ESA SCI Science Workshop #15
30 November – 2 December 2022

Program & Abstracts

Organising Committee:
Lisanne Braat, Jos de Bruijne, Giovanna Giardino, Matteo Guainazzi, Maximilian Guenther, Laura Hayes, Ana Heras, Peter Kretschmar, Erik Kuulkers, Marcos López-Caniego Alcarria, Theresa Lueftinger, Bruno Merín, Sophie Musset, Chris Nelson, Jan-Uwe Ness, Tim Rawle, Mylene Riemens, Lucie Riu, Paule Sonnentrucker, Jan Tauber, Colin Wilson & Jack Wright

ESA Space Science Faculty Workshop, SSW#15

30 November – 02 December 2022, Akersloot, The Netherlands

Wednesday, 30 November 2022

11:30 Bus ESTEC – Akersloot
12:00 Bus Schiphol – Akersloot

12:00 – 14:30 Arrival, Lunch (room keys available as of 14:00)
14:30 – 14:45 Welcome (Markus Kissler-Patig), Introduction (Chair), Start of program

14:45 – 15:45 Science Talks, Chairing: In-room: Oliver Hall, Online: Jack Wright
14:45 – 15:00 *Solar Jet Hunter, a citizen project to study jets in the solar corona*, Sophie Musset
15:00 – 15:15 *Bursts and bombs in the solar atmosphere - a magnetic reconnection story*, Chris Nelson
15:15 – 15:30 *Solar flare X-ray observations of time-variability with Solar Orbiter STIX*, Laura Hayes
15:30 – 15:45 *Solar System Objects as Observed by Euclid*, Aurélien Verdier

15:45 – 16:15 Coffee break

16:15 – 17:35 Science Talks, Chairing: In-room: Jack Wright, Online: Oliver Hall
16:15 – 16:30 *A Martian investigation: Where did the water go and where is it now?* Lucie Riu
16:30 – 16:45 *Understanding Recent River Flows on Mars,* Rickbir Bahia
16:45 – 17:00 *What lurks beneath the polar ice caps of Mars?* Colin Wilson
17:00 – 17:15 *The power of combining science and visualisations,* Tineke Roegiers
17:15 – 17:35 *JWST: New science results,* Chris Evans
17:35 – 18:35 Poster session (in person & online, poster pitch talks), Chairing: In-room: Ricci Bahia, Online: Chris Nelson &
Introduction of new Research Fellows, Chairing: Yannis Zouganelis

18:35 – 20:00 Welcome Cocktail/Snacks/Posters (@ venue)/Socializing

20:00 Dinner

Thursday, 01 December 2022

07:30 – 08:20 Special event: Yoga class at venue, Miho Janvier, Sophie Musset
09:30 – 10:30 Science Talks, Chairing: In-room: Eleni Bohacek, Online: Katja Fahrion
09:30 – 09:45 *Comparative (icy) planetology using photometry,* Ines Belgacem
09:45 – 10:00 *The 3.1 µm NIR feature is not due to surface water ice on asteroids,* Laurence O'Rourke
10:00 – 10:15 *What can impact ejecta from the Caloris basin tell us about Mercury's interior and formation?* Jack Wright
10:15 – 10:30 *Yes, Hollows on Mercury are made of sulfides and it drives their spatial distribution!* Sebastien Besse

10:30 – 11:00 Coffee break

11:00 – 12:30 Science Talks, Chairing: In-room: Katja Fahrion, Online: Eleni Bohacek
11:00 – 11:15 *Solar Orbiter and the solar/heliospheric fleet coordinated observations of a filament eruption: a test bed for a global eruptive flare model,* Miho Janvier
11:15 – 11:30 *Is AD Leo featuring a polarity reversal of the large-scale magnetic field? Long-term monitoring across near-infrared and optical domains with SPIRou, ESPaDOnS and NARVAL,* Stefano Bellotti
11:30 – 11:45 *Probing small exoplanets' evolution with the ESA-powered Antarctic telescope and HST,* Maximilian Guenther
11:45 – 12:00 *Precise Dynamical Masses of New Directly Imaged Companions from Combining Relative Astrometry, Radial Velocities, and Hipparcos-Gaia eDR3 Accelerations,* Emily Rickman
12:00 – 12:15 *Towards population studies of exoplanet atmospheres,* Quentin Changeat
12:15 – 12:30 *Data Science: The Good, the Bad and the Ugly,* Jan Reerink

12:30 – 14:00 Lunch

14:00 – 15:30 Science Talks, Chairing: In-room: Emily Rickman, Online: Ines Belgacem
14:00 – 14:15 *So, was I right or was I wrong?* Guido De Marchi
14:15 – 14:30 *A glimpse into the internal kinematics of globular clusters with HST ,* Mattia Libralato
14:30 – 14:45 *Characterising the asteroseismic Red Clump standard candle in Gaia magnitude, colour, metallicity and alpha abundance,* Oliver Hall
14:45 – 15:00 *White dwarfs, dust, discs and debris,* Nicola Gentile Fusillo
15:00 – 15:15 *Fast & Furious: The time-domain richness of X-ray transient phenomena,* Alicia Rouco Escorial
15:15 – 15:30 *Looking for observational signatures of feedback from accreting supermassive black Holes,* Chiara Circosta

15:30 – 16:00 Coffee break

16:00 – 17:00 Science Talks, Chairing: In-room: Ines Belgacem, Online: Emily Rickman
16:00 – 16:15 *Scientific landing site analysis for ESA's PROSPECT instrument,* Sarah Boazman
16:15 – 16:30 *Individual dust particle analysis in the sourroundings of 67P,* Julia Marin-Yaseli de la Parra
16:30 – 16:45 *Are spacecraft engineering data useful for science purposes?* Olivier Witasse
16:45 – 17:00 *Unraveling ion acceleration in solar energetic particle events with Solar Orbiter,* Nils Janitzek
17:00 – 17:20 Poster session (in person & online, poster pitch talks), Chairing: In-room: Lucie Riu, Online: Maximilian Guenther

