ESA SCI Science Workshop #12
12–14 November 2019
Aranjuez, Spain

Abstracts

Organising Committee:
Alba Alcol, Rune Floberghagen, Michael Küppers, Erik Kuulkers, Tanya Lim, Gabriele Matzeu, Jennifer Ngo-Anh, Mylène Riemens, Jan Tauber, Joe Zender.

Space Science Workshop #12
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Scientific Programme

Tuesday 12 November		
13:00 – 15:00	**Lunch**	**Poster Setup**
Session 1	Chair: Nuria Álvarez	
15:00	**Welcome**	Arvind Parmar
15:10	**Black holes: No hairs, no mercy (Invited)**	Richard Saxton
15:40	Modelling black hole variability with XMM	Michael Parker
16:00	Solving the X-ray Broadband emission in the NLS1 TON S180	Gabriele Matzeu
16:20	An upper limit on the mass of a central black hole in the large magellanic cloud	Nora Luetzgendorf
16:40	**Coffee Break**	**Poster Setup for stragglers**
Session 2	Chair: Héctor Canovas	
17:00	Further Investigations of Massive Stars Found Outside Prominent Star Clusters	Tony Marston
17:20	Polluting in time and space	Guido de Marchi
17:40	Dynamical histories of nearby star-forming regions	Catarina Alves de Oliveira
18:00	New RFs and YGTs introduction	Jan-Uwe Ness/Ana Heras
18:30	**End of Oral Session**	
18:45	**Poster Session + Icebreaker**	**All Poster first authors – Poster room**
20:00	**End of Sessions**	
20:15	**Buffet Dinner**	

Wednesday 13 November		
Session 3	*Chair:Georgina Graham*	
09:00	**Radar Interferometry of Volcanoes (Invited)**	Julia Kubanek
09:30	Unbuckling the Van Allen Belts: History and Physics	Lionel Métrailler
09:50	Radiation health risk assessment and mitigation beyond Low Earth Orbit.	Anna Fogtman
10:10	Discovering their Universe - consulting the public on Voyage 2050	Karen O'Flaherty
10:30	**Coffee Break / Posters**	**Poster room**

Session 4	Chair: Anezina Solomonidou	
10:50	Unlocking the Secrets of a Previously Unopened Apollo 17 Core Sample	Francesca McDonald
11:10	Constraints on the origin of the sources of lunar magnetic anomalies from orbital magnetic field data	Joana S. Oliveira
11:30	Investigations of Mercury's surface phenomena – It's a MeSSS	Sebastien Besse
11:50	Quantifying the Latitudinal Distribution of Climate-Related Landforms on Mars' Southern Hemisphere	Martin Völker
12:10	New insights into the geology and topography of Oxia Planum	Ottaviano Ruesch
12:30	**Lunch**	**Lunch room**
Session 5	Chair:Sandor Kruk	
14:00	Astrometric detection of gravitational waves	Uwe Lammers
14:20	Gaia and Carte du Ciel	Timo Prusti
14:40	Fitting exoplanet orbits to the Gaia scanning law	Daniel Michalik
15:00	Gaia DR2 observations of Evolved Stars	Pedro Garcia-Lario
15:20	PanGaia: A Python toolkit to study Star Forming Regions using Gaia astrometry	Hector Canovas
15:40	**Coffee Break / Posters**	**Poster room**
Session 6	Chair:Ciro Pinto	
16:10	Peanuts in the sky: classifying galaxy structure in large surveys	Sandor Kruk
16:30	Dusty star forming galaxies over cosmic time: what triggers their high star formation?	Laia Barrufet
16:50	Star formation properties of galaxies in extreme environments > 8 billion years ago	Lyndsay Old
17:10	Resolving high redshift star forming regions with gravitational lensing	Tim Rawle
17:30	Slow quenching of the star formation in the cores of galaxy clusters	Ivan Valtchanov
17:50	A catalogue of XMM Newton BL Lacs	Nuria Álvarez
18:10	GREEN ESA: A brain-storming discussion	Introduction: Felix Fürst (GREEN ESAC) and TBD (ESTEC)
18:40	**End of Sessions**	**Free time until SSW12 Dinner**
20:30	**Dinner**	

Thursday 14 November		
Session 7	Chair: Ottaviano Ruesch	
09:00	The young nuclear star clusters in NGC 5253	Linda Smith
09:20	**Cold lunar volatiles: So hot right now (Invited)**	Elliot Sefton-Nash
09:50	Space weathering of the surfaces of atmosphere-less icy bodies: overview of ESAC driven activities	Nicolas Altobelli
10:10	Energetic ion depletions near the Galilean moons: interaction with plumes and atmosphere	Hans Huybrighs
10:30	Titan's surface chemical composition constraints	Anezina Solomonidou
10:50	**Coffee Break / Posters**	**Poster room**
Session 8	*Chair:Michael Parker*	
11:20	Investigating flux tubes within the solar wind	Georgina Graham
11:40	Analytic form of electrostatic potential for solar wind acceleration	Pedro Osuna
12:00	How can a magnet hide its signature line? The case of 4U 1901+03 and 2S 1417-624	Felix Fürst
12:20	Fast & Furious: powerful winds unveil super-Eddington accreting compact objects	Ciro Pinto
12:40	**Wrap-up**	Markus Kissler-Patig
13:00	**Lunch**	**Lunch room**
14:00	**Bus to Barajas (ESTEC personnel)**	
14:30	**Bus to ESAC (ESAC personnel)**	

Participant list		Site
Alba	Alcol	ESAC
Bruno	Altieri	ESAC
Nicolas	Altobelli	ESAC
Nuria	Álvarez Crespo	ESAC
Catarina	Alves de Oliveira	Baltimore
Michele	Armano	ESTEC
Mari-Liis	Aru	ESTEC
Christophe	Arviset	ESAC
Deborah	Baines	ESAC
Laia	Barrufet	ESAC
Guillaume	Belanger	ESAC
Johannes	Benkhoff	ESTEC
Mark	Bentley	ESAC
Sebastien	Besse	ESAC
Alex	Bombrun	ESAC
Hector	Canovas	ESAC
Nicol	Caplin	ESTEC
Klara Anna	Capova	ESTEC
Andrea E. M.	Casini	Other
Thomas	Cornet	ESAC
Marc	Costa	ESAC
Nicolas	Crouzet	ESTEC
Jos	de Bruijne	ESTEC
Anik	De Groof	ESAC
Ignacio	de la Calle	ESAC
Guido	De Marchi	ESTEC
William	Dunn	Other
Xavier	Dupac	ESAC
Jacobo	Ebrero Carrero	ESAC
Matthias	Ehle	ESAC
Florian	Fillol	ESAC
Rune	Floberghagen	ESAC
Anna	Fogtman	Other
Felix	Fuerst	ESAC
Pedro	Garcia-Lario	ESAC
Bernhard	Geiger	ESAC
Charlotte	Götz	ESTEC
Georgina	Graham	ESAC
Börn	Grieger	ESAC
Emmanuel	Grotheer	ESAC
Matteo	Guainazzi	ESTEC
Lina	Hadid	ESTEC
Ana M.	Heras	ESTEC
Jose	Hernandez	ESAC
Hans	Huybrighs	ESTEC
Aitor	Ibarra	ESAC
Alexander	James	ESAC

Participant list (continued)		Site
Nils	Janitzek	ESAC
Emilia	Järvelä	Other
Oliver	Jennrich	ESTEC
Amy	Joyce	ESAC
Mark	Kidger	ESAC
Markus	Kissler-Patig	ESAC
Ralf	Kohley	ESAC
Detlef	Koschny	ESTEC
Peter	Kretschmar	ESAC
Sandor	Kruk	ESTEC
Julia	Kubanek	ESTEC
Michael	Kueppers	ESAC
Erik	Kuulkers	ESTEC
Uwe	Lammers	ESAC
René	Laureijs	ESTEC
Tanya	Lim	ESAC
Andrew	Lobban	ESAC
Marcos	López-Caniego	ESAC
Rosario	Lorente	ESAC
Nora	Luetzgendorf	Baltimore
Julia	Marin Yaseli de la Parra	ESAC
Anthony	Marston	ESAC
Patrick	Martin	ESAC
Juan-Manuel	Martin-Fleitas	ESAC
Arnaud	Masson	ESAC
Gabriele	Matzeu	ESAC
Francesca	McDonald	ESTEC
Paul	McNamara	ESTEC
Bruno	Merín	ESAC
Francois	Mernier	ESTEC
Lionel	Métrailler	ESAC
Daniel	Michalik	ESTEC
Helen	Middleton	ESAC
Simone	Migliari	ESAC
Alcione	Mora	ESAC
Daniel	Mueller	ESTEC
Carlos	Muniz	ESAC
Cillian	Murphy	ESAC
Jan-Uwe	Ness	ESAC
Karen	O'Flaherty	ESTEC
Lyndsay	Old	ESAC
Joana S.	Oliveira	ESTEC
Pedro	Osuna	ESAC
Michael	Parker	ESAC
Arvind	Parmar	ESTEC
Jacob	Parrott	ESTEC
Miguel	Perez Ayucar	ESAC

Participant list (continued)		Site
Göran	Pilbratt	ESTEC
Ciro	Pinto	ESTEC
Timo	Prusti	ESTEC
Eleni	Ravanis	ESAC
Timothy	Rawle	Baltimore
Mylene	Riemens	ESTEC
Ottaviano	Ruesch	ESTEC
Celia	Sanchez	ESAC
Richard	Saxton	ESAC
Norbert	Scharatel	ESAC
Elliot	Sefton-Nash	ESTEC
Linda	Smith	Baltimore
Anezina	Solomonidou	ESAC
Paule	Sonnentrucker	Baltimore
Hakan	Svedham	ESTEC
Jan	Tauber	ESTEC
Matt	Taylor	ESTEC
David	Teyssier	ESAC
Dm	Titov	ESTEC
Charles	Townsend-Rose	ESTEC
Jorge L.	Vago	ESTEC
Claire	Vallat	ESAC
Ivan	Valtchanov	ESAC
Bert	Vander Meulen	ESAC
Roland	Vavrek	ESAC
Martin	Voelker	ESAC
Andrew	Walsh	ESAC
David	Williams	ESAC
Olivier	Witasse	ESTEC
Joe	Zender	ESTEC
Yannis	Zouganelis	ESAC

Oral Presentations

Listed alphabetically by author last name

Nicolas Altobelli [ESAC]; T. Cornet, R. Lorente, A. Solomonidou, C. Vallat

Space weathering of the surfaces of atmosphere-less icy bodies: overview of ESAC driven activities

The JUICE (ESA) and EUROPA CLIPPER (NASA) missions will be launched in the next decade in order to study the habitability of the icy moons of Jupiter. The focus of both missions is to characterize the conditions that may have led to the emergence of habitable environment for life as we know it in the interior of Ganymede, Europa and Callisto.

The JUICE and Europa clipper mission will look in a complementary way for such habitats in the Jovian system. Without the existence of permanent plumes driven by cryo-volcanic activity that could be directly sampled from space, the clues for a subsurface ocean's composition have to be found on the moon's surface using remote sensing techniques. Fortunately, it is well established that there is a transport of material between the ocean and the surface. Hence, deciphering the surface composition should provide constraints on the ocean's composition. However, things are not so easy in the Jovian system, because the icy surfaces are constantly altered, weathered by a variety of agents found in the Jovian system. The exogenic bombardment of the surface by energetic electrons and ions that populate the Jovian magnetosphere as well as micro-meteoroids, modify on a short time scale (compared to the moon's evolution time scale) the surface ice composition and physical structure. Without a quantitative understanding of the effects of each weathering agent on the icy moon's surface, deciphering the intrinsic composition of the moon's surface, and hence, ocean composition, is impossible.

To contribute to the understanding of the alterations of icy surfaces subject to space weathering, we are coordinating at ESAC different studies, thematically connected to the understanding of Solar System Ices, in collaboration with different universities. Those studies are either theoretical, experimental or focused on the data analysis of previous missions to the Jovian system. This abstract aims at giving an overview of the activities kicked-off so far, their status, and the prospect for the near future.

1-One modeling study, carried out at ESAC (C. Vallat, R. Lorente and N. Altobelli) with the university of Oulu, is focused on estimating the flux of micro-meteorites impacting the Jovian icy moons. Dust populations, native from the Jovian system, as well as interplanetary and interstellar dust particles, are taken into account. The fluxes of particles per size bins , distributed in the moons body frame, are computed, in order to derive the kinetic energy and momentum flux received by the moons surface. The main objective of this study is to derive physical quantities, such as the kinetic energy and momentum flux deposited by the micro-meteoroid on the icy bodies, that can constrain the type and amount of physical alteration of the surface.

2-One data analysis based study, carried out at ESAC (T. Cornet, C. Vallat and the Complutense University), is focused on a new analysis of the Galileo-NIMS data. Those data provide a mean to derive maps of reflectances in different wavelength bands, indicative of products formed upon space weathering. The main objective of this study is the analysis of the distribution of specific species, indicative of space weathering processes, on Ganymede, Callisto and Europa.

3-One experimental study, carried out at the Georgia Tech facility, in the frame of a contract with the University of Heidelberg for ESAC (N. Altobelli, R. Lorente, C. Vallat), has been completed recently. This study had a focus on a process to fabricate icy targets, whose composition in water ice, salts and minerals could be adjusted such as to reproduce characteristics of the surfaces of the Jovian icy moons. The targets have been irradiated with protons in an energy range chosen to reproduce irradiation conditions that prevail in the Jovian magnetosphere, and the resulting alterations of the targets studied using infrared spectroscopy at various temperatures.

4-Another experimental study, carried out at the Centro de Astrobiology (CAB) of Madrid (A. Solomonidou as science lead and R. Lorente as technical officer) is just kicked-off, and aims at deriving measurements of di-electrical properties of ice samples representative of the Jovian icy moons.

