of the tilted axis between Titan Northern mid-winter (2004) and Northern Summer solstice (2017). Quantifying the tilt of the stratospheric rotation axis provides insight into the underlying dynamics causing the tilt and the mechanisms that drive superrotating atmospheres in general.

References: [1] Achterberg et al., 2008b [2] Achterberg et al., 2011 [3] Teanby et al., 2010 [4] Sharkey et al., 2020 [5] Roman et al., 2009 [6] Kutsop et al., 2022 [7] Vashist et al., 2023 [8] West et al., 2016 [9] Flasar et al., 2004 [10] Nixon et al., 2019

52. Limb-darkening approximation analysis for atmospheric retrievals on Titan

Joshua S Ford (University of Bristol, UK)

Co-authors: Nicholas A. Teanby (Uni of Bristol), Patrick G. J. Irwin (Uni of Oxford) , Conor A. Nixon (NASA), Lucy Wright (Uni of Bristol)

Key points: Using limb-darkening approximations to increase the Signal-to-Noise ratio of Cassini CIRS Titan data to improve our understanding of the abundance and vertical profiles of minor atmospheric species

In 2017 Cassini finished its 13-year mission to the Saturnian system, completing 127 close flybys of Saturn's largest moon, Titan. Cassini's Composite Infrared Spectrometer (CIRS) captured 8.4 million spectra in the thermal infrared (7 - 1000mm) [1], allowing Titan's atmospheric temperature and gas abundances to be retrieved. While much of this data has been analysed there are still uncertainties in our understanding, for example the abundance and vertical profiles of minor atmospheric species. Many gases exhibit emission lines that are so weak they are hidden amongst the noise, so robust detections are challenging. The current method to search for weak features is to average spectra, however this loses geometric information and can cause systematic bias by including a wide range of emission angles. Here we present a new technique based on limb-darkening approximations to increase Signal-to-Noise Ratio (SNR) while keeping geometric information.
Limb-darkening/limb-brightening is an effect whereby the limb of a planet/star is darker/brighter than the centre due to increasing optical depth. However as shown by [2] limb-darkening can be applied to planetary atmospheres in the visible/near-infrared to improve SNR, computational efficiency and robustness. In this study, we show that by applying an adapted stellar limb-darkening function [3] to synthetic and observed CIRS IR Titan spectra, we can increase the SNR substantially. By fitting the atmospheric radiance over emission angles 0°– 60°, a parameterised function can be retrieved for each wavelength. This allows re-construction of the spectra accounting for geometrical variations and improves fit quality approaching the instrument's noise floor.

53. Further analysis into the plumes of Enceladus

Anna Parsec-Wallis (MSSL, University College London, UK)

Co-authors: Andrew Coates (MSSL, UK), Geraint Jones (MSSL, UK)

Key points: Ahead of the announced large-class ESA mission with mission targets being Enceladus, we analyse the Cassini CAPS-ELS data from flyby E3 to resolve the composition of this icy moon's plumes.

One of the unexpected measurements of the Cassini-Huygens mission was the discovery of heavy negative ions in Titan's upper atmosphere and in the plumes Enceladus. Anions appear to be a feature of icy moons with subsurface oceans, signalling the potential for prebiotic chemistry. The primary focus of our research is to resolve the composition of icy moon atmospheres. Ahead of the announced large-class ESA mission with mission targets being Enceladus and Titan, it is important to analyse existing data with the most advanced methods available to unravel further details on the processes at work. In this poster we will present the current analysis of Enceladus flyby E3 and the composition of this icy moon's plumes that can be resolved.

54. Freezing behaviour of water droplets at the liquid-vacuum interface relevant to plume-forming regions on Enceladus

Jessica Hogan (The Open University, UK)

Co-authors: Rachael Hamp (OU, UK), Mark Fox-Powell (OU, UK), Jonathan Merrison (AU, DK), Jens Jacob Iversen (AU, DK), Manish Patel (OU, UK), Victoria Pearson (OU, UK)

Key points: Pure water and saline droplets were injected into low pressure conditions to investigate the effects of pressure and salinity on the freezing time of droplets under Enceladus plume conditions. With high-speed videography and laser doppler velocimetry, we simulate the formation and behaviour of the precursor salty liquid droplets that undergo freezing within the vents supplying the plume.