17:20 – 17:35 Short coffee break

17:35 – 18:35 Faculty Matters

18:35 – 20:00 Posters (@ venue) , Free time, Socializing

20:00 Dinner buffet

Friday, 02 December 2022

Before 09:00 Check-out from hotel

09:00 – 09:40 Science Talk, EDI, Chairing: In room: Gaitee Hussain, Online: Lucie Riu
09:00 – 09:40 *Diversity & Inclusion: Well-being in Astronomy*, Natalie Webb

09:40 – 10:40 Science Talks, Chairing: In room: Chiara Circosta, Online: Lucie Riu
09:40 – 09:55 *From the center of the Milky Way to the most distant objects in the Universe,* Alice Young
09:55 – 10:10 *Exploring the properties of interstellar dust in the Galaxy using infrared and X-ray Spectroscopy,* Sascha Zeegers
10:10 – 10:25 *How do nuclear star clusters form?* Katja Fahrion
10:25 – 10:40 *Preparing for JWST with HST/COS spectroscopy of Pox 186: a local analogue of z > 6 Galaxies,* Nimisha Kumari

10:40 – 11:10 Coffee break (final opportunity for check-out)

11:10 – 12:05 Science Talks, Chairing: In room: Oliver Jennrich, Online: Ricci Bahia
11:10 – 11:50 *How observing the Earth from Space supports our quest to tackle climate Change, Susanne Mecklenburg,* ESA Climate Office
11:50 – 12:05 *The Cosmological Likelihood for Observables in Euclid,* Guadalupe Canas Herrera

12:05 – 12:10 Thanks (Chair) and
12:10 – 12:30 Closing Remarks: Guenther Hasinger

12:30 – 13:30 Lunch

13:30 Bus for Schiphol leaving
14:00 Bus for ESTEC leaving

Presenter	Page

Oral presentations

Poster presentations

Oral Presentations

Listed alphabetically by 1st author last name

Rickbir Bahia [ESTEC]; Vilmos Steinmann, Eleni Bohacek

Understanding Recent River Flows on Mars

Valley networks are evidence of liquid water flows on the surface of Mars in the ancient past, with most forming during the Late Noachian - Early Hesperian (∼3.7 billion years old). After this point, Mars lost most of its atmosphere, and valley network incision rapidly decreased. However, valleys are observed incising Late Hesperian and Amazonian aged surfaces (3.4 billion years old to present). But how did they form? And what can they reveal about the climatic conditions on Mars after the loss of the global atmosphere? In this study, we conduct paleohydraulic analysis (Hack's Law, Flint's Law and aspect ratio analysis), drainage density analysis, and advanced formation timescale calculations on 13 Late Hesperian to Amazonian aged valley network to gain insight into their formation origins, the duration and sustainability of fluvial incision that formed them, and the climatic aridity at their time of formation. Our results show that the majority of the valley networks formed via episodic groundwater sapping, ice-melt or subglacial incision over tens of thousands of years in an arid climate. However, four of the valley networks have geometries consistent with formation via a really uniform precipitation under a semi-humid/semi-arid climate. These networks are located around Gale Crater (the site of the Curiosity Rover) and Holden Crater, and required a cumulative incision period of ∼20 thousand and ∼80 thousand years, respectively. These networks caused little change to the topography on which they formed and, therefore, were likely formed via episodic fluvial incision events, which is also evidenced by geomorphological features, indicating that this cumulative incision period may have been spread out over much longer time periods. Most of the valleys examined in this study are immature and less integrated than those of the Late Noachian - Early Hesperain, however, those adjacent to Gale Crater and Holden Crater are comparable to the general population. Our results provide support for the inference that localised semi-humid/semi-arid climates, comparable to the Late Noachian - Early Hesperian global climate, and essentially Earth-like hydrologic cycle fueled rivers, persisted after the loss of Mars' global atmosphere.

The surface of Mars is carved by vast arrays of valley networks, which are evidence of ancient rivers systems. The majority of these valleys are present in surfaces of Late Noachian - Early Hesperian (∼3.7 billion years old) in age. After this point, Mars lost most of its atmosphere, and valley network incision rapidly decreased. However, valleys are observed cutting into Late Hesperian and Amazonian aged surfaces (3.4 billion years old to present). But how did they form? And what can they reveal about the climatic conditions on Mars after the loss of the global atmosphere? In this study, we conduct analysis on the morphometry and morphology, and preform newly developed formation timescale calculations on 13 Late Hesperian to Amazonian aged valley network to gain insight into their formation origins, the duration and sustainability of water flow that formed them, and understand how humid the climate was at their time of formation. Our results show that most of the valley networks formed by reoccurring short episodes of water released from the subsurface, ice-melt or water released below an ice-sheet/glacier over tens of thousands of years in an arid climate. However, four of the valley networks have geometries consistent with formation via areally uniform precipitation (rainfall or snowfall) under a semi-humid/semi-arid climate. These networks are located around Gale Crater (the site of the Curiosity Rover) and Holden Crater, and required a total period of water erosion of ∼20 thousand and ∼80 thousand years, respectively. These networks caused little change to the surface on which they formed and, therefore, were likely formed by short reoccurring episodes of rainfall/snowfall, which is also evidenced by features present within the valley networks, indicating that this cumulative incision period may have been spread out over a much longer time. Most of the valleys examined in this study are immature compared to those of the Late Noachian - Early Hesperain, however, the valley networks adjacent to Gale Crater and Holden Crater are comparable to the general population. Our results provide support for the inference that localised semi-humid/semi-arid climates, comparable to the Late Noachian - Early Hesperian global climate, and essentially Earth-like hydrologic cycle fueled rivers, persisted after the loss of Mars' global atmosphere.