5-Following up the successful study of ice samples and their irradiation, the next step is planned to have mineral hypervelocity impactors shot on ice targets in a vacuum chamber, using a Van de Graaf accelerator, in order to simulate experimentally the dust bombardment conditions (as computed in the frame of the first activity of this

list). Subsequent analysis of the samples will be performed to understand the type of alteration triggered by dust impacts, compared to the better known effects of plasma irradiation.

6-In addition, in the frame of a NPI collaboration, the ice micro-physics will be studied in collaboration with the University of Paris Sud (and T. Cornet, N. Altobelli), focused on the radiative transfer of near-infrared light within ice samples with known physical characteristics. Comparison with data acquired using the samples irradiated in the laboratory (item 3 of this list) will be performed to calibrate the model.

Nuria Álvarez [ESAC]

A catalogue of XMM-Newton BL Lacs

A XMM-Newton catalogue of BL Lac X-ray properties is presented based on the cross-correlation with the 1374 BL Lacs listed in the 13th edition of the Veron-Cetty and Veron (2010) catalogue. X-ray counterparts to these objects are searched in the field of view of around 10000 XMM-Newton pointed observations. The cross-correlation yielded a total of 352 XMM-Newton observations which corresponds to 102 different sources. Data from the three EPIC cameras and OM were homogeneously analysed using the XMM-Newton SAS software. Images, light curves and spectral products are produced for those BL Lacs detected in any of the three EPIC cameras. Two different phenomenological models, with different variations of the absorbing column density, are tested: Log-Parabolic and Power-law. We determine the best fit model and extract its parameters, The results of the analysis are presented as a catalogue of X-ray spectral properties of the sample in the 0.2–10 keV energy band as well as in the V/UV band. Multi-wavelength information at radio and gamma-ray energies complete the catalogue.

Catarina Alves de Oliveira [ESAC]

Dynamical histories of nearby star-forming regions

The discovery and characterization of the least massive brown dwarfs is a fundamental test of the observational predictions of existing star formation theories. To that end, persistent spectroscopic surveys of nearby young clusters have resulted in exquisite census of their populations into the substellar regime. In Parker & Alves de Oliveira (2017), we used such a dataset to study the dynamical histories of the IC 348 and NGC 1333 star-forming regions in Perseus and hence the initial conditions of both regions. We then used those findings to predict the effect of dynamical interactions on the present-day population, in particular, the impact on young planetary systems and discs. In this contribution I will present our findings, as well as an outlook on how we can use future observations with the James Webb Space Telescope to further probe the low mass end of the initial mass function.

Laia Barrufet [ESAC]; Chris Pearson (RAL), H. Matsuhara (JAXA), Kasia Malek (NCBJ), M.C. Campos-Varillas (University of Sussex)

Dusty star forming galaxies over cosmic time: what triggers their high star formation?

The brightest dusty star-forming galaxies (DSFGs) are the most intense starbursts in the Universe. The high-z nature of DSFGs, their easy detection at submillimeter wavelengths and their high star formation rates (SFR), make them a perfect laboratory for studying the early galaxy star formation and evolution. I will present the results of a high-redshift DSFGs selection ($1 < z < 6$) using different methodology with Herschel-SPIRE and JCMT-SCUBA-2 data at the North Ecliptic Pole. The good multi-wavelength coverage in this field allows me to produce an accurate analysis by spectral model fitting using CIGALE. I will explain the importance of choosing appropriate models to fit the spectral energy distribution (SED) of DSFGs and I will show that some of the different results in literature could be due to the lack of assumption of AGN contribution in some DSFGs studies. I will evaluate the high-z DSFGs position on the so-called Main Sequence of galaxies (the correlation between SFR and stellar mass). I will show the results: galaxies above the Main Sequence have a more efficient star formation mode, probably due to mergers. I will discuss the possible influence on the galaxy evolution stage when this merger happens and connects the observations with the current models for DSFGs.

Sebastien Besse [ESAC]; Océane Barraud, Alain Doressoundiram, Thomas Cornet, Claudio Muñoz-Crego, Joana Oliveira

Investigations of Mercury's surface phenomena - It's a MeSSS

Although Mercury's surface is not as dynamic as planetary bodies such as Mars or some of the icy moons (Titan, Europa, Enceladus), its surface exhibit a important diversity of planetary and geological landscapes, with some of them unique to Mercury. The MESSENGER spacecraft in orbit around Mercury has returned a wealth of data that offers infinite research opportunities for Mercury. The objective of our small french-speaking (but not exclusive!) science team is to maximise the science exploitation of the visible to near-infrared spectrometer onboard the MESSENGER mission to unravel the misters of Mercury's surface.

Our analysis of volcanic material on the surface of Mercury has highlighted the property of explosive volcanism, and in particular the underestimation of its volume. Our latest analysis on the largest volcano on Mercury has shown that it's eruption mechanism might be somehow unique in the Solar System, with single-pulse eruption of a huge amount of material released in the exosphere and on the surface. Hollows are small depressions on the surface potentially created by degassing of the sub-surface. Our latest analysis using spectroscopic data favour scarp-retreat as one of the mechanisms explaining the growth of hollows.

Other scientific topics are planned to be investigated through the MASCS' spectroscopic data (space weathering, impact features, spectral properties of magnetic anomalies, etc.), and we aim at sharing our knowledge of the instrument and its calibration through a web service of our structured database. The Mercury Surface Spectroscopic Science (The MeSSS) project aims at collecting research investigations of Mercury's surface through data mining, knowing that the output of this work is of paramount importance for the preparation of the BepiColombo exploration of Mercury.

Hector Canovas [ESAC]; U. Lammers, B. Merín, A. Mora, C. Cantero.

PanGaia: A Python toolkit to study Star Forming Regions using Gaia astrometry.

Protoplanetary discs, the birth sites of planets, are a by-product of early stellar evolution. They are found around young (<10 Myrs old) stars formed in different Star Forming Regions (SFR). Finding potential new members of these regions is therefore a necessary step to increase the statistics of protoplanetary discs. The astrometric data in the Gaia DR2 catalogue allows to do this as members of any SFR have common proper motions and are spatially distributed in a relatively compact area. In this talk I will present PanGaia, a user-friendly Python toolkit that has been developed with the main purpose of identifying new member candidates of SFRs in the Gaia catalogue. This package allows the user to 1) easily download the Gaia data for a given SFR, 2) dynamically explore its associated astrometry, and 3) identify member candidates of the studied region by means of HDSBCAN, a machine learning, density-based clustering algorithm. I will briefly describe this software and present the results obtained after applying it to the Perseus SFR.

Guido De Marchi [ESTEC]; Nino Panagia (STScI)

Polluting in time and space

Through a detailed study of the extinction properties in the Tarantula Nebula at ultraviolet, optical, and infrared wavelengths, we show that massive stars exploding as supernovae (SN) deeply alter the local interstellar medium (ISM) in regions where they have been forming over extended periods of time (∼20 Myr). Compared to the diffuse Galactic ISM, the observed properties of the extinction curve include: a flattening at optical wavelengths, corresponding to a ratio of total-to-selective extinction Rv=Av/E(B-V) exceeding 4.5 and requiring fresh injection of big grains into the ISM; a steepening at wavelengths shorter than 2000 , requiring a larger fraction of small grains; and no appreciable variations in the fraction of very small carbonaceous particles (including possible graphitic grains and polycyclic aromatic hydrocarbons) traditionally associated with the 2175 feature. In environments such as the Tarantula Nebula, where formation of massive stars has been ongoing for over 20 Myr, a process able to naturally account for the injection of new grains is the explosion of massive stars as type-II SN. This modification is only temporary, lasting less than 100 Myr, because shattering will eventually affect the newly injected grains, breaking bigger grains, and shocks will ultimately destroy them and increase the abundance of small grains. However, this is the only time when star-forming regions are detectable as such in starburst and high-redshift galaxies. Improperly correcting the observed magnitudes using the standard Galactic

extinction law will result in severely underestimated luminosities and masses for young massive stars, typically by a factor of 1.5 or more.

Anna Fogtman [EAC]; Guillaume Weerts, Ulrich Straube

Radiation health risk assessment and mitigation beyond Low Earth Orbit.

Ionising Radiation has been recognised as no. 1 risk of human spaceflight in exploration class missions. As in the future humans will travel to deep space, extraordinary means will have to be taken to safeguard astronauts on the way to the Moon. During long duration deep space missions humans will experience different doses and spectra of ionising radiation than on the International Space Station, posing new, detrimental-level risks to living organisms during and after exposure to space radiation environment. International Space Agencies have already recognised the necessity to better understand the effects of space radiation to the human body, in order to estimate the health risk and predict the consequences of long-duration space flight. Including European Space Agency (ESA), where the Space Medicine Team (SMT) at the European Astronaut Centre (EAC) has been working towards understanding, predicting and reducing potential hazards for astronauts during deep space missions. Here, we present a summary on biological effects to the human body, that may occur due to ionising radiation in the deep space environment. We show current strategies for health risk assessment and the challenges for risk modelling of long-duration deep space missions. Finally, we discuss the use of potential biological countermeasures during long duration human spaceflight, that are currently investigated by SMT.

Felix Fuerst [ESAC]; M. Kuehnel, P. Hemphill, P. Kretschmar, J. Coley, P. Jenke, C. Malacaria, K. Pottschmidt, J. Wilms, M. Wolff, and the X-MAG collaboration

How can a magnet hide its signature line? The case of 4U 1901+03 and 2S 1417−624.

I present results form our analysis of recent outbursts of the Be X-ray binaries 2S 1417−624 and 4U 1901+03. Both sources enter outbursts only very rarely, but their giant outbursts in 2018 afforded us with the chance to study their accretion behaviour in detail using modern X-ray telescopes such as NuSTAR, NICER, Swift, and Chandra. For 2S 1417−624 we updated the orbital ephemeris and find a possible super-orbital period of 82d. For 4U 1901+03 we refined the position dramatically using Chandra, which allowed for the identification of the optical companion, i.e., the donor star and the clear classification of the source as a Be X-ray binary. The spectra of both sources could be well described with typical phenomenological models, and we also applied recently developed physical models. These allowed us to constrain the parameters of the accretion column better. However, neither source showed a Cyclotron Resonant Scattering Feature (CRSF), so a direct measurement of the magnetic moment was not possible. However, from the strong pulsations and spectral results, magnetic fields of the order of 10^{12}G are implied, which often lead to the production of an observable CRSF. I will put our findings into context with the larger sample of accreting highly magnetised neutron stars, and discuss the lack of a CRSF (despite an implied strong magnetic field) in the context of recent advances in modelling the emission profile of the accretion column.

Pedro Garcia-Lario [ESAC]

Gaia DR2 observations of Evolved Stars

Gaia provides a unique opportunity to review distances, luminosities, as well as the overall photometric and variability properties of Galactic Evolved stars. In this contribution I present an initial analysis of the information contained in the Gaia DR2 archive for low- and intermediate-mass evolved stars in our Galaxy, covering all evolutionary stages from the Asymptotic Giant Branch to the Planetary Nebula phase.

Georgina Graham [ESAC]; Allan Macneil (University of Reading), Pedro Osuna (ESA/ESAC),Yannis Zouganelis (ESA/ESAC), Andrew Walsh (ESA/ESAC)

Investigating flux tubes within the solar wind

Solar wind observations reveal plasma and magnetic field discontinuities over a range of different scales. It has been proposed that the larger observed discontinuities are in-fact 'flux tube' interfaces (Borovsky, 2008). In

other words, the solar wind is thought to have sub-structure which could be formed at the Sun and propagate outwards with the solar wind. Determining the nature of solar wind discontinuities, and whether their origins lie at the Sun or in-transit, has significant implications with regard to both the transport of heliospheric particles and to the development of solar wind turbulence. We investigate the discontinuity criteria used to detect possible flux tube boundaries at different heliocentric distances and we investigate the possible flux tubes themselves, in particular we examine the strahl electrons found within these boundaries. We thus present both an examination of the radial evolution of these structures and a comparison of observed properties within adjacent flux-tube-like structures.

Hans Huybrighs [ESTEC]; Elias Roussos, Norbert Krupp, Aljona Blöcker, Markus Fränz, Yoshifumi Futaana, Stas Barabash, Vincent Dols, Olivier Witasse, Mika Holmberg, Lina Hadid, Oliver Lomax

Energetic ion depletions near the Galilean moons: interaction with plumes and atmosphere

Due to the limitations of previous remote sensing observations large uncertainties exist in the properties of the atmospheres of the Galilean moons (e.g. density profile, structure, variability, see Plainaki et al., 2018) and eruption plumes (e.g. on Europa). Of the latter even the existence is still being debated. I will present an independent calculation of the Galilean moon's atmospheric properties by exploiting newly identified features in data of the historic Galileo mission that show the interaction of these tenuous atmospheres with energetic charged particles. Such estimates will be important for constructing models for the atmospheres of Europa, Ganymede and Callisto that future missions to Jupiter, such as ESA's JUpiter ICy moon Explorer (JUICE), will have the instrumentation to sample.

The flux of energetic ions (protons, oxygen and sulfur) near the Galilean moons were measured by the Energetic Particle Detector (EPD) on the Galileo mission (1995 - 2003). Near Galilean moons (such as Io and Europa) depletions of the energetic ion flux, of several orders of magnitude, are observed. Such energetic ion depletions can be caused by the precipitation of these particles onto the moon's surface or charge exchange with the neutral atmosphere. To interpret the depletion features in the EPD data, a Monte Carlo particle tracing code has been developed. The expected flux of the energetic ions is simulated under different scenarios including those with and without an atmosphere. By comparing the simulated distribution to the data the cause of the depletion features can be investigated.

Comparison of the data to the simulations show that there are depletion features during Europa flybys E12 and E26 that are not consistent with surface absorption or a global atmosphere, but are consistent with the presence of a plume. Furthermore I will discuss constraints on the atmospheric properties during Europa flybys E12 and E26, and during Io flyby I27.