Salt-rich ice grains entrained within the plume at Saturn's moon Enceladus emanate from cracks in the ice shell, via conduits/vents that transport subsurface ocean material to the surface, where accessible to spacecraft. Likely to originate as dispersed ocean spray droplets representative of source liquid reservoir composition, expelled grains can be used as a tool to elucidate the chemistry and habitability of the otherwise inaccessible subsurface. However, the effects of rapid temperature and pressure changes on the freezing times of ice grains during eruption, which are vital in determining how ocean minerals are transferred into observed plume particles, remain unknown. We aim to characterise freezing times of salty droplets under predicted vent conditions, between the liquid ocean and vacuum interface (≤ 6 mBar) and observe droplet interactions during the freezing process to explore fragmentation that could link to variation in salt-rich grain compositions.
Through novel experiments conducted at Aarhus University, we employed their planetary simulation chamber to inject pure deionised water and NaCl droplets into low-pressure (0.2 – 6 mBar) conditions. Specifically, we studied the effect of pressure and salt concentration on freezing time using high-speed videography and laser doppler velocimetry, with future work aiming to explore parameters affecting composition within simulated plume ice grains. Experimental techniques refined here are crucial for interpreting solid plume fallout and understanding plume material formation processes at Enceladus and other cryovolcanically active bodies.

55. Investigating the formation of martian biosignatures within open and closed systems.

Nisha Ramkissoon (The Open University, UK)

Co-authors: Michael C. Macey (The Open University, UK), Ezgi Kucukkilic-Stephens (The Open University, UK), Timothy Barton (The Open University, UK), Andrew Steele (Carnegie Institution of Washington, USA), Ben P. Stephens (The Open University, UK), Susanne P. Schwenzer (The Open University, UK), Victoria K. Pearson (The Open University, UK)

Key points: We have conducted simulation experiments that aims to identify potential biosignatures that could form within martian environments.

The presence of hydrated minerals and geomorphological features provides compelling evidence that water was once present on the surface of Mars, either in a planetwide hydrological cycle or in localised and transient occurrences. If aqueous environments were present on Mars, then it is possible that these environments could have supported microbial life, which would have left behind biosignatures that could be detected by current and future missions. Here, we present the results from a series of simulation experiments that aim to identify potential biosignatures that could have formed within martian environments.

Simulation experiments were conducted under abiotic and biotic conditions. The OUCM-1 regolith simulant and a modelled groundwater fluid were used to create the chemical environment. These were added to a bench-top reaction vessel in either the flow-through or batch configuration, which reflects the open and closed system alteration conditions found on Mars. Biotic experiments were inoculated with an analogue microbial community. At the end of the experiment, an investigation into microbially induced mineralogical changes was undertaken using SEM-EDS analysis, Raman spectroscopy, and Mössbauer spectroscopy.

These initial experiments showed that different biosignatures would form in open and closed systems. Under closed system and biotic conditions, Fe-rich tubular structures, CaCO3 crystals, and silica nano-particles were observed, whereas in an open system and biotic conditions, dissolution textures and little evidence of mineral deposits were identified. This suggests that microbial activity would leave behind detectable geochemical biosignatures but also highlights the importance of simulating both open and closed systems in biosignature investigations.

56. Evaluating the preservation of biosignatures within early terrestrial silica deposits

Nisha Ramkissoon (The Open University, UK)

Co-authors: Wim Van Westrenen (VU University, Netherlands)

Key points: We conducted high-pressure and high-temperature experiments to examine the effect high-grade metamorphism could have on the preservation of biosignatures within synthetic early Earth silica deposits.

To understand if life could develop elsewhere in the Solar System, we first need to establish the conditions that led to the development of life here on Earth. To achieve this, we can examine the rock record to search for evidence of life (biosignatures), which will help to constrain how long life has existed on Earth. Some of the earliest biosignatures found on Earth were identified in ancient silica deposits (cherts) with ages of up to 3.5 Gyrs old. However, the oldest fragments of crustal rocks are at least 3.8 Gyrs old and would have experienced significant metamorphisms, meaning that any potential biosignatures preserved in ancient deposits may be unrecognisable. This study examines how biosignatures preserved in silica deposits are modified when exposed to metamorphic conditions.