Ines Belgacem [ESAC]; T. Cornet, J. Hogan, F. Schmidt, G. Cruz Mermy and F. Andrieu

Comparative (icy) planetology using photometry

The study of photometry — reflectance variation with respect to the geometry of observation — can help us better understand the processes at play at the surface. The photometry of a surface is intimately linked to its microtexture (roughness, shape of particles, porosity, ...), and can strongly affect all remote sensing observations if performed in varied geometric conditions. As a result, having a clear understanding of a surface photometry is the first step for any remote sensing applications such as surface mapping or spectroscopy. Icy satellites are prime candidates in the search for habitability in our solar system. Using photometry, we want to better understand the history of these fascinating bodies and help identify potential areas of interest for future missions. We have carried out regional studies of Jupiter's icy moons Europa and Ganymede as well as Saturn's moon Enceladus and compared the photometric parameters we obtained with known geological context in order. With this, we aim to better understand the link between photometry and physical properties of planetary surfaces as well as to identify areas of recent activity.

Understanding how a surface reflects the light from the Sun can help us better understand its physical state. A rough surface, different densities of internal scatterers will affect the way we perceive it. The icy satellites of our solar system are prime candidates in the search for habitability - i.e., understanding if a planetary body has the minimum characteristics for forms of life to emerge. By studying the surface of Jupiter's icy moons Europa and Ganymede as well as Saturn's moon Enceladus, we try to understand the link between photometry and physical properties of planetary surfaces better and identify potential areas of interest for future missions.

Stefano Bellotti [ESTEC]; Julien Morin, Lisa Lehmann, Gaitee Hussain, Pascal Petit and the SLS Consortium

Is AD Leo featuring a polarity reversal of the large-scale magnetic field? Long-term monitoring across near-infrared and optical domains with SPIRou, ESPaDOnS and NARVAL.

Zeeman-Doppler Imaging has been applied on numerous stars to reconstruct their large-scale magnetic field topology and provide observational feedback on their internal structure. Several types of magnetic field topologies in low-mass fully convective stars have been reported and their explanation requires either two coexisting and stable dynamo branches (known as dynamo bistability) or long-term magnetic cycles with polarity reversals, but there is no definite conclusion on the matter. We analysed near-infrared spectropolarimetric observations of the active M dwarf AD Leo taken with SPIRou at CFHT between 2019 and 2020. We examined the long-term behaviour of the longitudinal magnetic field and we recovered the magnetic field geometry via both Zeeman-Doppler Imaging and a Principal Component Analysis. Including the optical data sets investigated in previous studies, we found evidence of a secular evolution of the magnetic field in the form of a decreasing strength and reduced axisymmetry (from 90% to 50%). Throughout the entire time series, the topology remained simple, i.e., predominantly poloidal and dipolar. This suggests that low-mass M dwarfs with a dipole dominated magnetic field can undergo magnetic cycles, a phenomenon which is known to introduce spurious radial velocity signatures preventing a reliable planetary detection and characterisation. Furthermore, activity cycles modulate the stellar radiation output and winds in which close-in planets are embedded, leading to a temporal variation in the planetary atmospheric stripping, and alteration of the chemical properties and habitability.

Spectropolarimetry allows us to study the magnetic field of stars. In practice, we can reconstruct the large-scale map of the field using tomographic techniques like Zeeman-Doppler Imaging. This can be used to inform dynamo theories and better understand the processes that generate magnetic fields in the interior of stars. One clear manifestation of dynamo action on the Sun is the 22-yr magnetic cycle which sees the oscillation between a predominantly poloidal configuration to a toroidal one and vice versa. At the same time, the magnetic polarity of the field flips back and forth. Despite we have some evidence of cycles on other sun-like stars, low-mass, cool M dwarfs are still an unexplored territory. They represent excellent laboratories to study dynamo mechanisms because their interior may differ from solar-like, i.e., they can be fully convective instead of having a radiative core surrounded by a convective envelope. For this reason, long-term spectropolarimetric monitoring of these types of stars is essential to potentially catch magnetic cycles. AD Leo is an excellent M dwarf for our purposes because it has a strong magnetic field and was observed for 14 years both with optical instruments (ESPaDOnS and NARVAL) and near-infrared ones (SPIRou).

Sebastien Besse [ESAC]; Sebastien Besse, Oceane Barraud

Yes, Hollows on Mercury are made of sulfides and it drives their spatial distribution!

MESSENGER mission to Mercury led to the discovery of hollows. These geological flat-floor shallow depressions have no close counterpart on other airless silicate bodies. Multispectral images and geochemical measurements suggest that hollows are formed by the loss of volatiles-bearing minerals. We investigate the mineralogical composition of the hollows using near-ultraviolet to near-infrared spectra. We compared reflectance spectra of hollows with laboratory spectra of Mercury's analogs: sulfides, chlorides, silicates and graphite. The best candidates to reproduce the curvature of the hollows spectra are CaS, MgS and Na2S. Our results show that the enrichment of sulfides in hollows material is up to two times higher than the sulfide concentration derived from chemical measurements of Mercury's high-reflectance smooth plains. This result explains the small percentage of hollows found within these plains. BepiColombo observations will help in improving our understanding of hollows on Mercury as well as laboratory measurements.

For the first time, we could unambiguously characterise minerals associated to hollows on Mercury. The identified mineral phase, sulfide, is consistent with the overall bulk and regional distribution of elemental composition of Mercury. Those results provide very strong constraints on the formation and evolution of Mercury that is definitively not made only of rocks, and is to some extent, geologically active!