Sandor Kruk [ESTEC]; Mike Walmsley (Oxford), Chris Lintott (Oxford), Peter Erwin (MPE), Victor Debattista (UCLan), and the Galaxy Zoo Team

Peanuts in the sky: classifying galaxy structure in large surveys

The upcoming Euclid mission will provide an unprecedented number of galaxies with exquisite imaging. This includes ∼100 million galaxies the internal structure (the presence of bars, bulges, clumps, rings, spiral arms etc.) of which can be assessed, which is challenging with current techniques. I present the novel Galaxy Zoo approach to combine human and machine intelligence to infer posteriors for the visual morphology of galaxies and predict the probabilities of possible labels. In addition, I present results from a recent work studying for the first time the redshift evolution of vertically thickened bars, known as boxy/peanut bulges, in galaxies from z=1 to z∼0, in a large sample of barred galaxies selected from the HST COSMOS survey and from the Sloan Digital Sky Survey. This study places important constraints on the formation time of boxy/peanut bulges, and demonstrates what can be achieved with future large imaging surveys such as Euclid.

Julia Kubanek [ESTEC]

Radar Interferometry of Volcanoes (Invited)

Spaceborne synthetic aperture radar interferometry (InSAR) has proven to be a useful tool to study deformation of the Earth surface. InSAR uses the phase difference between two (or more) SAR images of the same target

area acquired at different times and allows measurements of ground deformation on a mm to cm scale. With a specific constellation of satellites, the technique also enables to derive digital elevation models (DEMs).

Topographic data are of high value in various disciplines like glaciology, geology, or volcanology, and can be used in a variety of applications such as volcanic flow modeling or hazard assessment. However, topographic data acquisition and provision is a challenge. Very often, high-resolution data only exists within a small spatial extension, or the available data is already outdated when the final product is provided. This is especially true for very dynamic landscapes, such as volcanoes.

Launched in 2010, the bistatic TanDEM-X radar satellite mission enabled for the first time to generate up-to-date and high-resolution DEMs repeatedly using the interferometric phase. The repeated acquisition of TanDEM-X data facilitated the generation of a time-series of DEMs. Differencing DEMs generated from bistatic TanDEM-X data over time can contribute to monitor topographic changes at active volcanoes, and can help to estimate magmatic ascent rates and to improve our understanding of active volcanoes in general.

During my research, I have developed a strategy to process the bistatic TanDEM-X data with open-source software. The processing relies on the generation of DEMs from repeatedly acquired bistatic data pairs using the interferometric phase. Within the last years, the method was applied to study different volcanoes around the globe to better understand different styles of active volcanism, including dome-building volcanoes, basaltic lava flows and the opening of a graben structure. The latter was also used to better understand the origin of graben forming on Mars.

During my talk, I will introduce how radar interferometry is used to study active volcanism and will show results of topographic change studies to investigate different kinds of volcanic activity.

Uwe Lammers [ESAC]; Robin Geyer, Sergei Klioner (Lohrmann Observatory, Technical University Dresden, Germany)

Astrometric detection of gravitational waves

A gravitational wave (GW) passing through an observer causes periodic shifts of the apparent positions of all stellar sources on the celestial sphere. Even for massive GW emitters these shifts are extremely small, but may still be measurable using high-precision astrometry of e.g. Gaia or future missions.

In this talk we will demonstrate that Gaia is in principle sensitive to GWs with periods of days to years, provided the wave's strain is large enough. Since the effects of GWs are not modeled in the standard astrometric solution, their presence leads to characteristic systematic errors of the stellar parameters solved for. The nature and properties of such GW-induced systematics will be discussed and an estimation of Gaia's sensitivity be given.

A refined method to detect GW signals from the residuals of an astrometric solution will also be presented. Using this method on simulated data we demonstrate that it is possible to detect a GW signal without any prior knowledge of its parameters.

Nora Luetzgendorf [Baltimore]; Boyce, H.; van der Marel, R.P.; Baumgardt, H.; Kissler-Patig, M.; Neumayer, N.; de Zeeuw, P.T.

An upper limit on the mass of a central black hole in the large magellanic cloud

We constrain the possible presence of a central black hole (BH) in the center of the Large Magellanic Cloud (LMC). This requires spectroscopic measurements over an area of order a square degree, due to the poorly known position of the kinematic center. Such measurements are now possible with the impressive field of view of the Multi Unit Spectroscopic Explorer (MUSE) on the ESO Very Large Telescope. We used the Calcium Triplet (850 nm) spectral lines in many short-exposure MUSE pointings to create a two-dimensional integrated-light line-of-sight velocity map from the 108 individual spectra, taking care to identify and remove Galactic foreground populations. The data reveal a clear velocity gradient at an unprecedented spatial resolution of 1 arcmin. We fit kinematic models to arrive at a 3 sigma upper-mass-limit of $10^7 M_\odot$ for any central BH - consistent with the known scaling relations for supermassive black holes and their host systems.

Anthony Marston [ESAC]; P. Morris, IPAC, Caltech, USA, S. Van Dyk, IPAC, Caltech, USA

Further Investigations of Massive Stars Found Outside Prominent Star Clusters

It is the common belief and assumption that all massive stars are born, and predominantly remain, in massive stellar clusters during their short lifetimes. However, in recent years investigations have suggested that rather more of these than expected are to be found in more extended environments. In a previous SSW workshop some early evidence was presented that suggested a proportion of massive stars are to be found away from prominent stellar clusters. In this presentation, I conclude the investigations of possible cluster expulsion of Wolf-Rayet stars (massive stars of a few Myr age) and provide preliminary results on a low mass star clustering around the Wolf-Rayet star WR138a.

Gabriele Matzeu [ESAC]

Solving the X-ray Broadband emission in the NLS1 TON S180

We present a detailed analysis of a joint XMM-Newton & NuSTAR observation of the nearby (z=0.062) NLSy1 TON S180 taken in 2016. The goal of this work is to differentiate whether the broadband X-ray spectra between 0.4–30 keV, can be self-consistently reproduced by either relativistic reflection alone or a two-corona scenario. We find that the soft X-ray continuum is likely produced by thermal Comptonization of seeds disc-photons by a warm optically thick corona whereas the high energy continuum is dominated by Comptonization from hot and optically thin plasma. The broad Fe K line is likely produced from a mild contribution of reflection off the disc with a moderate black hole spin .

Francesca McDonald [ESTEC]; Francesca McDonald representing the Consortium for the Advanced Analysis of Apollo Samples (CAAAS), as part of the Apollo Next Generation Sample Analysis (ANGSA) Program

Unlocking the secrets of a previously unopened Apollo 17 core sample

Background. The Apollo Program had the great foresight to specially contain and curate select lunar samples for analyses at a time in the future when analytical techniques and capabilities had advanced. The special containers, including the Core Sample Vacuum Container (CSVC), were designed with a view to best preserving sample integrity, including delicate and transient properties (e.g. implanted solar wind volatiles, loosely bound volatiles). As envisioned, analytical techniques have become significantly more sophisticated and sensitive, particularly with the importance of volatiles on the Moon becoming increasingly recognised. This year, as part of the Apollo Next Generation Sample Analysis (ANGSA) Program, a consortium of scientists and engineers will open and analyse specially curated Apollo 17 CSVC core sample 73001, which has remained unopened since being sealed at the lunar surface in 1972 [1]. Apollo 17 astronaut and geologist Harrison 'Jack' Schmitt, who was present when fellow astronaut Eugene Cernan extracted 73001, is also a valuable member of this consortium.

Science goals. The Apollo 17 landing site, the Taurus Littrow Valley, is a geologically complex region with an intriguing landslide deposit and fault scarp. Sample 73001 is the bottom segment of a double drive tube (paired with upper segment 73002) taken from near the fault scarp, and which provides a cross sectional view of the landslide deposit and the underlying lunar surface. A previous study suggests that the core also sampled a region of the lunar subsurface at an estimated temperature of 250K [2]. The specially curated sample 73001, therefore, presents a unique opportunity for directly measuring loosely bound lunar volatiles, as well as being the first lunar landslide deposit to be analysed.

The consortium as a whole will be applying a complementary suite of advanced analytical techniques to address multiple science goals including: (1) Characterising and investigating the history of the landslide and fault scarp; (2) Defining volatile reservoirs and volatiles cycles on the Moon and assessing their potential for utilisation and resources; (3) Understanding surface processes on airless planetary bodies and interaction with the space environment; (4) Study new lunar lithologies to reconstruct the magmatic-volatile-thermal-impact history of the Moon.

A perspective for future sample return missions. As well as being involved in addressing the aforementioned key geological and science questions, ESA has a core role of establishing lessons learned during the whole process from initial sample selection to the present day analyses. Such lessons will enable the development of design concepts for new CSVCs, sample curation processes, and consortium analyses that can be applied to future sample return missions, with a focus on best preservation and analyses of volatile-rich samples. This is particularly relevant

for upcoming robotic and human missions to lunar polar regions, and has synergies for Mars sample return planning.

References: [1] Nature (2019) 567, 441-442 [2] Keihm and Langseth (1973) Proc. Lunar Sci. conf. 2503-2513.

Lionel Métrailler [ESAC]; Guillaume Bélanger (ESAC), Peter Kretschmar (ESAC), Erik Kuulkers (ESTEC), Ricardo Pérez Martinez (ESAC), Jan-Uwe Ness (ESAC), Pedro Rodriguez (ESAC), Mauro Casale (ESAC), Jorge Fauste (ESAC), Timothy Finn (ESOC), Celia Sanchez (ESAC), Thomas Godard (ESOC), Richard Southworth (ESOC)

Unbuckling the Van Allen Belts: History and Physics

The Earth's radiation belts, also called the Van Allen Belts, were theorised before the launch of the first US space mission Explorer 1. In 1958 and 1959, both the inner proton and the outer electron belts were discovered by in-situ measurements. Since then, the study and knowledge of the Earth's radiative environment have grown much more important for manned and unmanned space operations. Many physical and phenomenological models have been made in an attempt to capture the main features and dynamics of the radiation belts. This talk will present an overview of their discovery and discuss the main physical processes known to be taking place in the belts.

Daniel Michalik [ESTEC]

Fitting exoplanet orbits to the Gaia scanning law

Astrometry space missions, such as Gaia or Hipparcos, measure proper motions of systems over baselines of a few years. The underlying model initially assumes all catalogue sources to exhibit single star behaviour; i.e. to follow a linear uniform proper motion trend.

Unseen companions can cause significant acceleration trends. Solving for the catalog proper motions with epoch astrometry will eventually fully account for this effect. It will allow us to fit the orbital parameters of the star and companion accurately. However, in the context of Gaia, epoch information will only be available at the final catalogue release of the nominal mission.

We developed a code to use the scanning laws of Hipparcos and Gaia to extract covariances of individual observations of a given star at individual observation epochs. This allows us to simulate the astrometry Hipparcos and Gaia would report assuming a single star model, for all kinds of complex system configurations. We can add hypothetical exoplanets and reproduce the catalog five-parameter astrometric solutions of the primary component, and then compare the expected values to Gaia, Hipparcos, and combined Gaia-Hipparcos astrometry. This enables us to assign astrometric likelihoods to proposed system configurations. Our code can also fit seven and nine-parameter astrometric solutions to full epoch astrometry, in preparation of future Gaia releases.

Michael Parker [ESAC]; Stefanie Komossa, Norbert Schartel, Dirk Grupe, Fiona A. Harrison, Wolfram Kollatschny, Rebecca Mikula, Maria Santos-Lleo, and Laura Tomas

Modelling black hole variability with XMM

Because of their small size, black holes can vary in brightness extremely quickly compared to other astrophysical objects. Since the early days of XMM, it has been common practise to quantify this by calculating variance spectra, showing the flux variability of the X-ray emission as a function of energy. However, the standard spectral models developed over the years to fit X-ray spectra cannot be used to fit variance spectra. This means that these analysis of variance spectra is typically restricted to qualitative analysis, comparing the spectrum with a simulated equivalent for a given physical process to see if the overall shape is a good match. We have developed a selection of new models, based on physical processes and simple assumption, which can be fit to variance spectra. This allows us to quantitatively constrain the mechanisms of black hole variability, giving us a powerful new probe of the physics behind these extreme objects.

Karen O'Flaherty [ESTEC]; Luigi Colangeli (ESA), Fabio Favata (ESA), with Eric Jensen (Institute for Methods Innovation) and Benjamin Smith (Institute for Methods Innovation)

Discovering their Universe - consulting the public on Voyage 2050

In March 2019, the Director of Science invited the public to share their views on future directions for space science, and in particular on the questions that Voyage 2050, ESA's space science programme for the 2035–2050 time frame, should address. In this talk, I will describe this public consultation and present results from a first analysis of the data.

Lyndsay Old [ESAC]; Balogh, M., Rudnick, G., Muzzin, A., McGee, R.F.J., van der Burg, S.L., Chan, J.C.C., Wilson, M., Nantais, J., Cerulo, P., Biviano, A., Altieri, B., Cooper, M.C., Demarco, R., Forrest, B., Lidman, C., Noble, A., Pintos-Castro, B., Forrest, I., Reeves, A.M.M., Webb, K.A., Yee, H.K.C., De Lucia, G., Marchesini, D., Stefanon, M., Vulcani, B., Poggianti, B., and Zaritsky, D.