In these experiments, silica sinters were created from two silica-saturated fluids, pure H2O and an early Earth ocean analogue, under abiotic and biotic conditions. These samples were then individually subjected to a pressure of 12 kbar and a temperature of 650 °C, using an end-loaded piston (VU University, Amsterdam), which mimicked the initial conditions of high-grade metamorphism. These conditions were held for 20 hours, and the samples were analysed using Raman spectroscopy and GC-MS to identify changes in the mineralogy and modifications to preserved organic biosignatures.

We will present the initial results from these experiments, which will contribute to our understanding of the effects high-grade metamorphism will have on biosignatures preserved in silica.

57. Spectral Identification of the Precursors for Life

Emily Ingman (University College London, UCL)

Co-authors: Jessica Caughrty (UCL), Louisa Preston (UCL)

Key points: IR reference spectra of minerals, ice and organics were obtained experimentally to aid in the confident characterisation of icy bodies in the Solar System. Experimental procedures and results will be discussed, in addition to the implications for habitability.

The presence of water and a range of organic molecules in potentially habitable environments is considered to be essential when searching for signs of life in the Universe. Water is abundant and commonly observed in the form of ice. Not only is water ice common on Earth, it has been detected on the moons of Jupiter and Saturn, in comets and asteroids and in the subsurface and poles of other Solar System bodies. However, water ice is not pure and is composed of a mixture of dust, minerals and the organic molecules necessary for life. Infrared (IR) spectroscopy, both in-situ and remote, is a powerful technique used to identify the mineral, dust, ice and organic content of Solar System bodies, providing crucial insight into their composition and subsequent habitability potential. Due to the complex composition of these icy bodies and the current scarcity of returned samples and reference spectra of analogous Earth materials, the accurate interpretation of spectra is challenging, often leading to the incorrect identification of astrophysical materials.
This work provides a range of IR reference spectra of minerals, ice and organics, obtained through experimental simulations, in order to aid in the accurate characterisation of extraterrestrial materials. Through the identification and characterisation of analogous materials using IR spectroscopy, this work aims to improve the in-situ and remote techniques used to characterise planetary bodies whilst refining the current understanding of the formation, preservation and evolution of precursor molecules throughout the Solar System.

58. Unveiling the origins of prebiotic material: a systematic spectroscopic study exploring the effects of energetic processing on astrophysically relevant ice

Vassi Spathis (University of Kent, University of Leicester, Institute for Space)

Co-authors: A. Traspas Muiña (QMUL, ICMM), D. Ramsamoedj (Radboud University), F. de Almeida Ribeiro (MPIEP), J. G. M. Schrauwen (Radboud University), J.D. Tandy (Uni. of Kent) , B.M. Giuliano (MPIEP), Z. Kaňuchova (Slovak Academy of Sciences), B. Redlich (Radboud University), S. Ioppolo (QMUL, Aarhus University)

Key points: We performed laboratory experiments to investigate amino acid and complex organic molecule (COM) formation within a prebiotic-like ice mixture consisting of simple molecules prevalent in our Solar System and the ISM.

Understanding the origin of prebiotic molecules in our Solar System can provide insight into the emergence of life on Earth. Amino acids, vital for life as we know it, have been detected beyond our planet and, as such, hint at a wider distribution of organic material which was potentially transported to the early Earth via meteorite impact, undergoing transformative processes which could contribute to, or result in, fundamental compositional or structural alterations. Here, laboratory experiments were performed to investigate amino acid and complex organic molecule (COM) formation within a prebiotic-like ice mixture consisting of simple molecules prevalent in our Solar System and the ISM. The ice mixture was characterised utilising spectroscopic techniques such as IR, VUV, and THz, with IR and VUV spectroscopy serving as controls for the various radiation processes explored here. Experiments including FEL-IR, FEL-THz, and electron gun irradiations were conducted at the HFML-FELIX facility in the Netherlands; electron gun irradiation and VUV monitoring was performed at ASTRID2 at Aarhus University, Denmark as a complementary study, and THz spectroscopic characterisation was performed at the Max-Planck Institute in Germany. We observed that, while FEL irradiations did not induce chemical reactions, they did affect the ice lattice modes, causing structural changes upon resonance irradiation. Preliminary results from the electron gun experiments indicate the formation of various COMs, although analyses are still ongoing. Our findings are discussed in the context of missions such as JWST and Juice, exploring their implications for understanding Solar System chemistry and potential sources of prebiotic compounds.