Sarah Boazman [ESTEC]; David Heather, Csilla Orgel, Elliot Sefton-Nash, Berengere Houdou and the Lunar Lander Team

Scientific landing site analysis for ESA's PROSPECT instrument

The south pole of the Moon is a target for upcoming missions both for national space agencies and for commercial missions, including for ESA's PROSPECT instrument. PROSPECT will sample the lunar surface and test the samples for volatiles in particular for water ice, in the onboard laboratory called ProSPA. In order for PROSPECT to sample volatiles a landing site that has the best scientific value and is accessible should be chosen. Therefore as part of ongoing work, we are analyzing the lunar south polar region using a multitude of datasets, including analyzing the topography, thermal conditions, and surface features present, which may be a hazard to landing. We will present areas of interest for PROSPECT, which will be explored further.

The south pole of the Moon is an area of interest for future missions including for ESA's PROSPECT instrument. To learn where is suitable to land PROSPECT analysis of the surface using multiple datasets was carried out and areas of interest have been selected. We have identified areas for further analysis.

Guadalupe Canas Herrera [ESTEC]; The Euclid IST:Likelihood

The Cosmological Likelihood for Observables in Euclid

Our universe is composed mostly of dark matter and dark energy. Thanks to the observations of the Cosmic Microwave Background (CMB), cosmologists have established a successful model that aims to explain our universe: the LCDM model. However, the era of cosmology based on observations of the CMB is close to an end. In the near future, most of the constraining power will come from the observations of the Large Scale Structure of the universe. In this sense, the ESA Euclid mission, whose launch is approaching, will be essential. This mission will create one of the largest catalogues of galaxies ever. Euclid will precisely map the universe's structure by studying two cosmological observables: the Weak Lensing effect, which studies the apparent change of the shapes of galaxies, and Galaxy Clustering, which focuses on how well the distribution of galaxies in the universe can trace the underlying matter distribution.
To extract the cosmological information contained in the catalogue, scientists will use a Bayesian statistical approach to compare data and models. The Euclid Inter-Science Group Taskforce Likelihood is in charge of developing and delivering the official likelihood software for the Euclid Consortium. This code will be essential for the future analysis of cosmological models once the Euclid data is available. During the last two years, the Taskforce has been working on the implementation of the Weak Lensing and Galaxy Clustering observables' recipes and in the development of the data analysis pipeline. As cosmologist of the Theory Science Working Group and one of the main software developers within the Taskforce, I will guide you through the goals of the Euclid mission, show how the observables are modeled, explain the main characteristics and functionalities of the likelihood code as well as some preliminary results obtained with it.

Our universe is dark. Indeed, the main two ingredients are dark matter (a type of substance that seems to interact only gravitationally) and dark energy (an unknown substance that seems to be responsible of the current accelerated expansion of the universe). But, how have cosmologists came up with this conclusion? The answer relies on astrophysical data and statistics. In fact, cosmologists have compared for years the relic radiation from the Big Bang (also known as the Cosmic Microwave Background) with the corresponding theoretical predictions. Using Bayesian Statistics, cosmologists have concluded that the Standard Cosmological Model, with only those two ingredients and few assumptions, is able to explain the current structure present in our universe. Still, although successful, the Standard Cosmological Model fails to provide answers about the nature of dark matter and dark energy.
In this context, it is expected that the incoming ESA Euclid mission will be able to bring some light. Euclid, whose launch is planned for next year, will study millions of galaxies on the sky. By analysing the shape and space distribution of those galaxies along time, cosmologists expect to constrain extensions of the Standard Cosmological Model to eventually discern the nature of dark matter and dark energy. As a member of the Euclid Consortium Theory Science Working Group and as one of the main developers of the mission analysis pipeline for the Bayesian comparison of models against future Euclid data, I will guide you through the goals of the Euclid mission, the Euclid observables, main challenges and future forecasts.

Quentin Changeat [Baltimore]; Edwards Billy

Towards population studies of exoplanet atmospheres

In the last decade, the study of exoplanets has moved from the detection to the characterization of their atmospheres. Space telescopes such as Hubble, have allowed to infer the chemical properties, the thermal structures and the presence of clouds in exotic worlds. However, due to difficulty of performing such measurements, most studies have so far been limited to individual targets. With the data becoming more and more available, as well as the recent launch of JWST and the scheduled ESA Ariel mission, we are now entering a new era, where the recovery of atmospheric properties can be done at the population level. This presentation will focus on recent results obtained by uniformly studying spectroscopic data obtained with Hubble, and present future perspectives from next-generation space telescopes.

This talk will present atmospheric studies of exoplanets. It will show what and how information can be recovered from observed data and explain what can be understood about the population of exoplanets we observe.

Chiara Circosta [ESAC]

Looking for observational signatures of feedback from accreting supermassive black holes

Feedback from accreting supermassive black holes (a.k.a. active galactic nuclei, AGN) is thought to be key in shaping the life-cycle of host galaxies. AGN inject a significant amount of energy into the surrounding interstellar medium and launch gaseous winds. They are therefore able to potentially suppress or inhibit future star formation in their hosts. An ideal cosmic epoch to study how AGN regulate galaxy growth is the so-called cosmic noon ($z \sim 2$), i.e., the peak of AGN accretion activity when their energy output is overall maximized. In this talk I will describe our recent efforts to systematically characterize the impact of AGN on star formation in galaxies at cosmic noon. To this aim, we are exploiting integral field spectroscopy data obtained with SINFONI and ALMA observations of the ionized and molecular gas as well as dust continuum.

In the Universe we observe that some galaxies keep forming stars while others do not. The processes that "kill" galaxies halting their star formation are subject of intense research. Since stars form from the collapse of clouds made of molecular gas, removing and/or heating up such molecular gas means stopping the star-formation activity of the galaxy. Supermassive black holes residing at the center of galaxies are thought to be among the most likely culprits of such "crime". Indeed, they grow by eating gas and dust - when they become active - and emit a huge amount of energy that can have a profound influence on galaxy's life. In this talk I will describe our search for imprints of the actions supermassive black holes are capable of.

Guido De Marchi [ESTEC]

So, was I right or was I wrong?