Star formation properties of galaxies in extreme environments > 8 billion years ago

Galaxy clusters are among the most massive structures in the Universe, with up to 1000-trillion times the mass of the Sun contained in stars, gas and dark matter. In addition to being excellent cosmological tools, galaxy clusters are extraordinarily valuable as astrophysical laboratories: hosting the most massive galaxies and some of the first luminous objects to form in the Universe. As such, they play a central role in studies of mechanisms which may govern how galaxies evolve through cosmic time. Thanks to extensive studies in the local Universe, we typically see that galaxies in higher-density environments like galaxy clusters have ceased forming stars compared to those in lower-density environments. Above redshift z$\sim$1 ($>$ 8 billion years ago), however, the typical properties of galaxies in galaxy clusters are almost completely unknown. To understand the dominant mechanisms at play in the quenching of star formation in galaxies from high redshift to the present day, we need to characterise the properties of cluster galaxies at this fairly unconstrained epoch. During this talk, I will present early science results from the Gemini Observations of Galaxies in Rich Early Environments (GOGREEN) survey. The GOGREEN survey is a multi-object spectroscopic campaign of 21 groups and clusters at high redshift ($1 < z < 1.5$), targeting the evolutionary counterparts of local groups and clusters, and is aimed at providing a first look at environmental effects on galaxy evolution at a time when galaxies were growing in a fundamentally different way from the present day.

Joana S. Oliveira [ESTEC]; Foteini Vervelidou, Mark A. Wieczorek

Constraints on the origin of the sources of lunar magnetic anomalies from orbital magnetic field data

Magnetic field anomalies of crustal origin are found to be heterogeneously distributed over the entire lunar surface. In general, the magnetic field anomalies are not related to known geological structures, and their origin is still debated. Impactors contamination that could deliver iron-rich material to the lunar surface, or heating associated with magmatic activity that could alter rocks into strong magnetic carriers, are some of the current suggestions to explain the sources origin. It is accepted that the inducing field that magnetized the lunar crust was a global magnetic field generated by a core dynamo, however. In order to get insights on the time evolution of the lunar dynamo, it is important to know when and how each magnetic anomaly was formed. In this work, we aim to constrain the origin of random magnetic anomaly sources using orbital magnetic field data without making any a priori geometry assumption. We invert for the crustal magnetization using a unidirectional model, to constrain the magnetization source geometry. We test the performance of this method in by conducting a variety of synthetic tests using magnetized bodies of different geometries, intended to represent the many possible magnetized source origin scenarios such as basis, dykes, and lava tubes. Preliminary synthetic tests show that the location of the dipoles having the strongest magnetic moments is found to coincide with the region where the magnetized volume is buried. Further inversion results using samples from our synthetic tests library will allow us to explore the effect of all input parameters on the correct determination of the sources location. This will allow us to place constraints on the source origin, including anomalies which are not related to swirls or impact craters. Analysis of many lunar magnetic anomalies will lead to new constraints on the origin of their sources, and some of which may be of value in constraining the evolution of the lunar dynamo.

Pedro Osuna [ESAC]

Analytic form of electrostatic potential for solar wind acceleration

An analytic solution for the total potential in the solar wind is sought. The basic assumption of the problem is that the flow of electrons and protons is collisionless. This approximation is good above the so called 'exobase', for which the Knudsen number is greater than 1 (Zouganelis et al. 2004, ApJ 606, 542). Under this assumption, any meta-equilibrium solution of the Vlasov equation will be static, i.e., will not vary in time. This means that an equilibrium solution at the exobase will continue to be so after the flow has evolved radially outwards from the sun.

Assuming that protons are well described at the exobase by a Maxwellian distribution function, while electrons are better described by a Kappa function, and making the assumption that the plasma is quasi neutral, the first moment of the distribution functions is made equal throughout the flow to obtain an analytic form of the total potential.

Further refinement of the solution is sought by including a separation in the velocity space taking into account the initial perpendicular velocity, related to the magnetic field by the conservation of the magnetic moment. Following this, Bi-Maxwellian distribution for protons and Bi-Kappa for electrons are used to find a proper accelerating electrostatic potential.

Ciro Pinto [ESTEC]; Dom Walton, Erin Kara, Michael Parker, Roberto Soria, Matthew Middleton, Peter Kosec, Andrew Fabian, Matteo Guainazzi, Tim Roberts, Felix Furst, William Alston, Mike Nowak and Didier Barret

Fast & Furious: powerful winds unveil super-Eddington accreting compact objects

The detection of fully-grown supermassive black holes in active galactic nuclei at high redshift, when the Universe was young, challenges the theories of black holes growth, requiring long periods of high accretion, most likely above the Eddington limit. These objects will be difficult to probe even with future advanced observatories. Ultraluminous X-ray sources (ULXs) are nearby stellar-mass black holes or neutron stars accreting above their Eddington limit. This was understood after the discovery of coherent pulsations and cyclotron lines in some ULXs, indicating that at least a fraction of them hosts neutron stars as compact objects and, finally, our discovery of powerful winds as predicted by theoretical models of super-Eddington accreting black holes and neutron stars. ULX winds carry a huge amount of power owing to their mildly relativistic speeds ($\sim$0.2c) and are able to significantly affect the surrounding medium, producing the observed 100s pc super bubbles. The winds substantially limit the amount of matter that can reach the central accretor, which slows down its growth and extends its lifetime - in the case of an accreting neutron star. The study of ULX winds is therefore quintessential to understand 1) how much and how fast can matter be accreted by black holes and 2) how strong is their feedback onto the surrounding medium in the regime of high accretion rate such as for quasars and supermassive black holes at their peak of growth. In this talk I will provide an overview on this vast phenomenology and its state-of-art, focusing on our recent discoveries of outflows in ULXs and their characteristics thanks to new, deep, XMM-Newton observations.

Timo Prusti [ESTEC]; Lehtinen, K., de Bruijne, J., Lammers, U., Manara, C., Michalik, D., Morrison, O., Muinonen, K., Ness, J.-U., Poutanen, M., Siddiqui, H.

Gaia and Carte du Ciel

Carte du Ciel project was 'the Gaia project' of the 19th century. The, then recently, invented photography was used to record the full sky on glass plates with standard instrumentation across several observatories on the Earth. The deep survey element of it was for most participating observatories too ambitious and observations were not completed nor analysed. The Helsinki observatory finished its designated part of the sky, but the deep (down to 14th magnitude) plates have never been analysed. Gaia DR2 is the modern Carte du Ciel project and the data can be used, both for brightness and stellar motion parts, to predict what the sky should have looked like a century ago. The science of our 'Gaia and Carte du Ciel' project is in the deviation: what does Carte du Ciel plates show that is discrepant with the Gaia DR2 based prediction? The project is in its final 'operational' year with the completion of plate digitisation and calibration by the end of the year. The first science question being addressed parallel to the digitisation activity concerns long period binaries. An unresolved (for Gaia)

binary with a century time scale orbital period, will have in the Gaia DR2 proper motion the combination of the system proper motion and fraction of the orbital motion of the photocentre. This 'wrong' proper motion will lead to a wrong anticipated position on the Carte du Ciel epoch, which we can discover by looking where the star truly is on the plate. The presentation will go through the methods used, calibration quality achieved and give the first results from scientific exploration of the data.

Tim Rawle [Baltimore]; B. Altieri (ESAC), F. Boone (Toulouse), F. Combes (Paris), M. Dessauges-Zavadsky (Geneva), E. Egami (Arizona), P. G. Pérez-González (Madrid), J. Richard (Lyon), W. Rujopakarn (Thailand), D. Shaerer (Geneva), I. Valtchanov (ESAC)

Resolving high redshift star forming regions with gravitational lensing

Cold molecular gas in nearby galaxies is structured in discrete cloud complexes in virial equilibrium. These giant molecular clouds, with 10^4–10^7 solar masses and 5–100 parsecs radii, are the seeds of star formation. The analysis of the molecular gas structure at such small scales in the most distant galaxies (in the early Universe) is observationally challenging. Only a handful of molecular clouds have been reported in extreme star-bursting submm galaxies at high redshift, with gravitational lensing offering a mechanism to push the limits further. Here, I describe the ongoing follow-up originating from the Herschel Lensing Survey, which explores high redshift galaxies at spectacular spatial resolution.

Ottaviano Ruesch [ESTEC]

New insights into the geology and topography of Oxia Planum

The landing site of the ExoMars rover is centered on an ancient (Noachian) clay-rich terrain covered by younger volcanic units. With the help of new topographic maps, this work investigated several key properties of this area, from the possibility of remnant hydrothermal deposits within the clay-rich terrain, to the distribution of blocks eroded and fragmented from volcanic material.

Richard Saxton [ESAC]; S. Komossa, Andy Read, Kate Alexander, Paulina Lira

Black holes: no hair, no mercy

A star which approaches too close to a black hole will inevitably be pulled apart by the strong differential gravity and subsequently accreted. In the past few years the study of these catastrophic events has advanced rapidly as X-ray and optical surveys have discovered increasing numbers of events which have been well monitored at multiple wavelengths. Some have been found to create relativistic jets, others powerful outflows of material while a few seem to just disappear as quickly as they arose. In this talk, I will summarise the current state of the field - what we know for certain, what we can guess and what just doesn't seem to make any sense right now.

Elliot Sefton-Nash [ESTEC]

Cold lunar volatiles: So hot right now (Invited)

With growing interest in science and exploration of, on, and from the Moon, lunar polar volatiles have gained focus in recent years.

Areas of minimal illumination, including Permanently Shaded Regions (PSRs), persist in lunar polar terrain due to the Moon's low axial tilt. Crater interiors and other topographic depressions act as cold traps and offer conditions suitable for long-term stability of surface or subsurface volatiles. Here, upwelling heat flow from the lunar interior, non-solar starlight, scattered light from illuminated surfaces, and thermal emission from warm surfaces, are important factors in the radiative balance of the subsurface. This is at odds with equatorward regions where direct solar illumination dominates the thermal regime. At the poles, the total energy imparted to PSRs is negligible, allowing them to remain at very low temperatures more akin to those observed on bodies in the outer solar system.

Recent studies of the lunar poles, particularly using data from NASA's Lunar Reconnaissance Orbiter (LRO) and ISRO's Chandrayaan -1 have focussed on isolating potential signatures of such volatiles, following the detection

by the Lunar Crater Observation and Sensing Satellite (LCROSS) of water and other volatiles in a plume of material ejected from Cabeus crater by the impact of a spent rocket stage (Colaprete et al., 2010). The body of results to date does not conclusively resolve the distribution of volatile abundance at the surface, nor in near-surface regolith layers. Work to determine the presence of surface volatiles in the lunar South Polar region is generally consistent with laterally discontinuous veneers of water ice. Tantalisingly, the few datasets that have revealed evidence for subsurface water-ice suffer from poor generally poor spatial coverage or resolution.

Thus, the goals of upcoming lunar polar missions lie firmly in assessing the abundance, spatial distribution, and composition of polar volatiles, driven by goals to determine their origin, behaviour and resource potential. New and renewed efforts, including by the Russian, Chinese, American and European Space Agencies, increasingly are engaging the commercial space sector.

Linda Smith [Baltimore]

The young nuclear star clusters in NGC 5253

Very few forming super star clusters have been discovered to date in the nearby universe because of the lack of suitable, high pressure environments. The central clusters in the blue compact dwarf galaxy NGC 5253 are probably the best local examples. Radio, infrared and optical observations of the core of this galaxy show that there are at least two massive, young (< 1 Myr) clusters. I will present a new view of the cluster content of the central few parsecs of NGC 5253 by using GAIA DR2 astrometry to precisely align the HST optical/IR imaging with the radio data.

Anezina Solomonidou [ESAC]; A. Coustenis, R.M.C. Lopes, M.J. Malaska, S. Rodriguez, P. Drossart, C. Elachi, B. Schmitt, K. Lawrence, N. Altobelli, K. Stephan, S. Le Mouélic, A. Le Gall, O. Witasse

Titan's surface chemical composition constraints

The investigation of Saturn's moon Titan surface nature is of great importance for the understanding of the atmosphere-surface-interior system of this moon. The Cassini cameras and especially the Visual and infrared Mapping Spectrometer has provided a sequence of spectra showing the diversity of Titan's surface spectrum from flybys performed during the 13 years of Cassini's operation. In the 0.8-5.2 μm range, this spectro-imaging data showed that the surface consists of a multi-variable geological terrain hosting complex geological processes. The data from the seven narrow methane spectral 'windows' centered at 0.93, 1.08, 1.27, 1.59, 2.03, 2.8 and 5 μm provide some information on the lower atmospheric context and the surface parameters. Nevertheless, atmospheric scattering and absorption need to be clearly evaluated before we can extract the surface properties. In various studies (Solomonidou et al., 2014; 2016; 2018; 2019; Lopes et al., 2016; Malaska et al., 2016; 2019), we used radiative transfer modeling in order to evaluate the atmospheric scattering and absorption and securely extract the surface albedo of multiple Titan areas including the major geomorphological units. We also investigated the morphological and microwave characteristics of these features using Cassini RADAR data in their SAR and radiometry mode. The results show that Titan's surface composition, at the depths detected by VIMS, has significant latitudinal dependence, with its equator being dominated by organic materials from the atmosphere and a very dark unknown material, while higher latitudes contain more water ice. The albedo differences and similarities among the various geomorphological units give insights on the geological processes affecting Titan's surface and, by implication, its interior. We discuss our results in terms of origin and evolution theories.

Ivan Valtchanov [ESAC]; L. Rodrìguez-Muñoz, G. Rodighiero, et al.

Slow quenching of the star formation in the cores of galaxy clusters

We quantify the star formation (SF) in the inner cores of 24 massive galaxy clusters at $0.2 < z < 0.9$ observed by the Herschel Lensing Survey and the Cluster Lensing and Supernova survey with Hubble. We find that the SF activity is suppressed with respect the field in terms of both the fraction (F) of star-forming galaxies (SFGs) and the rate at which they form stars. On average, F of SFGs is a factor $\sim$2 smaller in cluster cores than in the field. Furthermore, SFGs present average SFR and sSFR typically $\sim$0.3 dex smaller in the clusters than in the field along the whole redshift range probed. Our results favour long time-scale quenching physical processes as the main driver of SF suppression in the inner cores of clusters since z$\sim$0.9 (6.3 Gyr since the Big Bang), with shorter time-scale processes being very likely responsible for a fraction of the missing SFG population.