BPSC Posters - Earth
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

59. K11-DIAD: An image-guided diffraction beamline for studying geo-processes

Liam Perera (Diamond Light Source)

Co-authors: Sharif Ahmed (DLS), Alberto Leonardi (DLS)

Key points: We present DIAD, an imaging and diffraction beamline that is ideally suited to studying extra-terrestrial and terrestrial geo-processes. We wish to expand our planetary and geoscience user community.

DIAD (Dual Imaging And Diffraction) is a beamline at Diamond Light Source, the UK's synchrotron light facility. DIAD utilises two independent X-ray beams that are spatially registered allowing "quasi-simultaneous" X-ray Computed Tomography (XCT) and Wide Angle X-ray Powder Diffraction (XRD). DIAD enables its users to visualise macrostructure in 2D/3D with a 1.5 µm spatial resolution as well as identify composition/phase information. The key functionality of the beamline is its ability to perform "image-guided diffraction" whereby regions within a sample can be identified with 3D X-ray imaging and then probed directly with diffraction. Our unique set up also allows users to carry out in-situ experiments that require spatially correlated information. DIAD is ideally suited to study samples with spatial heterogeneity and for studying in-situ and dynamic processes. DIAD's range of sample environments allows users to study environmentally relevant processes involving: variable temperature, humidity, gas, fluid flow, and uni-axial loading (tension/compression). The DIAD team are looking to expand our planetary and geoscience user community and we welcome questions and proposals from new and experienced synchrotron users alike.

60. Unusual shrinkage and reshaping of Earth's magnetosphere under a strong northward interplanetary magnetic field

Xiangyu Wang (Shandong University, China)

Co-authors: Xiang-Yu Wang (SDU, China), Qing-He zhang (SDU, China), Chi Wang (NSSC, China), Yong-Liang Zhang (JHUAPL, USA), Bin-Bin Tang (NSSC, China), Zan-Yang Xing (SDU, China), Kjellmar Oksavik (UoB, Norway), Larry R. Lyons (UCLA, USA), Michael Lockwood (UoR, UK), Qiu-

Gang Zong (PKU, China), Guo-Jun Li (CUPT, China), Jing Liu (SDU, China), Yu-Zhang Ma (SDU, China), Yong Wang (SDU,China)

Key points: Dual-lobe reconnection will short the magnetotail and leading to a quasi-dipole magnetosphere with very low open magnetic flux

The Earth's magnetosphere is the region of space where plasma behavior is dominated by the geomagnetic field. It has a long tail typically extending hundreds of Earth radii (RE) with plentiful open magnetic fluxes threading the magnetopause associated with magnetic reconnection and momentum transfer from the solar wind. The open-flux is greatly reduced when the interplanetary magnetic field points northward, but the extent of the magnetotail remains unknown. Here we report direct observations of an almost complete disappearance of the open-flux polar cap characterized by merging poleward edges of a conjugate horse-collar aurora (HCA) in both hemispheres' polar ionosphere. The conjugate HCA is generated by particle precipitation due to Kelvin-Helmholtz instability in the dawn and dusk cold dense plasma sheets (CDPS). These CDPS are consist of solar wind plasma captured by a continuous dual-lobe magnetic reconnections, which is further squeezed into the central magnetotail, resulting in a short "calabash-shaped" magnetotail.