For years I have entertained you with wonderful results from Hubble, revealing that, in nearby low-metallicity galaxies, stars like the Sun take much longer to form than in the Milky Way. And that the discs of gas around those stars feed them more and and for a longer time. Yet not everyone agreed with those results. The point is that, to study those beautiful star-forming regions in the Magellanic Clouds, my collaborators and I only had imaging, in broad and narrow bands. And even though an image is worth a thousand words, a spectrum is worth a thousand images. So some esteemed colleagues in the community kept saying 'all nice Guido, but we won't trust you until you show us a spectrum'. Well, finally we have a fantastic tool on JWST, built by ESA and called NIRSpec, that can take spectra of those very faint, still forming stars in the crowded Magellanic Clouds. And we have taken those spectra, discovering that ... [to be continued in Akersloot].

For years I have entertained you with wonderful results from Hubble, revealing that, in nearby low-metallicity galaxies, stars like the Sun take much longer to form than in the Milky Way. And that the discs of gas around those stars feed them more and and for a longer time. Yet not everyone agreed with those results. The point is that, to study those beautiful star-forming regions in the Magellanic Clouds, my collaborators and I only had imaging, in broad and narrow bands. And even though an image is worth a thousand words, a spectrum is worth a thousand images. So some esteemed colleagues in the community kept saying 'all nice Guido, but we won't trust you until you show us a spectrum'. Well, finally we have a fantastic tool on JWST, built by ESA and called NIRSpec, that can take spectra of those very faint, still forming stars in the crowded Magellanic Clouds. And we have taken those spectra, discovering that ... [to be continued in Akersloot].

Katja Fahrion [ESTEC]; M. Lyubenova, G. van de Ven, M. Hilker, M. Rejkuba, O. Mueller, T. Bulichi, N. Neumayer, F. Pinna, R. Leaman

How do nuclear star clusters form?

Nuclear star clusters (NSCs) are dense, massive star clusters found in the centres of at least 70% of all galaxies. NSCs are known to co-exist with central black holes (BHs), our own Milky Way being the most prominent example, and are known to follow the same scaling relations with host galaxy properties, suggesting a connected evolution. To understand the detailed buildup of galactic nuclei we study NSCs that still contain records of their formation and evolution imprinted in their stellar populations and kinematics. Generally, two main scenarios are discussed for NSC formation: in-situ from gas at the galactic centre or via the dissipationless accretion of globular clusters (GCs) that spiral inwards due to dynamical friction. Most likely, a mixture of both pathways is realized in nature, but the dominant channel nor the mass fractions are unknown. I will present results from integral-field spectroscopy of NSCs hosted by dwarfs and massive early-type galaxies that allow to constrain NSC formation for individual galaxies. These results indicate a clear dependence of the dominant NSC formation channel from GC-accretion to in-situ formation with increasing galaxy and NSC mass. Further, I will present recent results from novel observations of nucleated star forming dwarf galaxies, a regime that has not been explored with spectroscopy.

Star clusters are dense collections of stars, sometimes comprising millions of stars tightly packed together. Because of their density and brightness, they can be observed in distant galaxies where they appear as bright compact sources. Nuclear star clusters are the most massive and densest of star clusters and are commonly found in the very centres of galaxies, including our Milky Way. I will present how we can use spectroscopy to understand the average ages and chemical compositions of nuclear star clusters and how we can use that information to explore how these extreme star clusters form in different galaxies.

Nicola Gentile Fusillo [ESAC]; Boris Gaensicke, Christopher Manser

White dwarfs, dust, discs and debris

It is now an accepted fact that planets can survive the late evolution of their host stars and that white dwarfs can still host the remnants of planetary systems. Evidence of this is seen in the metal pollution observed in white dwarf atmospheres, in the IR signature of circumstellar dust discs, and in the spectral emission features from gas discs. These systems not only allow us to study the final phases in the evolution of planets and peek into the future of our own solar system, but also offer the unique opportunity to probe the chemical composition of rocky extra-solar objects. A property simply inaccessible to the study of exo-planets around main-sequence stars. Despite their huge scientific potential, white dwarfs suitable for the study of evolved planetary systems are extremely rare and the restricted size of the available sample has severely limited the impact of this field of study for years. However, the advent of Gaia marked a turning point and today we can search for these systems of interest on an unprecedented scale... but with great numbers come even greater questions! In this talk I will give an overview of the ongoing quest to identify white dwarfs with planetary remnants highlighting some of the most puzzling recent discoveries.

The vast majority of all stars in the Galaxy including virtually all known planet host and our own Sun will one day evolve into white dwarfs: small stellar embers devoid of an energy source and simply destined to cool down and fade over billion of years. But what happens to the planets around these stars? Today we know that remnants of planetary systems can still be found around white dwarfs and the study of these objects can teach us a lot about the properties of these ancient worlds. Thanks to the ESA mission Gaia, we now have hundreds of thousands of white dwarfs to scan for the presence of planetary remnants. Now the quest is on to find the answers to key questions like: when did planets first form? How did they end? How common is the Earth? and what is the future of our own solar system?

Maximilian Guenther [ESTEC]; Laurel Kaye, Thomas Mikal-Evans, ESA/ASTEP POC, ASTEP science team, NGTS science team, SPECULOOS science team, TESS science team, TFOP

Probing small exoplanets' evolution with the ESA-powered Antarctic telescope and HST