Martin Voelker [ESAC]; Ernst Hauber, Alejandro Cardesín-Moinelo, Patrick Martin

Quantifying the Latitudinal Distribution of Climate-Related Landforms on Mars' Southern Hemisphere

In order to understand the latitudinal distribution of climatic environments on Mars, we applied the so-called grid-mapping approach for quantifying the geography of 19 climate-related landforms. Grid-mapping combines small-scale mapping with large-scale analyses; thus, it is possible to reveal relations that are only visible from a wider perspective. The focus of this approach is to map and analyse multiple study areas, representative of the southern highlands. We considered all latitudes (from equator to pole) and climate-related landforms of all Martian eras (Amazonian, Hesperian, Noachian). We detected three major climatic environments in the study area; desiccated low latitudes, a transition zone within the volatile-rich mid-latitudes, as well as the polar region, covered by deep volatile-rich deposits being partially eroded by sublimation activities. Our observations fit well into existing models of distribution of water-ice on the Martian surface. However, we could not detect clear evidence for climate-zones pre-dating the Amazonian. Grid-mapping also enabled the finding of a widely undescribed crater morphology on Mars; palimpsests. They are characterised by an even topography, small diameters (<1 km), and a multi-ring facies. We suggest they were formed during deposition and erosion of multiple layers of the latitude-dependent mantle.

Poster Presentations

Listed alphabetically by author last name

[Poster #1] Deborah Baines [ESAC]

pyESASky: An ESASky widget for Jupyter

ESASky allows scientists to explore large collections of multi-wavelength astronomical data with the click of a button. At the same time, Jupyter Notebook and more recently JupyterLab provide the framework for quick and effective manipulation, visualization and analysis of datasets. To take advantage of both tools, the ESAC Science Data Centre (ESDC) have developed pyESASky, a Jupyter Widget for ESASky. pyESASky is an extension library for Jupyter Notebook and JupyterLab that gives the user full control of the basic functionalities of ESASky from a notebook. In practice, scientists can instantiate ESASky with all the usual features found in the web version within Jupyter, but with the possibility to interact with it. With just a few commands, scientists can change the background skies, select targets, field of view, etc, and most importantly, can overlay their own datasets, from catalogues to HiPS. The ESASky Jupyter Widget also allows scientists to share their work with colleagues, students, journals, etc., greatly improving the reproducibility of their research. This poster presents the tool and example Jupyter notebook science cases that include accessing the ESA Gaia archive, combining multi-wavelength data from various missions and visualising the data in pyESASky.

[Poster #2] Mark Bentley [ESAC]

Classification of comet 67P dust at the nanometre scale with MIDAS on-board Rosetta

The properties of the smallest sub-units of cometary dust contain information on their origin and clues to the formation of planetesimals and planets. The MIDAS Atomic Force Microscope (AFM) on-board the ESA Rosetta orbiter collected dust in the coma of comet 67P/Churyumov-Gerasimenko. These particles, collected at low velocities, were analysed to measure the structural properties of minimally altered material with a known origin. This can be used to further the investigation of our early Solar System. A novel method is presented to achieve the highest spatial resolution of imaging possible with the MIDAS instrument. 3D topographic images with resolutions of down to 8 nm are analysed to determine the sub-unit sizes of particles on the nanometre scale.

[Poster #3] Hector Canovas [ESAC]

Data mining Gaia DR2: the quest for Pre-Main Sequence Stars (and their discs)

As the birth-sites of planets, protoplanetary discs have become the object of intense study during the last years. Constraining their typical lifetimes, masses and/or sizes is crucial to understand the process of planet formation. These objects are a natural by-product of early stellar evolution, and therefore a high fraction of Pre-Main Sequence Stars (PMS) are surrounded by a protoplanetary disc. The current census of PMS (and discs) has been limited due to instrumental restrictions (i.e. sensitivity), but this situation is going to change thanks to projects like Gaia. In this poster I will present the results of applying machine learning, density-based clustering algorithms to the Gaia DR2 dataset with the aim of identifying new members of the Ophiuchus star forming region. I will briefly describe our methodology and present the 280 potential new PMS that we find.

[Poster #4] Klara Anna Capova [ESTEC]

The Socioeconomic Benefits of the European Space Exploration

Space exploration develops a large number of technologies that will benefit other fields with key applications on Earth (e.g. health-care, meteorology). It also catalyses the attention of the young generations towards science and engineering subjects. A global effort in space exploration leads to the establishment of long lasting and productive partnerships among countries that would otherwise be excluded from major technological and scientific developments. Widespread access to technology facilitates social evolution in emerging countries and refocuses their strategic interest from local to global goals.

ESA has put in place a Benefit Management process in order to optimise, monitor and communicate the outcomes and positive impacts of its exploration programme. It will allow to better focus investments having benefit targets in mind and optimise and specify broader expected outcomes upfront. The ESA Space Exploration Strategy calls for delivering benefits in four domains: knowledge gain; economic growth; global cooperation; and inspiration. It addresses both the direct programme outcomes under the control of ESA and the downstream impacts achieved by contractors, users or partners, generating even wider socioeconomic impacts.

The research into the socioeconomic benefits of space exploration currently performed at HRE-S contributes to a systematic approach for defining, delivering and monitoring of expected benefits to the broader society. The poster introduces the benefit management framework and shows how exploration activities contribute to addressing global challenges/the UN Sustainable Development Goals (UN SDGs).

[Poster #5] Andrea E. M. Casini [EAC]

The Spaceship EAC initiative: current research projects and future perspectives

The Directorate of Human and Robotic Exploration (D/HRE) is the main ESA entity in charge of supporting and coordinating efforts towards the current and the future endeavours of human spaceflight. The exploration activities are part of the strategic plans in securing a central role for Europe with respect to the global initiatives. The European Exploration Envelope Programme (E3P) is integrating the ESA activities in this field to ensure a single exploration process. The strategy includes four cornerstones for the three destinations where humans will work with robots to gather new knowledge: Low Earth Orbit (LEO), the Moon, and Mars. The 'Spaceship EAC' initiative is investigating low Technology Readiness Level (TRL) technologies for supporting the future cislunar space mission as well as surface activities on the Moon as part of the Exploration Preparation, Research and Technology (ExPeRT) team. This multidisciplinary innovation-driven team composed by researchers, graduate and undergraduate students is based at the ESA European Astronaut Centre (EAC). The mission statement of 'Spaceship EAC' is based on three main pillars: enhance, enable and inspire. The founding idea behind this initiative is indeed to enhance the capabilities of EAC via exploiting the spaceflight experience of the centre to develop and validate new operational concepts and valuable technologies in support of lunar human exploration scenarios. A pragmatic and research focused approach is adopted and knowledge acquired is disseminated within ESA and the relevant scientific community. The individual concept/technology development and demonstration projects within the 'Spaceship EAC' initiative are coordinated with ESA centres. Other synergies exist with EAC facilities and personnel as well as with the surrounding DLR campus and European research groups. The main areas into which the initiative is currently doing research are: energy production and storage; radiation shielding; In Situ Resource Utilization (ISRU), materials and additive manufacturing; exercise hardware and countermeasure concepts; simulations, virtual reality and analogue; robotics and human factors; life support, habitability and system architecture. This wide range of activities and the most significant results will be addressed in the present work.

[Poster #6] Thomas Cornet [ESAC]

The face of the icy moons in the infrared: A look at Galileo/NIMS and Cassini/VIMS data

The place of the icy moons of Jupiter and Saturn in the search for favourable habitability conditions is primordial. Evidence of internal activity on Enceladus (Saturn) and Europa (Jupiter) have been gathered thanks to the detection and/or compositional analysis of ejected matter into space, through cryovolcanic processes connecting their internal water ocean to their surface (geysers). Insights on the relationship between the interior and surface of the icy moons can also be gathered in general through the analysis of their surface physico-chemical properties, especially in the infrared domain. However, the surface of these moons is usually exposed directly to their close space environment, which makes them react to impacts by dust and energetic particles in various ways (space weathering), and potentially lose the pristine information recorded in their icy crust. Here, we present a preliminary assessment of the infrared imaging spectrometer Galileo/NIMS and Cassini/VIMS data sets publicly available in order to perform comparative compositional mapping and ice microphysics studies of the surface of Jupiter's and Saturn's icy moons, and determine the relative impact of space weathering on their spectral signatures.

[Poster #7] **Marc Costa** [ESAC]

Reconstructing Apollo 15 pointing from images: prototyping an Attitude C-Smithing method with SPICE

Precise Spacecraft attitude is often not directly available for planetary missions yet is necessary for some high-precision science applications. A method for systematically reconstructing the attitude of the spacecraft by comparing simulated images generated with SPICE and actual observations is presented. Using the images from the Apollo 15 Mapping camera, this method has been used to improve the accuracy of the computed attitude information of the CSM (Command and Service Module) as obtained for the pointing of the XRFS (X-Ray Fluorescence Experiment).

SPICE is an information system which uses ancillary data to provide Solar System geometry information in order to analyze scientific observations from space-born instruments. In the presented method, SPICE is the basis on which the tool is built, containing the required mission geometric information as S/C and target body positions; high-precision target body orientation; initial guess of S/C attitude; instruments parameters (FOV, boresight, pixels) and shape model of the target body. SPICE subroutines provide a fast way of manipulating these geometric data, which after configuring the scenario, will be used to generate the simulated images. Prior generating the simulated images that the tool will use to compare with the actual observations, a few considerations must be taken into account. The first is that either the limb of the target body or features on the surface must appear in the observations, otherwise the tool would have nothing to compare between images. The second one is that the maximum accuracy achievable with this method is given by the pixel size.

In order to generate the simulated images, a grid of vectors is defined, each vector corresponding to one pixel of the instrument sensor. This grid is defined in the reference frame of the instrument. Knowing the pixel size and pixel samples (IK), the grid of vectors is defined in such a way that the origin of all vectors is the focal point of the sensor and the endpoint of each of them are the coordinates of each sensor pixel, with the boresight of the sensor at the center of the grid. Considering that the SPICE scenario knows the relation between involved reference frames (FK), the previous grid of vectors can be expressed with respect to a Moon body fixed frame, the intersection of these vectors with a digital shape model of the surface can be computed with SPICE routines. Finding these intersections and computing the corresponding solar angles from the geometry of the mission, after some processing the simulated image is obtained.

Ultimately the attitude correction is computed by means of an optimization process, nevertheless, once the simulated images are obtained, both these ones and the actual observations should undergo some pre-processing to facilitate the job of the optimizer. These first manipulation include, filtering by minimum/maximum light values; simplifying both images assigning only binary values to each pixel based on illumination criteria; and initial displacements of the simulated images.

Finally, the optimization process minimizes the cost function, defined as the number of non-zero pixels in the image resulting of subtraction of simulated and real images. The optimization parameters are contained in the displacement vector, composed by columns pixel displacement; rows pixel displacement and rotation about the boresight of the sensor. After optimization, these parameters can be easily transformed to a quaternion of attitude correction. Knowing the fixed angular separation between XRFS and Mapping camera, the pointing of the instrument can be determined with improved accuracy.

This technique is still under development. It has already been used providing good results not only for Apollo 15 mission but for Rosetta NAVCAM and OSIRIS images. Still, some improvements are pendant so the tool is able to deal with other types of mission, to mention; target bodies with non-black and white albedo or atmospheric effects.

[Poster #8] **Marc Costa** [ESAC]

ESA SPICE Service: Support science operations and data analysis

SPICE is an information system the purpose of which is to provide scientists the observation geometry needed to plan scientific observations and to analyze the data returned from those observations. SPICE is comprised of a suite of data files, usually called kernels, and software -mostly subroutines. A customer incorporates a few of the subroutines into his/her own program that is built to read SPICE data and compute needed geometry parameters for whatever task is at hand. Examples of the geometry parameters typically computed are range or altitude, latitude and longitude, phase, incidence and emission angles, instrument pointing calculations, and

reference frame and coordinate system conversions. SPICE is also very adept at time conversions. The ESA SPICE Service (ESS) leads the SPICE operations for ESA missions. The group generates the SPICE Kernel datasets (SKD) for missions in missions in and legacy). ESS is also responsible for the generation of SPICE Kernels for Solar Orbiter and Hera. The generation of these datasets includes the operation software to convert ESA orbit, attitude and spacecraft clock correlation data into the corresponding SPICE format. ESS also provides consultancy and support to the Science Ground Segments of the planetary missions, the Instrument Teams and the science community. ESS works in partnership with the Navigation and Ancillary Facility (NAIF), a group at the Jet Propulsion Laboratory (JPL/NASA) originator and responsible of evolving and maintaining the SPICE system components.

ESS offers other services beyond the generation and maintenance of SPICE Kernels datasets, such as configuration and instances for WebGeocalc (WGC) and SPICE-Enhanced Cosmographia (COSMO) for the ESA Missions WGC provides a web-based graphical user interface to many of the observation geometry computations available from SPICE. A WGC user can perform SPICE computations without the need to write a program; the user need have only a computer with a standard web browser. COSMO is an interactive tool used to produce 3D visualizations of planet ephemerides, sizes and shapes; spacecraft trajectories and orientations; and instrument field-of-views and footprints. This contribution will outline how the Cosmographia and WGC instances for ESA Planetary missions can be used, out of the box, for the benefit of the science community.

[Poster #9] Nicolas Crouzet [ESTEC]

Searching for transiting exoplanets with ASTEP at Dome C, Antarctica

Dome C in Antarctica provides exceptional conditions for photometry thanks to the continuous night during the Antarctic winter, a high clear sky fraction, low wind speeds, and a cold and dry atmosphere. The ASTEP project (Antarctic Search for Transiting ExoPlanets) aims at detecting and characterising transiting exoplanets and qualifying this site for photometry in the visible. The main instrument, a 40 cm telescope, was designed to perform high precision photometry under the extreme conditions of the Antarctic winter and has operated at the Concordia station since 2010. It will be upgraded with two new cameras that will provide simultaneous two-color photometry and substantially increase its throughput. ESA takes part in this upgrade by purchasing one of the cameras via a Faculty research project. This new setup will allow us to discover transiting exoplanets including low mass exoplanets orbiting bright stars, and to provide targets for follow-up with CHEOPS and atmospheric characterisation with JWST. In this poster, we describe recent results obtained with ASTEP and present the plans for the upgrade.