61. Elfen: A Novel CubeSat to Probe Plasma Composition in the Earth's Magnetosphere

Bhargav Narasimha Swamy (University of Leicester, UK)

Co-authors: Jennifer A Carter (Leicester, UK), Piyal Samara-Ratna (Leicester, UK), Amy L Fleetham (Leicester, UK), Oliver Blake (Leicester, UK), Ronek Bijur (Leicester, UK), Simona Nitti (Leicester, UK), Patrick Brown (ICL, UK), Jonathan Eastwood (ICL, UK), Jim Raines (Michigan, USA), Sue Lepri (Michigan, USA), Tyler Eddy (Michigan, USA)

Key points: Elfen is a cost-effective, timely and high-value science return mission proposal that can provide insights about the much-debated origin and dynamics of heavy Ions in the Earth's magnetosphere

Elfen is a mission aimed at understanding the heavy ion composition of the upstream solar wind and the origin of ions in the night-side plasma sheet of the Earth's magnetosphere. The origin and dynamics of heavy ions in the magnetosphere is poorly understood with multiple theories attempting to explain both day-side and night-side entry. Secondary processes, such as soft X-ray emission via solar wind charge exchange that affect imminent X-ray imaging missions, are also linked to ions of solar origin.

The spacecraft will be a CubeSat placed in a circular orbit in the ecliptic plane, at a distance of twelve Earth radii from the centre of the Earth. This will allow high duty cycle measurements of the unshocked and shocked solar wind on the day-side of the orbit and plasma sheet on the night-side, over a total baseline mission science period of one year.

Elfen is led by co-principal investigators at Universities of Leicester and Michigan, and Imperial College London. The scientific measurements needed for this mission are plasma heavy ion (C6+, O7+) compositions and the local magnetic field vector. To measure the ions, Elfen will carry an instrument called Triple Fast Imaging Plasma Spectrometer (T-FIPS), being developed by the University of Michigan, inherited and modified from the FIPS instrument flown on the Messenger mission to Mercury. The magnetic field measurements will be aided by a dual-magnetometer instrument called MAGIC, developed by Imperial College London. University of Warwick will support the hardware development with detailed kinetic modelling of magnetospheric ions.

BPSC Posters - Community
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

62. Planetary Materials Research and Facilities at Leicester

Leon Hicks (University of Leicester, UK)

Key points: Leicester has been involved with planetary science research for over sixty years. Today the university provides specialist support with a comprehensive range of microscopy instrumentation and laboratories, researching a range of planetary materials from the meteoritical to space sample return.

Leicester has been involved in space and planetary science research for over sixty years. Today, the University of Leicester and now Space Park Leicester, provide specialist support for researchers in physics, space science, engineering, geology, and chemistry, etc., including the investigation of planetary materials.

Previous studies of planetary materials at Leicester range from the meteoritical, including aqueous alteration in Martian meteorites and thermal history of Martian regolith breccias, to space sample returns such as iron oxides in Stardust comet 81P/Wild2 samples and space weathered Hayabusa Itokawa asteroid grains. Many of these investigations were successful collaborations, involving institutions throughout the UK and globally.

The University of Leicester and its Advanced Microscopy Facility (AMF) provide a comprehensive range of instruments, including FEG-SEMs equipped with EDS, WDS, and Cathodoluminescence detectors and micro-XRF, as well as FIB-SEM and TEM instruments, CT scanning, and a suite of light microscopes. The university also provides sample preparation laboratories, such as polished thin sectioning for geological samples, and powder pellets or fused beads for WD-XRF analyses. More recently, the AMF now includes the Hercules facility with a Micro-CT for macroscale X-ray 3D imaging and a LaserFIB-SEM equipped with femtosecond laser.

Over the coming years, the recent asteroid sample returns from Ryugu (Hayabusa-2) and Bennu (OSIRIS-Rex) are being compared to carbonaceous chondrite meteorites, and terrestrial and/or synthetic comparisons will be made to Mars and BepiColombo Mercury analyses. Preparations are also being made for Mars Sample Return. Leicester will continue to play an important role in planetary material research.

63. Expanding the scope of the UK Planetary Forum

Peter Fawdon (The Open University, UK)

Co-authors: Peter Mc Ardle (Manchester), James Darling (Portsmouth), Karen Devoil (UCL), Lee White (OU), Peter Fawdon (OU), Mark Fox-Powell (OU), Stephanie Halwa (Manchester), Thomas Harvey (geolsoc), John Pernet-Fisher (Manchester), Duncan Lyster (Oxford), Isabelle Mattia (Imperial), Meg Schwamb (Queens Belfast), Jordan Stone (Imperial), Martin Suttle (OU), Dimitri Veras (Warrick),

Key points: This year the UK Planetary forum has embarked on a new initiative to expand the scope of its activities. We present an overview of these developments and our vision for how they will benefit the community.