The nearby exoplanet system TOI-270 provides an unparalleled opportunity to observationally probe hypotheses for planet formation and evolution. The system hosts one super-Earth ($1.2\,R_{\mathrm{Earth}}$) and two sub-Neptunes (2.4 and $2.1R_{\mathrm{Earth}}$) transiting a bright (K-mag 8.25) M3V dwarf near mean-motion resonances (5:3 and 2:1). Strangely, for still unknown reasons, such systems spanning the radius valley (around 1.6 R_{Earth}) are rare - and we know barely a handful of them bright enough for precise mass measurements and atmospheric studies. TOI-270's planets are exceptionally favourable for detailed transit timing variation (TTV) and transmission spectroscopy observations. First, our 3-year long observing campaign with 8 different observatories yields clear TTV signals with amplitudes of $\sim$10 min and a super-period of $\sim$3 yr. With this, we significantly constrain the exoplanets' radii, mass ratios, and eccentricities using dynamical models. Second, we can characterise and compare the atmospheres of the two sub-Neptunes formed from the same protoplanetary nebula using HST observations. This enables us to test hypotheses like photoevaporation, core-powered mass-loss, and gas-poor formation. As one of the best-constrained small exoplanet systems to date, TOI-270 serves as a unique observational testbed for formation and evolution theories. Our observing campaign relied heavily on our ESA-powered Antarctic telescope, ASTEP. The unique conditions, such as 24h long nights, enabled us to observe a wealth of transits not visible from anywhere else. While I highlight the example of TOI-270, we also characterised dozens of other exoplanets and even monitored the impact of DART on Dimorphos thanks to this ESA/ASTEP program. This proves the remarkable synergy of space and ground for exoplanet and small-body science, with lots more to come.

The nearby red dwarf star TOI-270, only 40% the size and mass of our Sun and half its temperature, has three planets in orbit. One is slightly bigger than Earth and likely rocky. The other two are double the size of Earth and probably of a similar composition as Neptune, rocky cores covered by a thick gas atmosphere. Being one of the only known systems of this kind and remarkably bright, TOI-270 can be a true testbed for various theories of exoplanet formation and evolution. Our 3-year long monitoring campaign has put rigorous constraints on the planets' radii and dynamical interactions, allowing us to precisely measure their masses. We can also probe the atmospheric compositions of these planets and compare them with one another to test various hypotheses. As one of the best-constrained small planet systems, TOI-270 serves as a unique observational testbed for formation and evolution theories. Our observing campaign relied heavily on our ESA-powered Antarctic telescope, ASTEP. The unique conditions, such as 24h long nights, enabled us to observe a wealth of data not visible from anywhere else. While I highlight the example of TOI-270, we also characterised dozens of other exoplanets and even monitored the impact of DART on Dimorphos thanks to this ESA/ASTEP program. This proves the remarkable synergy of space and ground for exoplanet and small-body science, with lots more to come.

Oliver Hall [ESTEC]; G.R. Davies, J. de Bruijne, A. Lyttle

Characterising the asteroseismic Red Clump standard candle in Gaia magnitude, colour, metallicity and alpha abundance

When stars of solar-like masses evolve along the red giant branch, their degenerate cores will eventually ignite Helium fusion. The event these stars undergo is called the Helium flash, after which they will settle onto a region of the HR diagram called the Red Clump. Because these stars ignite Helium at near-identical core masses, they also have similar magnitudes. This allows us to use Red Clump stars a standard candles, and the better we understand the physics of the Clump, the better this standard candle becomes.
Recent studies (e.g., Hall et al. 2019, Chan & Bovy 2020) have used Gaia DR2 to look at the magnitude and spread of the Red Clump, and how these change with properties such as colour, metallicity, and abundance of alpha-elements. However with the precision of Gaia eDR3, and spectroscopic data afforded to us by APOGEE and soon the full Gaia DR3, we can extend this approach. In this talk, I outline how we are using a new Hierarchical Latent Variable Model to measure the correlations between fundamental stellar observables of Red Clump stars (identified using asteroseismology), and how this improves the available precision on the Red Clump standard candle.

There is a certain class of Red Giant - stars like the Sun that have evolved and grown to a massive size - that all have roughly the same brightness due to their cores all being of a similar size. Because we know how bright they're supposed to be, and we can see how bright they appear, we can calculate how far away they are! This is a really useful property in astronomy, as stellar distances can be hard to come by.
However, due to additional effects such as the stars temperature and metal content, their brightness can actually vary quite a bit. In this project we're carefully quantifying by how much the brightness of a red clump star changes due to these additional effects, which can dramatically improve the precision on the distances we can measure for these stars.

Nils Janitzek [ESAC]; M. Roco Moraleda, A. Walsh, I. Zouganelis, and the SOLO Energetic Particle Detector Team

Unraveling ion acceleration in solar energetic particle events with Solar Orbiter

Coronal mass ejections (CMEs) release large amounts of plasma from the outer solar atmosphere into interplanetary space. These large eruptions have been shown to be the primary cause of large solar energetic particle (SEP) events, but we still lack a detailed quantitative understanding how these particles are efficiently accelerated. One crucial ingredient for the acceleration efficiency of CMEs might be the ambient so-called seed particle population which is energized at the accompanying shock front and/or turbulent plasma sheath of the CME. This seed population could be either the ubiquitous solar wind or a more variable population of suprathermal particles that can be produced by solar flares. In our study we use data from Solar Orbiter close to its perihelion in March 2022 to investigate whether suprathermal particles from ambient solar flares are preferentially accelerated at CMEs and might therefore play a key role in the formation of SEP events.

Coronal mass ejections are eruptions on the Sun that release large amounts of plasma from the solar atmosphere into the solar system. These mass ejections also produce high energetic particles that can disturb the operation of satellites, harm astronauts in space, and even affect our infrastructure on Earth in extreme cases. For our study we use measurements from the Solar Orbiter spacecraft - that has just recently observed several coronal mass ejections very close to the Sun - to improve our understanding of these large solar eruptions and the associated high energy particles.