[Poster #10] Matthias Ehle [ESAC]

Can we observe reconnection heating in spiral galaxies?

In some spiral galaxies the so-called 'magnetic arms' have been reported, being interarm areas with significant polarized radio emission that suggests high ordering of the magnetic field. The most prominent example of such a galaxy is NGC 6946. The nature of these magnetic features is still under debate. One of the possible explanations is the action of reconnection heating that could convert the energy of the magnetic field into thermal energy of the surrounding gas. We summarize the analysis of the radio and X-ray emission (measured with XMM-Newton) from NGC 6946 and conclude that we might see hints for such reconnection heating (cf. Wezgowiec et al. A&A 585, 3, 2016). A similar analysis is on-going for further galaxies: For one of them, M 83, we present preliminary results.

[Poster #11] Björn Grieger [ESAC]

Direct and inverse numerical modeling of the gravitational lens effect of arbitrary extended deflectors

In the thin lens approximation, the gravitational lens effect is completely described if the deflection angle can be computed for every point in the deflector plane. Analytical expressions are available for the deflection angle of a point mass and a circular disk of homogeneous surface mass density. From the latter, the deflection angle of any circular symmetric mass distribution can be obtained by summing over rings of constant surface mass density.

Here, we have derived an analytical expression for the deflection angle of a rectangular area of constant surface mass density by solving the double surface integral. With this, for any arbitrary surface mass distribution defined on a rectangular grid of cells with constant surface mass density within each cell, the total deflection angle at any point can be obtained by adding up the deflection angles of all cells.

The expression for the deflection angle of a rectangular area can also be employed for inverse modeling of the surface mass distribution in the deflector plane. We simulate observations of galaxy shears (with underlying intrinsic ellipticities) and retrieve from these the surface mass distribution of a deflector defined on a grid of rectangular cells with the kriging method.

[Poster #12] Lina Hadid [ESTEC]

Saturn's ionosphere: Electron density altitude profiles and ring shadowing effects using the Langmuir Probe data from Cassini's Grand Finale

The electron density altitude profiles of Saturn's ionosphere at near-equatorial latitudes from all 23 orbits of the Cassini's Grand Finale will be presented. The data are collected by the Langmuir probe part of the Radio and Plasma Wave Science investigation. A high degree of variability in the electron density profiles is observed. However, organizing them by consecutive altitude ranges revealed clear differences between the southern and northern hemispheres. The electron density profiles are shown to be more variable and connected to the D-ring in the southern hemisphere. This observed variability is explained to be a consequence of an electrodynamic interaction with the D-ring. Moreover, from the ring shadow signatures on the total ion current collected by the LP, the A and B ring boundaries are reproduced. Observed variations with respect to the inner edge of the B ring shadow imply a delayed response of the ionospheric H+ due to its longer chemical lifetime compared to H3+ and H2+.

[Poster #13] Lina Hadid [ESTEC]

Polarization electrostatic field and ambipolar diffusion in the presence of negatively charged grains near Saturn's F ring: case study using RPWS/LP data

It is well known that in the magnetosphere of Saturn, even in the absence of an electric current, a polarization electrostatic field develops along the field lines to maintain the charge neutrality of the plasma. It is also well established that certain regions of the Saturnian system (ionosphere, moons, rings) are populated by significant amount of nm and μm charged grains. Hence, in order to estimate this electric field ($E_{||}$), it is important to take into account the dusty plasma as well. In the present work, we derive a more general form of $E_{||}$ by including the presence of negatively charged nm-sized grains. Moreover, using the Cassini RPWS/LP data, we calculate $|E_{||}|$ from one case study near the F ring, by integrating over 1nm-100 nm grains. We show that in the region close the ring plane ($|Z| < 0.1$ Rs) the additional dust diffusion and gravitational terms of the momentum equation amplify $|E_{||}|$ to $\simeq 3\text{x}10^{-6}$ V/m, at least one order of magnitude larger than the case without the charged grains ($\simeq 3\text{x}10^{-8}$ V/m). Eventually we discuss how this has a direct consequence on confining the electrons to the ring plane.

[Poster #14] Ana M. Heras [ESTEC]

Multi-band exoplanet transit observations with the ESA OGS Spectrograph

We present the observations of exoplanet transits carried out with the ESA OGS Spectrograph in 2018 and 2019, and the plans for the next observing campaigns. We use the Spectrograph to perform quasi-simultaneous multi-band photometry, by alternating two or more filters (B, V, R, and/or I) successively for each exposure time interval. In particular, we have observed the transits of WASP-59 b, KELT-16 b, KELT-8 b, Qatar-4 b (two transits), and WASP-135 b (two transits). We describe the framework that we have implemented for the modelling of the light curves and simultaneous fitting of the transits in all observed bands, which is based on Gaussian process regression. The dependence of the exoplanet radius with colour has been examined for each target, and the results discussed in terms of atmospheric scale height and stellar activity. This research programme has been funded by the ESTEC Faculty.

[Poster #15] Zsofi Igo [ESAC]

Searching for outflows in AGN using variability spectra

Ultra-fast outflows (UFOs) are winds launched from the accretion disk of active galactic nuclei (AGN), capable of reaching relativistic speeds of around 0.3c. They can have significant impact on the feedback processes of AGN as their mechanical power exceeds 0.5–5% of the AGN's bolometric luminosity, the total energy radiated over all wavelengths. Therefore, they can drive out gas and dust from their host galaxies, thereby quenching star formation and limiting the central black hole growth. Our sample consists of archival X-ray data of 59 AGN from observations by ESA's XMM-Newton, and is the present largest model-independent statistical search for UFOs, relying on fractional variance methods.

[Poster #16] Alexander James [ESAC]

Combining Models and Observations to Forecast CME Initiation

Coronal mass ejections (CMEs) are eruptions of billions of tonnes of plasma from the Sun, and they can cause severe space weather effects. By developing methods of predicting CMEs, we can improve space weather forecasts and mitigate the consequences of solar activity. Additionally, predicting the occurrence of CMEs will be crucial for the efficient planning of remote-sensing observations by ESA's upcoming Solar Orbiter mission. By studying the mechanisms involved in CME initiation using a combination of models and observations, quantitative insight may be gained in to the likelihood that a given solar active region will produce a CME.

[Poster #17] Amy Joyce [ESAC]

Cross-calibration between XMM-Newton and NuSTAR

More than 20% of XMM-Newton's observation time is coordinated to observe astrophysical objects simultaneously with other satellites, in particular with NASA's NuSTAR. XMM-Newton is most sensitive to X-ray photons at softer energies (between 0.3 keV and 12 keV) while NuSTAR is more sensitive at harder energies (between 3 keV and 78 keV). The advantage of taking simultaneous observations with these satellites is that information collected at harder energies can better constrain spectral models fitted at softer energies, allowing us to obtain more information about the object we are observing. The accuracy and scientific potential of the data collected from these observations can be greatly improved, both by calibration of the instruments themselves, and also by cross-calibration between the two satellites, which is possible due to the overlap in their energy ranges (between 3 keV and 12 keV). Here I introduce a pipeline for quick, semi-automated processing of XMM-Newton and NuSTAR data to allow for easy comparison between the two. The pipeline can be used on any data-set; here I focus on a sample of observations from 10 AGN, chosen because they are bright enough in X-rays to supply ample photon count rates but not so bright as to saturate the detectors. The pipeline selects and reduces data that is strictly simultaneous between the EPIC-pn camera on-board the XMM-Newton and both the FPMA and FPMB telescopes on-board NuSTAR. A spectral model was fitted to each XMM-Newton observation, usually in the form of an absorbed power-law, with the addition of a red-shifted Gaussian to model the 6.4 keV Fe emission line in some cases. The NuSTAR data was then added, without refitting, in order to extract the ratio between this data and the existing model. The preliminary results show that the average ratio across all data-sets analysed exceeds 10% in most energy bins and exceeds 20% in many, showing the clear need for cross-calibration between these two instruments.

[Poster #18] Mark Kidger [ESAC]

OJ-2019: finding out if black holes do really have no hair

OJ287 is a particularly interesting extreme blazar in which our line of sight appears to look down the throat of the relativistic jet. One of the most interesting characteristics of this object is the appearance of regular outbursts at $\simeq$12 year intervals in the light curve since 1891, as first noted by Sillanpää et al. (1988, ApJ, 325, 628), with a superflare at maximum that defines the timing of the peak. The underlying model for this is a supermassive black hole binary (Sundelius et al., 1997, ApJ 484, 180) in which the impact of the secondary with the primary accretion disk causes massive infalls of material onto the primary. A large, multinational consortium has been studying OJ287 since 1993, initially with the aim of confirming the 1994 outburst but,

more recently, attempting to determine more exactly the sixteen free parameters that define the system fully (primary and secondary mass, period, orbital precession, black hole spin, energy lost by the system through gravitational radiation, etc.). Exact timing of the maximum of the 2015 superflare – known as the General Relativity Centenary Flare – which reached R=12.9, has allowed us determine the primary spin to be 0.31 ± 0.01 (Valtonen et al., 2016, ApJL, 819, 2).

At the time of writing, OJ287 has just passed the second maximum of this outburst cycle, corresponding to the impact with the accretion disk at the Ascending Node of the orbit. While this outburst could not be observed from the ground, as OJ287 was close to the Sun, a major effort was made to obtain observations with Spitzer (in the near-IR), with STEREO-B and with the Parker Solar Probe (in the visible) to define the time of maximum to a precision of $\simeq$3hrs. This will allow us to validate the No Hair Theorem for black holes to $\simeq$10%. An intensive simultaneous observing campaign between Spitzer and ground-based observations, carried-out in February 2019, will help us to calibrate the Spitzer fluxes to their visible equivalents, while further Spitzer data will be taken into September to compare with the post-maximum Spitzer data.

This presentation will look at the ground and space-based observations that have been made over the 2015-2020 observing campaign (in part coordinated from ESAC), the consistency of data taken in different frequency ranges and with radically different techniques, how they fit in with the predictions made prior to the start of the campaign, the refinements that have been made in the model(s) as a result of this campaign and a look forward to the next observing campaign, due to start in 2026, which, potentially, can validate the No Hair Theorem to $\simeq$3%.

[Poster #19] Mark Kidger [ESAC]

The Far-IR Properties of a Large Sample of Asteroids in the Herschel-SPIRE Catalogue of Serendipitous Solar System Observations

The European Space Agency's Herschel Space Observatory has been the only space facility to date to cover a spectral range from the far infrared to sub-millimetre (55–672μm), observing $\sim$10% of the sky, making many serendipitous detections of solar system objects, in addition to the targeted observations, ranging in heliocentric distance from NEOs to TNOs. A total of 1174 asteroids were identified in at least one SPIRE observation, of which 833 were detected at multiple epochs. In total, 4203 observations made simultaneously at 250, 350 and 500 microns: a total of 12609 individual fluxes. These data are made available to the community as the Herschel-SPIRE Catalogue of Serendipitous Solar System Observations (Romero et al., 2019, in preparation).

We provide listings of data and plots of flux against heliocentric distance at the three SPIRE wavelengths, normalizing the flux to a geocentric distance of 1AU. The median ratio of 250μm/350μm and 350μm/500μm fluxes are 1.89 and 1.98, with minimal variation. We find that, for the 184 objects for which a sufficient range of heliocentric distance is observed to extract reliable conclusions, the median slope (b) of the 250μm flux variation with heliocentric distance (r), defined as:

$F_{250} = a \cdot r^b$

is, $b = -0.341$. There is a tendency to steeper slope at higher heliocentric distance, with the power law exponent increasing from -0.26 at r=2AU, to -0.44 at r=4AU. However, more unexpectedly, 10% of our sample show anomalous results, with the normalized flux increasing at greater heliocentric distance. Of this 10% of anomalous objects, approximately three times as many were receding from perihelion when observed by Herschel as were approaching perihelion: the probability of this asymmetric distribution around perihelion is $\sim$1%.

There are several possible explanations of this behaviour including the possibility that these objects may have particularly high thermal surface inertia, or that we are seeing radiation from a sub-surface layer that shows high thermal lag relative to the surface insolation.

[Poster #20] Markus Kissler-Patig [ESAC]

Variable White Dwarfs as seen by the TESS mission - A search for Post-Main Sequence Planets

We have been searching for transiting exoplanets orbiting white dwarf stars, selected from the Gaia Data Release 2, by taking advantage of the unique capability of the Transiting Exoplanet Survey Satellite (TESS) mission. A number of white dwarfs show periodic signals - we discuss the possible causes and the likelihood of the signals stemming from a post-main sequence exoplanet.

[Poster #21] Detlef Koschny [ESTEC]

CLUPI - The Close-Up Imager for the ExoMars 2020 mission

CLUPI is the Close-Up Imager for the ExoMars 2020 mission, i.e. its 'geologist's hand lens'. SCI-S has been providing the optical calibration and the planetary protection activities for this instrument. The first author was the ESA Prodex Technical Officer for the activity. This presentation will show how we have contributed to the calibration and planetary protection cleaning activities of the instrument.

[Poster #22] Sandor Kruk [ESTEC]

Hubble Asteroid Hunter

We present results from one of the first citizen science projects exploring the ESA Science Archives. The Solar System Objects pipeline was implemented in ESASky by Elena Racero and Fabrizio Giordano, cross-matching the orbits of known asteroids with ESA archival HST images. Nevertheless, inspecting the images, the predicted positions of the asteroid trails did not exactly match the observed positions, due to the uncertainties in the ephemerides of the asteroids. Therefore, we built a citizen science project, in collaboration with Zooniverse, asking volunteers online to identify and mark the position of asteroid trails in the HST images, providing a better measure of the asteroids ephemerides. The project was launched around International Asteroid Day (30 Jun 2019) and was highly successful, attracting more than 1,900 volunteers who provided 300,000 classifications of 11,000 images in one month an a half.