The UK Planetary Forum exists to promote planetary research among scientists in the UK. Currently, this consists of a mailing list, website, running the annual UKPF ECR meeting and involvement with biannual British Planetary Science Conference (BPSC). However, the community has grown substantially over recent years. To better enable us to fulfill our mission supporting this community we have started a new initiative to expand and enhance the role of the UK Planetary Forum. To achieve this expansion in our operations, we formed a transitional committee to help define the structure of UKPF and are forming a special interest group under the joint auspices of the Royals Astronomical Society and Geological Society of London. We present an overview of these ongoing developments and our vision for how the UKPF will be able to serve the community in the future and we invite you to share your thoughts and constructive feedback with us about how we do this. We hope that this will bring in a new wave of people and allow for many more years of success for UKPF.

64. The Open University's Hypervelocity Impact and Space and Environment Simulation facilities

Zoe Emerland (The Open University, UK)

Co-authors: Manish Patel (OU, UK), Matthew Sylvest (OU, UK)

Key points: Presentation of the hypervelocity impact and space and environment simulation facilities available for the community to use at the Open University.

The Open University’s HyperVelocity Impact (HVI) Laboratory is uniquely equipped with both an All-Axis Two-stage Light Gas Gun (AALGG) and a 2 MV Van de Graaff accelerator. The AALGG has the distinctive ability to rotate between horizontal and (downwards) vertical firing enabling a range of impact angles and the use of loosely consolidated targets. The AALGG can accelerate spherical/cylindrical projectiles of up to 3.5 mm diameter to velocities up to 6 km/s. Loose particles can also be fired as “buckshots”, enabling the investigation of ices, dust and salts. High-

speed cameras record high-resolution (>1M frames per second) videos of the impact. Further in situ assessments include analysing the outgassed volatile headspace from impacts into ice using a quadrupole mass spectrometer and measuring the thermal profile of an impact flash using a high-speed pyrometer.
The Space and Planetary Environments Laboratory (SPEL) is equipped with vacuum chambers ranging in size and purpose for simulating environments on other planetary bodies. The Large Mars Chamber ("George"), 1.8 m long and 0.9 m diameter, is a large, adaptable environmental simulation chamber suitable for 'dirty' applications not typically associated with vacuum chambers, such as mud-volcanism, surface runoff and CO2 sublimation experiments. "Edmund" is a 1.2 m long and 0.7 m diameter chamber that provides a clean environment for space instrumentation testing and qualification including TQCM measurements. "Baldrick" is a 60 m diameter 20 m tall chamber, designed specifically for astrobiology exposure experiments. All of these chambers (and more) are available for use by the planetary community.

65. Novel custom sabot designs for use in hypervelocity impact experiments

Ethan Finch (University of Kent, UK)

Co-authors: Penny Wozniakiewicz (UoK), Jon Tandy (UoK), Mark Burchell (UoK), Luke Alesbrook (UoK), Elliot Sefton-Nash (ESA, ESTEC), Chrysa Avdellidou (UoL), Vassilia Spathis (Institute for Space, UoL) Detlef Koschny (TUM)

Key points: High resolution 3D printers allow for the use of new custom projectiles in impact experiments. This provides a greater ability to use a range of geological and composite materials in investigations.

Hypervelocity impact experiments using light-gas guns have long played a key role in planetary science investigations. Design limitations of guns, however, often restrict both the speed over which they can be fired and the variety of projectiles that can be investigated. Whilst development needed to significantly increase the speed range over which a projectile can be fired is considerable, the revent development of accessible high resolution 3D printers has provided a route for the development of novel sabot designs. The study presented here probes the utility of resin 3D printed sabot designs for use within the single-stage light-gas gun at the University of Kent and their application to the field of planetary science. An initial shot programme was performed ensuring sabot designs allowed the maximum amount of projectile material to reach the target whilst preventing damage to the gun barrel used. This sabot design allows for a ~5 mm diameter projectile (compared to 3 mm in our standard sabots) to be fired at speeds up to 1 km/s. The results show the iterative process undertaken during the development of these novel 3D printed sabots and how they behaved when fired in the gun. One particular feature is that instead of using pre-existing projectiles, the projectiles used within these tests were cast in-situ within the sabots, filling the whole of the interior with the projectile material. This, combined with the larger than before interior volume, provides a much greater ability to use a range of geological and composite materials in impact studies.