Nimisha Kumari [Baltimore]; Will give later

Preparing for JWST with HST/COS spectroscopy of Pox 186: a local analogue of $z > 6$ galaxies

ALMA has revolutionized the study of reionization-era galaxies. With the launch of JWST last year, it is crucial to establish a local reference sample of high-redshift 'analog' galaxies covering essential UV, optical and FIR emission lines that will soon become available in the upcoming JWST+ALMA era. A local ($z \sim 0.0040705$), metal-poor ($12 + \log(O/H) = 7.76$) blue compact dwarf galaxy, Pox 186, exhibits the brightest CIII] 1908 emission (equivalent width ∼36 Å) observed at any redshifts as revealed by the HST/COS observations, along with an extreme [OIII] 88/[CII] 158 (∼10). This extreme CIII] is comparable to those observed in galaxies at redshifts of $z \sim$6–7, when the reionization process is thought to be completed. I will present the analysis of UV nebular and stellar lines as revealed in this galaxy by the HST/COS observations. The work is very timely as reionization era galaxies galaxies are now being routinely detected with the JWST.

This contribution about a recent result about a dwarf galaxy, Pox 186, which could potentially be the best local analogue of reionization era galaxies. The results are based on data from the Hubble Space Telescope and very timely as the reionization era galaxies are now being routinely detected with the JWST.

Laura Hayes [ESTEC]; Hannah Collier, Säm Krucker

Solar flare X-ray observations of time-variability with Solar Orbiter STIX

The X-ray emission associated with solar (and stellar) flare energy release typically exhibits pulsations and time-varying behavior. This emission variability, which can occur on timescales of seconds to tens of seconds, is thought to be linked to the energy release process itself, however to date the underpinning mechanisms causing the emission modulation remains unclear. The new X-ray imaging spectroscopic observations from the STIX instrument on-board Solar Orbiter provides a new opportunity to study this time-variability associated with solar flare emission, and to constrain the proposed mechanisms driving the modulation. STIX provides quantitative measurements with a time resolution as low as 0.3 s of the intensity, spectra, and imaging of both thermal and non-thermal solar X-rays in the energy range of 4–150 keV. This capability makes it uniquely suited to perform spatio-temporal analysis of flare X-ray emission over the timescales and energy ranges flare time-variability is typically identified. In this talk, I will highlight recent results of flare-time variability observations with Solar Orbiter/STIX, and how these can be used in coordination with other Solar Orbiter instruments observations to learn more about solar flare energy release.

During a solar flare, the X-ray emission from the Sun can increase significantly and often this emission shows pulsations and oscillations. It is hypothesized that this emission variability is related to the flare processes itself, however to date we do not know what causes them. We also observe these pulsations in the emission from stellar flares on solar type stars, so our interest in their study also links to the solar-stellar connection. With the launch of Solar Orbiter in 2020 we have a new opportunity to study solar flare X-rays with the STIX instrument onboard which provides temporal, spectral, and spatial properties of solar X-ray emission. In this talk I will present the new and exciting observations STIX has provided, and how it can help us understand the flare emission variability.

Miho Janvier [ESTEC]; S. Musset, A. Kouloumvakos, A. Rouillard, I. Plotnikov, R. Kieokaew, B. Lavraud, S. Mzerguat, E. Buchlin, M. Maskimovic, T. Horbury, D. Long, D. Baker, S. Yardley, P. Démoulin, P. Louarn, V. Génot, C. Owen, R. Colaninno, P. Hess, S. Baccar, P. Young, K. Barczynski, L. Harra, G. Pelouze, L. Klein, Frédéric Auchère, Mats Carlsson, Andrzej Fludra, Don Hassler, Hardi Peter, Daniel Müller, David Williams, Regina Aznar Cuadrado, Martin Caldwell, Terje Fredvik, Alessandra Giunta, Tim Grundy, Steve Guest, Terry Kucera, Sarah Leeks, Susanna Parenti, Joseph Plowman, Werner Schmutz, Udo Schuehle, Sunil Sidher, Luca Teriaca, Bill Thompson, Natalia Zambrana-Prado, L. Bellot Rubio, S. Solanki, G. Valori, A. Fedorov, J. Rodriguez-Pacheco, R. Wimmer-Schweingruber, EUI team, MAG team

Solar Orbiter and the solar/heliospheric fleet coordinated observations of a filament eruption: a test bed for a global eruptive flare model

Eruptive solar events can lead to the formation and the expulsion of large-scale magnetic structures in the interplanetary medium, called coronal mass ejections (CMEs), as well as, the acceleration and injection of particles within the heliosphere. CMEs transport solar plasma and magnetic field in the solar system; along with high energy particles, they can interact with the space environment of planets. It is critical to improve our understanding of how these drivers of space weather evolve, from their initiation at the Sun's outer atmosphere, the corona, to their propagation in the interplanetary space. However, while CMEs and high energy particles are routinely measured remotely and in situ by spacecraft dedicated to observe the Sun and the solar wind, so far our measurements have been restricted to few positions close to 1 au and near the ecliptic. In the first remote-sensing campaign of its nominal phase, Solar Orbiter and the heliophysics fleet of other solar missions (SDO, SoHO, Hinode, IRIS and STEREO-A) were ideally placed to observe simultaneously, and from different vantage points, eruptive solar events occurring on April 2nd 2022 and its accompanying CME detected in situ a few hours later. In this presentation, we will review first the unprecedented wealth of data covering the pre-eruption phase, to the eruption and early coronal propagation, the high energy particles and plasma waves detections and, finally, the in situ measurements of the CME detected directly by Solar Orbiter. We will then focus on the solar wind connectivity and CME/shock propagation to understand the timings, features and the widespread nature of high energy particles and plasma waves detected by several spacecraft. By providing simultaneous observations at different positions in the inner solar system, Solar Orbiter and the other spacecraft can now help us integrate models of eruptive flares and CMEs and energetic particles into one global solar eruption model linking the Sun's atmosphere to the inner heliosphere. The April 2nd 2022 eruptive event also provides a great example of the capabilities of joint observation campaigns and what is next for the future observation windows of the Solar Orbiter nominal mission.