[Poster #23] Marcos Lopez-Caniego [ESAC]

Development of Patch Phased-array Microstrip Antenna for a Microwave Polarization Calibration Cubesat

Experiments measuring the polarization of the Cosmic Microwave Background (CMB) typically calibrate their data performing cross-correlations with other experiments with well determined absolute calibrations (like WMAP and Planck) or using point sources in the sky, usually planets or well known astrophysical sources like the Crab nebula.

Nowadays, the focus from the new generation of CMB ground experiments like QUIJOTE, the Atacama Cosmology Telescope or the South Pole Telescope, among many others, is on the polarization of the CMB. These experiments have been designed to detect, or set limits, of the so-called primordial B-modes, the imprint on the CMB polarization from gravitational waves produced in the very early Universe. These experiments need better absolute calibrations in polarization and the usual approaches are not good enough taking into the account not only the very weak signal we are after, but the need to characterize the statistical and systematic uncertainties of these measurements.

With this need of the Community in mind, the cubesat team at ESAC has requested resources to the Department to continue the activities started in previous years to study the feasibility, and build a prototype, of a CMB polarization calibration cubesat based on patch phased-arrays of micro-strip antennas that would emit well characterized linearly polarized signals that could be used by ground experiments to calibrate their detectors. The same antenna design, but at a lower frequency, will be used to expand the communication capabilities of the existing cubesat ground station at ESAC to increase the downlink bandwith in S-band for scientific telemetry.

[Poster #24] Julia Marin-Yaseli de la Parra [ESAC]

Automated determination of dust particles trajectories in the coma of comet 67P

We present the preliminary results and methods for an automated determination system of dust particles positions and trajectories in the near coma of comet 67P.

This study is part of a PhD project and its objective is to understand the physical processes in the inner coma of the comet through measurements with the OSIRIS scientific camera system on Rosetta. As a first exercise of the methods to be employed a set of images taken during the Rosetta operational phase will be analysed. Many thousand images of the dust coma were obtained by both dedicated sequences and serendipitous detections on frames acquired for different purposes. In many of those observing sequences, 100s of dust particles are

identifiable in single images. Both the narrow angle camera (NAC) and wide angle camera (WAC) observed same area through several (60–90) minutes. The focus of the study will be identify the individual dust particles. Of particular interest are the long trajectories that remail in the field of view during several minutes. The dust detected by OSIRIS can be divide into near-spacecraft dust with its apparent motion being dominated by spacecraft motion and near nucleus dust, moving radially away from the nucleus. In the latter case, the distance is known approximately and the size (with an assumed albedo and phase function) and velocity of the particles can be determined. In addition, the rotational light-curve of some particles is detectable in the images, providing additional information about spin period and shape.

Different data sets will be used to address the following scientific questions:

- Describe the evolution of the cometary dust population over the mission
- Search for changes both within an observing sequence and through the perihelion passage. The outcome will be used to evaluate if there is a preferred size range of dust particles as they leave the nucleus and if the their measured size distribution is primordial or the result of processes on the cometary nucleus and in the coma.
- Extract orbital parameters from individual dust particles to analyze the trend of the radiant trajectories, analyze if there are preferred regions of dust emissions and contextualize with gas emissions and surface activities of the comet.

There are many software tools focused in the search of the perfect algorithm that traces particles from micro sizes to meter scales. The true is there is no exist such a 'one size fits all' tracking method [3]. But it is common to divide the image analysis method in two different steps.

The first one would include all technical conversions of the image to detect the particle itself. The output would be a spot extraction from background and their coordinates in every frame of the image sequence characterized. When finding maxima algorithms are pretended to be used automatically we found aggregation of 2 scenes, when the particle is spherical either when velocities and distances make the particle elaborate a path in the frame.

The second part of the methodology is based on the particle linking using other criteria. A simple nearest-neighbor method is the simplest approach to the problem. LAP framework proposed by Jaqaman in [2] or particle algorithms relied in Kalman filters to tackle

Part of the software used for this method is a plugin called 'Trackmate' [1] contained in ImageJ open source software. Images were converted from PDS3 to bmp with Fairwood PDS Viewer. After that, the whole set of images was opened with ImageJ in 8 bit image. different threshold must be applied in order to compensate the different exposition times of the set of data. It is necessary to adjust the threshold to the images individually. An automated system will be applied in the future for this middle-step.

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[Poster #25] Arnaud Masson [ESAC]

Multispacecraft observations of tailward propagation of transient foreshock perturbations to mid-tail magnetosheath

Three events from multiple spacecraft observations are presented to show that a day-side transient foreshock perturbation associated with an IMF directional discontinuity (DD) can propagate in the midtail magnetosheath and affect the magnetopause. In the first event, perturbations in density and flow were first observed in the day-side foreshock and later in the tail magnetosheath at X ~ -40 RE, showing that the foreshock-originating perturbations remained intact as they propagated to the midtail. The second event shows that foreshock-originating perturbations were observed in the tail magnetosheath at two radial distances (X ~ -30 and -50

RE) at different times. This delay indicates that the perturbations propagated tailward along with the DD. In the third event, a significant change in the dynamic pressure associated with a foreshock perturbation caused a transient magnetopause outward/inward motion that was first observed on the dayside and later in the midtail at X ~ -55 RE. These events indicate that foreshock perturbations, as they propagate tailward, should have an extensive impact on the night-side magnetosphere and ionosphere.

[Poster #26] Lionel Métrailler [ESAC]

Data-Driven Modelling of the Earth Radiation Belts

The magnetosphere sustained by the rotation of the Earth's liquid iron core traps charged particles, mostly electrons, and protons, into structures referred to as the Van Allen Belts. These radiation belts, in which the density of charged energetic particles can be very destructive for sensitive instrumentation, have to be crossed on every orbit of satellites traveling in elliptical orbits around the Earth, as is the case for ESA's INTEGRAL and XMM-Newton missions. This paper presents the first working version of the 5DRBM models; globals, data-driven models of the radiation belts for trapped electrons and protons. These models are based on in situ measurements of electrons by the radiation monitors on-board the INTEGRAL and XMM-Newton satellites along their long elliptical orbits for respectively 16 and 19 years of operations. These new models can be used to provide reliable predictions along widely different orbits around Earth for the purpose of designing, planning, and operating satellites with more accurate instrument safety margins.

[Poster #27] Helen Middleton [ESAC]

Boundary characterisation using Cluster

The determination and characterisation of region boundaries in the magnetosphere are fairly common tasks within investigations of the solar system and planets. The approach, assumptions and methods are varied and depend upon the conditions of the environment and the data available. Given good data from 4 spacecraft (such as that available from Cluster) many parameters can be calculated quantitively as well as qualitatively, but the route through the assumptions and methods is not immediately clear.

This technote will explain the journey in clear simple terms, such that a relative beginner can find the path more easily than is currently possible by trawling through the literature.

This tech note is the second in a series of Multi-Spacecraft Analysis Techniques technical notes; the first one was on the Curlometer method (using 4 s/c to find the current density inbetween them) and is available on the Cosmos website (https://www.cosmos.esa.int/web/csa/multi-spacecraft).

[Poster #28] Simone Migliari [ESAC]

Assessing fast variability in the Gamma-ray Binary LSI +61 303

In order to disentangle the nature of the compact object in one of the most powerful Gamma-ray Binaries (LSI +61 303), we propose to analyze the aperiodic variability of all its archival high time resolution X-ray data (XMM-Newton, RXTE) and compare it with the system PSR B1259−63, which is known to be a Gamma-ray Binary hosting a Neutron Star. Our future analysis will require the detection of timing features which match the behavior of those in canonical accreting BHs and NSs. For this purpose, we will make use of a well-tested, open-source Python implementation of a collection of core algorithms and methods used in spectral timing: the Stingray Software.

[Poster #29] Alcione Mora [ESAC]

Naked-eye stars Gaia PSF fitting

Gaia provides superb astrometry for stars up to magnitude G $\sim$ 20.7. The basic principle is the simultaneous observation of objects with two telescopes superimposed on the same focal plane. Centroids are obtainded from individual images and then combined into the global astrometric solution. CCD electronic gates are applied to bright stars to artificially reduce the observing time and avoid saturation. This strategy is not perfect, and

a significant fraction of saturated observations is obtained for stars brighter than G $\sim$ 11, mostly due to two factors, the errors in the onboard magnitude determination, and the G $<$ 6 naked-eye stars, too bright even for the shortest CCD gate. The main consortium strategy to deal with saturated stars has been to carefully model the PSF to produce precise centroids even if saturated pixels are masked. However, additional effort is needed to reach the expected accuracy floor for bright stars.

The brightest stars (G $<$ 2–3) produce such a large saturation that they may not be observed at all. Special modes are applied in this case: SIF imaging (small portions of the Sky Mapper video are recorded) and VO-sync (star positions are predicted in advance and observations forced around the foreseen location). SIF images in particular have been collected during the whole nominal mission. The consortium has not been able to analyse them yet.

Bright stars are important for multiple reasons, from the construction of the best accurate astrometric solution to the unbiased detection of Jupiter-size exoplantes in the closest stars. The SOC is trying its best to help DPAC to improve the treatment of saturated sources. Significant progress has been made due to the recent contribution of a YGT, an Irish National Trainee and an EXPRO contract with CAB (INTA-CSIC). The science case, current status, pending actions and extra resource needs will be provided in this presentation.

This poster presents results obtained thanks to Departmental funds and the Irish Research Council - European Space Agency Traineeship

[Poster #30] Daniel Mueller [ESTEC]

The Solar Orbiter SPICE instrument - An extreme UV imaging spectrometer

The Spectral Imaging of the Coronal Environment (SPICE) instrument is a high-resolution imaging spectrometer operating at extreme ultraviolet (EUV) wavelengths. In this contribution, we present the concept, design, and pre-launch performance of this largely ESA-funded facility instrument on the Solar Orbiter mission.

We discuss the mission's science objectives, with a focus on the SPICE-specific aspects, as well as the instrument's design, characterisation and calibration. We conclude with descriptions of the operations concept and data processing. The SPICE instrument is ready to perform measurements that will provide vital contributions to the scientific success of the Solar Orbiter mission.

[Poster #31] Daniel Mueller [ESTEC]

3D Visualisation of Solar Data with JHelioviewer - Preparing for Solar Orbiter and Parker Solar Probe

The next generation of ESA/NASA heliophysics missions, Solar Orbiter and Parker Solar Probe, will focus on exploring the linkage between the Sun and the heliosphere. These new missions will collect unique data that will allow us to study the coupling between macroscopic physical processes to those on kinetic scales, the generation of solar energetic particles and their propagation into the heliosphere and the origin and acceleration of solar wind plasma. Within a few years, the scientific community will have access to large volumes of complex remote-sensing and in-situ observations from different vantage points, complemented by petabytes of simulation data. Answering overarching science questions like "How do solar transients drive heliospheric variability and space weather?" will only be possible if the science community has the necessary tools at hand to visualize these data and assimilate them into sophisticated models. A key piece needed to bridge the gap between observables, derived quantities like magnetic field extrapolations and model output is a tool to routinely and intuitively visualize large heterogeneous, multidimensional, time-dependent data sets. The open-source JHelioviewer software, which is part of the ESA/NASA Helioviewer Project, is addressing this need. This poster highlights recent extensions of JHelioviewer's functionality.

[Poster #32] Claudio Muñoz Crego [ESAC]

Data mining on Mercury using Messenger's MASCS data

There are many science observations of Mercury from the Mariner 10 and MESSENGER missions that are archived and accessible, they are ready to use for any science analysis although it is usually not easy to make use of this large amount of data. Typically some instrument's observations such as the MASCS visible and near-infrared spectrometer on-board MESSENGER are not available via user-friendly interface though they are plenty of valuable information. With the ambitious objective to mine this thesaurus, we have implemented a postgress Database that is populated with the MESSENGER's MASCS data. Those data are then mined to derive interesting science results to better understand Mercury's history and surface. The analysis of those scientific observations should also be useful for the planning of the science observations of future Bepicolombo mission that will be orbiting Mercury in 6 years from now. Here, we present our data model and summarize the science investigations we are expecting.

[Poster #33] Cillian Murphy [ESAC]

Investigating very bright stars in Gaia data

This poster presents the results of the work done by the Irish National Trainee, Cillian Murphy, during the first year of his contract at ESAC as a member of the Gaia team. It is part of the analysis on naked-eye stars led by the Gaia SOC and presented by Alcione Mora in this workshop. This work began with the verification, continuation and conclusion of analysis of residuals when pixels are masked in Gaia data, which was started by a YGT working previously on the project. Following this he took on an operational role in the SIF image analysis branch of the bright stars project, taking charge of several tools developed by other members of the team to conduct early investigations into centroid determination for very bright stars using data from the full duration of the Gaia mission. This poster presents results obtained thanks to the Irish Research Council - European Space Agency Traineeship.

[Poster #34] Jan-Uwe Ness [ESAC]

X-ray Observations of the recurrent Nova V3890 Sgr

The recurrent nova V3890 Sgr exploded in 1962 and 1990, and this year the 3rd recorded outburst occurred. The Swift satellite has monitored this nova in X-ray and UV, observing shock emission from the nova ejecta interacting with the stellar wind of the companion donor star. The NASA X-ray telescope Chandra observed these shocks in high spectral resolution. The UV emission decreases while the atmospheric radius (photosphere) shrinks and exposes successively hotter layers. About 2 weeks after outburst, the photosphere reached X-ray temperatures, and XMM-Newton took a spectacular observation showing astonishing variability and high-resolution spectra showing deep, blue-shifted absorption lines. A second observation may be available by the time of the presentation, and all available data with interpretation approaches will be presented.