BPSC Posters – Space
Main atrium and small atrium, Space Park Leicester
Tuesday 18th June – Friday 21st June

66. Extending Sustainability Initiatives Beyond Earth's Orbit: A Responsible Approach to Space Exploration

Ryan Laird (Green Orbit Digital Ltd)

Key points: This presentation explores the integration of circular economy principles and key space sustainability initiatives—Space Sustainability Rating, Astra Carta, and the Zero Debris Charter—in space missions, emphasising their application beyond low Earth orbit.

As space exploration advances, the imperative for sustainable practices becomes increasingly apparent. This presentation delves into the integration of circular economy principles and key space sustainability initiatives—Space Sustainability Rating (SSR), Astra Carta, and the Zero Debris Charter—in space missions. The focus extends to Lunar exploration and Mars, emphasising the significance of sustainable approaches. The British Planetary Science Conference 2024 serves as a platform to discuss innovative approaches and mission parameters that prioritise environmental responsibility.

Circular economy involves minimising waste, reusing resources, and recycling materials to establish a self-sustaining system. This approach is crucial in mitigating the environmental impact of planetary missions. Exploration of the Moon and Mars demands a careful balance between scientific discovery and ecological responsibility. Lessons from the ESA Rosetta mission underscore the effectiveness of communication from the inception of a space mission. Involving communicators early in the mission planning process optimises the development of a sustainable "brand" for more impactful public engagement and support in an ever-increasing environmentally-conscious society.

Additionally, this presentation advocates for the integration of space sustainability initiatives, such as the SSR, Astra Carta, and the Zero Debris Charter, into the broader framework of space exploration. Applying these initiatives beyond low Earth orbit ensures responsible practices during the exploration of our Solar System. By amalgamating circular economy principles with space sustainability initiatives, we can forge a path toward environmentally responsible space exploration, mitigating risks, and preserving the space environment for future generations. The collaborative efforts of scientists, engineers, communicators, and private entities are essential for a sustainable future in space.

67. Orbyts: Partnering Researchers with Schools

Michaela Mooney (University of Leicester, UK)
Presented by Connor Ballard (University College London)

Co-authors: Jasmine Sandhu (UoL, UK), Will Dunn (UCL, UK), Abbie Bray (LCN, UK)

Key points: Orbyts believes that science should be truly inclusive for everyone, regardless of income-background, ethnicity or gender. To facilitate this, we pair researchers with schools to empower school students, researchers and teachers through inspirational science research partnerships.

STEM subjects, and particularly physics, suffer from a systemic lack of diversity and long-standing barriers to inclusion. Girls, Black students and students from low-income backgrounds are highly under-represented at all levels of physics from age 16+. Meanwhile, UK science education faces substantial shortages in physics teachers, with 1 in 7 UK schools not having a physics teacher. The Orbyts programme aims to address these issues by partnering passionate science researchers with school students to work on original science research projects.
At Leicester, we have successfully run 5 researcher-school partnership projects since 2022, directly involving around 50 school students in cutting-edge science research. The science covered in these projects has ranged from exploring Jupiter's upper atmosphere using JUNO data to the Earth's magnetosphere, supporting the upcoming SMILE mission.
The long-term engagement and partnership style of Orbyts projects is key to widening access to science. Orbyts researchers provide relatable role models and humanise science research on an individual level, breaking down harmful stereotypes and misconceptions of who can be a scientist. Our programme evaluation shows that Orbyts delivers profound improvements in inclusivity (e.g. the programme sees 100% increases in girls taking A-level physics when run at GCSE and similar impact across income background and ethnicity).
The research-focus of an Orbyts partnership supports researchers to carry out their science research in a different context while mentoring and inspiring young people. The programme has proven to enhance essential transferable skills for our researchers including communication skills training, project leadership and applied pedagogical experience.