[Poster #35] Michael Parker [ESTEC]

The XMM-Newton view of Changing-Look AGN

Accreting supermassive black holes (active galactic nuclei, or AGN) in the centers of galaxies are divided into two types: Seyfert 1s and Seyfert 2s. Most AGN sit cleanly in one of these classes, which were thought to be determined primarily by the viewing angle. Changing look AGN challenge this picture, as they change their Seyfert classification. NGC 1566 is a repeat offender, regularly changing from Sy 2 to Sy 1 and back. Recently, we tracked an outburst of this AGN with XMM, revealing the complex behaviour of the source and shedding new light on the changing-look phenomenon.

[Poster #36] Miguel Perez Ayucar [ESAC]

Solar Eclipse 2019 results from La Silla ESO observatory

A series of posters will illustrate the ESA-CESAR expedition to Chile, La Silla Observatory, for the Solar Total Eclipse on 02 July 2019. The posters will display the expedition and the fruitful ESO collaboration, the main results of the Corona measurements taken from polarization devices, and the Educational and Outreach aspects of the live transmission.

[Poster #37] Eleni Ravanis [ESAC]

Supporting Science with the Mars Express Visual Monitoring Camera

The Visual Monitoring Camera (VMC) on board ESA's Mars Express (MEX) orbiter was originally designed as an engineering camera whose purpose was to monitor the separation of the Beage-2 lander in 2003. Later, in 2007, the camera was switched on again for outreach purposes, and following the subsequent use of VMC data for Mars atmospheric science, the VMC was designated a scientific instrument in 2016. Since then, new observation planning procedures have been developed, as well as a new data processing pipeline to maximise the scientific return of the instrument. The MEX Science Ground Segment team (SGS) at the European Space Astronomy Centre (ESAC) in Madrid maintains close collaboration with the VMC science team located at the University of the Basque Country (UPV/EHU) in Bilbao. This work presents an overview of the current operations and data processing for the instrument, as well as examples of the scientific studies made possible by this "webcam" around Mars. These studies include monitoring of the global dust storm over the south pole in 2018, analysis of twilight clouds, and discovery of a seasonally recurrent double cyclone in the Northern latitudes of Mars.

[Poster #38] Celia Sanchez [ESAC]

Burst-induced coronal cooling in GS 1826−24

Type-I X-ray bursts are thermonuclear explosions on the surface layers of weakly magnetized neutron stars (NS) accreting mass from a low mass companion. GS 1826−24 is known to present regular bursting properties over long periods of time. Therefore, we stacked the spectra of the X-ray bursts detected by INTEGRAL and XMM-Newton to study the effect of the burst photons on the properties of the inner accretion flow. The extended energy range provided by these instruments allows the simultaneous observation of the burst and persistent emission spectra. We detect an overall change of the shape of the persistent emission spectrum in response to the burst photon shower. As traditionally the persistent emission was assumed to be invariant during X-ray bursts, the observed change of the persistent emission level during X-ray bursts may trigger the revision of existing neutron star mass-radius constraints.

[Poster #39] Elliot Sefton-Nash [ESTEC]

Alignment of Mars Elongated Crater Azimuths with Orbit Planes Representing Paleo-Equators

Elongated craters can form from low angle impacts. The distinguishing morphological properties of elongated craters and their ejecta become more pronounced with decreasing impact angle, which allows ease of identification of craters formed by grazing impacts. Following construction of an updated database of elongated craters on Mars and retrieval, via an ellipse-fitting algorithm, of best-fit parameters describing crater location and orientation, we determine the best-fit azimuth of craters and use this to retrieve the inclination of the orbit from which possible grazing impactors on Mars originated. We find that no elongated craters originated from orbits inclined within 10 degrees of the present-day equator, but many have azimuths requiring their origin from high inclination trajectories for Mars' present-day rotation pole. Moonlets from an equatorial debris disk caused by a giant impact (a mechanism by which Phobos and Deimos may have formed, may have had slowly decaying orbits leading to craters formed at low impact angles ($< 5°$). The absence of crater morphologies consistent with very low impact angles has been used to argue against the spiralling moonlet hypothesis for the formation of elongated craters [4]. The absence of comprehensive atmospheric entry and impact modelling for decaying moonlets leaves open the possibility that some only moderately elongated craters on Mars were formed by decaying moonlets in a thicker atmosphere. Using a 2D ballistic entry model we find that impacts can occur at high impact angles for bodies with estimate moonlet-like properties. Intuitively impact angles are higher for

impactors with low ballistic coefficients, and under higher atmospheric density. True Polar Wander (TPW) of Mars' rotation axis is expected to be the predominant factor determining whether crater azimuths align with paleo-equators, above which moonlets in a quasi-stable debris disk could gradually decay. While obliquity cycles would indeed modify the relationship between latitude, azimuth and orbit plane inclination, a transient debris disk that lingered for several Ma would be expected to align with Mars' equator throughout obliquity variations. To investigate alignment of crater azimuths with paleo-equators, we place the Mars rotation pole at positions in a global geographic grid. For each position (each which produces its own coordinate reference system, CRS) we transform elongated crater geographic parameters into the new CRS then retrieve the corresponding azimuths and orbit inclinations. We calculate the number of elongated craters in our database with orbit inclinations that are within azimuth-error of the paleo-equator for each rotation pole position. We find several candidate polar areas where Mars' rotation pole would have needed to be for groups of elongated craters may align with the corresponding paleo-equators. Further analysis of individual craters, including consideration of derived ages, would work towards a clearer picture of whether any individual or groups of elongated craters on Mars originated from a debris disk formed by a giant impact.

[Poster #40] Anezina Solomonidou [ESAC]

The raised ramparts around Titan's northern lakes

We investigate the spectral characteristics of a selection of Titan's small northern lakes that have raised ramparts around their perimeters using Cassini Visual and Infrared Mapping Spectrometer (VIMS) and RADAR data. Ramparts (which are distinct from raised rims) are radar-bright mounds that extend from the shores of some lakes out for up to tens of kilometers. We performed a comparative spectral analysis among the lakes, their ramparts, and the surrounding regions. We overcome the profound difference in spatial resolution between VIMS and SAR data by using a method that provides overlays between the spectral images and SAR, thus enabling the correct selection of VIMS pixels. The surface properties of the selected areas are obtained using a radiative transfer analysis on the selected VIMS pixels, in addition to emissivity obtained from the RADAR in radiometry mode. Analysis of these combined and co-registered data provides new constraints for the formation mechanism(s) of raised ramparts observed around a subset of Titan's northern lakes. The results show that the microwave emissivity of the raised ramparts is close to that of Titan's labyrinthic terrains and to that of empty lake floors in the northern polar regions. The infrared analysis also shows that the spectral response of the raised ramparts is very similar to that of some empty lake floors. This suggests that both areas are made from or are covered by a similar material. In addition, two out of the eight lakes with raised ramparts show spectral differences at three specific wavelengths, 1.6, 2.0, and 5.0 μm, between the ramparts and the surrounding terrain. We hypothesize that this could be due to some component, or mixture of components, in the ramparts that is less absorbent at these specific wavelengths, or it could be an effect of different grain sizes. A number of theories for the formation of the raised ramparts are discussed.

[Poster #41] Paule Sonnentrucker [Baltimore]

HD 62542: Probing the Bare, Dense Core of a Translucent Interstellar Cloud

The interstellar medium (ISM) is a complex environment composed of gas and dust constantly shaped by star and galaxy evolution. Decades of multi-wavelength observations (space and ground-based) have shown that the ISM is constituted of different types of clouds, that have been categorized by their dust, atomic and molecular contents. Observations of these types of clouds are then compared with cloud model predictions in order to better understand the physical and chemical processes at play in the ISM. Translucent clouds, have been long predicted to represent a transitional phase between the well-studied diffuse atomic and diffuse molecular clouds and specific diagnostic tracers have been proposed to detect this particular ISM phase. However, unambiguous detection of these translucent clouds has been elusive to date mostly due to sight line confusion. Using the exquisite high-resolution spectroscopic mode offered by the HST/STIS instrument, we devised a simple but powerful experiment that allowed us to resolve this sight line confusion toward HD 62542, a hot star lying behind a ridge of material in the western part of the Vela shell, foreground to the Gum Nebula. I will present observational evidence that reveal the presence of a translucent cloud, for the first time. I will then discuss how gathering such unique and comprehensive set of observations are critical to guide and constrain existing modeling efforts to better describe the physical and chemical processes that shape the ISM and ultimately produce organic complexity in Space.

[Poster #42] Claire Vallat [ESAC]

ESA Micro-meteoroid models applied to surface weathering and exosphere formation of the Jovian Icy Moons

Galileo imaging and reflectance spectroscopy data show alterations in the Galilean Moon surfaces. Different hemispheres (leading/trailing) show distinct characteristics in terms of albedo, structural properties and composition. On the other hand Galileo dust instrument DDS detected dusty exospheres at Ganymede, Europa and Callisto. Micro-meteoroid impacts contributes, among other processes (radiolysis, thermal desorption, plasma sputtering) to the exogenic energy deposit that alter the surface of the Jovian moons, leading to both surface weathering and possibly to exosphere formation. Simulations of the dust environment around the Jovian icy moons are of great interest in order to get insight in the characteristics of the dust population triggering such phenomena.

1- The Interplanetary Meteoroid Environment Model (IMEM) Primary interplanetary dust impacts are simulated using the prediction of the Interplanetary Micrometeoroid Environment Model (IMEM) computed at Jupiter's Hill radius. IMEM was built for ESA as explained in [1], primarily used to assess the hazard arising from meteoroid impacts onto spacecraft structures, but also used to predict the Interplanetary Dust particle (IDP) fluxes for scientific purposes. This model is a truly (dynamical) evolutionary model that considers the orbital elements of known interplanetary dust sources, in particular, comets and asteroids. The model computes the evolution of the orbital elements of the released particles, taking into account radiation pressure, Poynting-Robertson drag (the relativistic, tangential component of the radiation pressure), gravitation, and mutual collisions of particles. The simulated dust complex is assumed to have its properties (flux and orbital element distribution) to be axisymmetric with respect to the ecliptic axis. The mass of the simulated grains ranges from 10^{-18} g to 1 g, and the heliocentric distance up to which IMEM predictions can be made is 5AU.

2- The Jovian Micrometeoroid Environment Model (JMEM) Impacts of dust particles coming from the Galilean moons (secondary impactors) and evolving dynamically in the Jovian system are being simulated using the Jovian Micrometeoroid Environment Model (JMEM, developed for ESA by J. Schmidt and collaborators of the University of Oulu, [2]). This model was initially built to provide an estimate of the micro-meteoroid fluences (integrated flux) of dust impactors (between 5e-8 m to 1e-2m) on the ESA JUICE spacecraft along its trajectory in the Jovian system. The model is based on the primary impacts of interplanetary dust onto the major icy moons, that eject dust particles from the moons surface. The ejected particles that have sufficient velocity to escape the moon's gravity are injected into the Jovian system and their trajectories evolve under the action of various forces: Lorentz forces, radiation pressure including Poynting-Robertson drag, solar and moons gravity, plasma drag, and gravitational effects due to Jupiter non-sphericity. Dynamical evolution of Ejected particles from the major Moon surfaces due to interplanetary dust impacts on their surfaces is computed. This provides their spatial distribution in the system. The expected flux of secondary impactors on the moons surface can then be estimated at different true anomalies along the orbit of the moon.

3- References [1] Dikarev et al. The new ESA meteoroid model, Advances in Space Research, 2005 [2] Liu et al., Dynamics and distribution of Jovian dust ejected from the Galilean satellites, JGR, 2016

[Poster #43] Olivier Witasse [ESTEC]

Combined study of the Martian upper atmosphere using MEX and MAVEN data

An emerging finding stemming from the last few years' work by the scientific community is the evidence that the Mars' atmosphere behaves as a single coherent system. For example, the existence of water supersaturation in the atmosphere is important for regulating the water cycle, including the propagation of water vapour from the surface up to the exosphere where it can escape to space. The communication between the well-mixed lower atmosphere and the external envelope is more direct and much faster than anticipated. Coupling between the lower/middle and upper atmospheres is indeed now one of the key objectives of the Mars Express mission extension, as well as collaborations with the NASA MAVEN mission. In this study, funded by the Faculty (contractor: LATMOS laboratory) we examine some aspects of atmospheric erosion using the data sets from these two missions, which are very complementary and still largely unexploited in a synergistic way. The activity is coming to and end in December 2019. This poster will focus on one particular result of this year, namely the influence of extreme ultraviolet irradiance variations on the precipitating ion flux.

[Poster #44] Joe Zender [ESTEC]

Extension of the Plasma Radiation Database PARADE for the Analysis of Meteor Spectra

The observation of a meteor entering the Earth atmosphere is probably one of the oldest astronomical observations. The impressive glowing trail of a shooting star is actually the physical process of an atmospheric entry of interstellar rocks into the Earth atmosphere. Until the late 1990s, the observation of meteor entries was mainly based on counting events and calculating trajectories based on the observed meteor trails using video camera systems. With the improvement in detector and spectrometer technology spectral observations of entries became possible. The background idea is that the spectral analysis allows to identify the meteor types and eventually the parent body in space. A recent development of a two camera system called CILBO (Canary Island Long-Baseline Observatory) with intensified cameras and transmission gratings allows to detect the emission spectra of entering meteors. With an appropriate radiation simulation code, this spectra can be analyzed in more detail and further physical effects of the re-entry can be identified. A collection of measured meteor spectra was published by Vojacek. The various measured meteor entries are mainly characterized by the appearance of prominent emission lines of Mg, Na and Fe. The identification of the lines in the paper from Vojacek was conducted by a simple comparison of the line position of the measured emission line with appropriate emission line databases from Borovicka. In this poster, an attempt is presented to combine the rather sophisticated plasma radiation database PARADE for the analysis of meteor spectra. After a description of PARADE, the extension of the database are presented together with some comparisons to simple models. The update of the PARADE database with the most interesting chemical elements and molecules was partly funded by the ESTEC Faculty.