This study focuses on a very well observed solar eruption that was captured by all the instruments on board the Solar Orbiter mission. The consequences of this large eruption lead to changes in the interplanetary medium that were felt at different locations by interplanetary and planetary exploration space missions. With the variety of data we have, from images of the plasma at the Sun, to direct measurements of particles, waves, plasma and magnetic fields in the inner heliosphere, I will show how these can better constraint models developed over the years of solar eruptions and their consequences in the solar system.

Mattia Libralato [Baltimore]

A glimpse into the internal kinematics of globular clusters with HST

Over the past twenty years, new photometric and spectroscopic data have radically changed our picture of Galactic globular clusters (GCs). We went from thinking we knew everything there was to know about these ancient fossils to now not even having models to explain how they could have possibly formed.
We have recently started to combine the wealth of information available in the Hubble Space Telescope (HST) archive to compute high-precision proper motions with the goal of analyzing the internal motions within GCs. The internal kinematics have a lot to tell us about how GCs formed and have evolved, and we have only begun to scratch the surface of what they can provide us.
In this talk, I present our recent work in which we computed proper motions for stars in 57 stellar clusters by combining archival HST data. The astro-photometric catalogs we made represent the most complete and homogeneous collection of proper motions of stars in the cores of stellar clusters to date, and expand the information provided by the current (and future) Gaia data releases to much fainter stars and into the crowded central regions. I discuss our analysis of their bright members, and present an overview of the general kinematic properties both of clusters as a whole and of their multiple stellar populations.

Globular clusters are dense structures made by hundreds of thousands of stars. Until a few decades ago, these objects were described as simple spherical systems in which stars are 'buzzing' around like bees in a beehive. Recently, we have started to study how stars in globular clusters move in the plane of the sky over time, and found that these structures are much more complex than previously thought.
In this talk, I present our recent work in which we used data taken with the Hubble Space Telescope to compute proper motions with the goal of analyzing the internal motions within stellar clusters. I discuss our analysis of their bright members, and present an overview of their general kinematic properties.

Julia Marin-Yaseli de la Parra [ESAC]; M. Kueppers

Individual dust particle analysis in the surroundings of 67P

During the perihelion phase of the orbit of Churyumov-Gerasimeko a huge number of dust particles were discovered with the WAC and NAC cameras of the Osiris instrument. The study of the dust behaviour is vital for understanding the global evolution of the comet and has direct consequences in the research of the origins of the solar system. [1] Dust jets increase the halo of dust around the comet. We can observe this behavior from 100–150 km and determine the trajectories of the individual particles. That helps for calculating the average mass loss rate per period. Calculations are not so simple since two situations may occur. The diurnal thermal cycle plus the irregularities in the shape of the comet produces a flow of particles from the southern hemisphere to the northern and most particles are redeposited. However, some areas, like Hapi region, are eroded around 1.0 ± 0.5 m per orbit. Some other areas are growing with deposits of dust creating moving shifting dunes. Some other particles can escape from the coma with open trajectories. A simple image of the OSIRIS instrument can contain hundreds of dust and grain particles around a 4 km sphere around the core. The images above show the level of complexity when processing an image. Partly, most image sequences are processed manually [5] There is no universal method for calculating dust trajectories in comets [7]. To date, studies have been carried out on:

* Trajectories close to the surface of the comet [2]
* Calculation of trajectories through parallax between two cameras on board Rosetta [13], [15], [16]
* Orbital determination for long periods of time [11]

To determine dust trajectories, neither of these methods would work individually, but a combination of them could be effective. Using the satellite's displacement as a parallax source the position and velocity could be determined if the particle remains long enough in the camera's field of view. The biggest drawback is the large number of false positives (stars, cosmic rays, etc ...) that make real detections difficult.

We will present a method of calculating the trajectories with ImageJ [7] and SPICE [9] and will determine the amount of dust particles per frame studied.

This abstract is part of the on-going PhD work made in University Complutense of Madrid in collaboration with the ESA Rosetta mission data.

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State of the art of the dust investigations in the surroundings of 67P and my last research data tracking individual dust particles as part of my PhD thesis.

Sophie Musset [ESTEC]; Paloma Jol, Ramana Sankar, Lindsay Glesener, Daniel Mueller

Solar Jet Hunter, a citizen project to study jets in the solar corona

Solar coronal jets, collimated ejections of solar plasma, are ubiquitous in the solar atmosphere. Frequently observed in EUV (extreme ultraviolet), they are often seen at the origin of energetic particle events detected in the heliosphere. These ejections seem to illuminate open magnetic field line onto which accelerated charged particles are injected and escape from the solar corona. To better understand the role of solar jets in particle acceleration and injection in the heliosphere, we aim to perform a statistical study of the link between jets and signatures of energetic particles. To construct a reliable catalogue of solar jets, we rely on volunteers participating in our citizen science project 'Solar Jet Hunter'. This project was launched one year ago, and thousands of short movies of the solar corona have been analyzed by volunteers, who reported hundreds of jets, thus creating the largest and most consistent catalogue of solar jets so far. We will present here the early results of the Solar Jet Hunter project.

Citizen science is a scientific method using volunteers to perform science on a large data set, with minimum training. This method is particularly useful to analyze large datasets, and perform tasks which cannot be automatized or performed by algorithms at this point. This is the case for the detection of solar jets, small ejections in the solar atmosphere. We created a citizen science project called 'Solar Jet Hunter' in which the volunteers are asked to find and report solar jets, by looking into extreme ultraviolet images of the Sun. In a few months, hundreds of jets have thus been found by the solar jet hunters!

Chris Nelson [ESTEC]; L. Kleint, N. Freij, D. Berghmans, F. Auchere, D. Mueller, L.A. Hayes, S. Musset

Bursts and bombs in the solar atmosphere - a magnetic reconnection story

Localised transient brightenings occur ubiquitously throughout the solar atmosphere, from the photosphere to the corona. These events go by many names including bursts and bombs, and are thought to be primarily driven by magnetic reconnection, the rapid and explosive reconstruction of the local magnetic field. Although we know that such magnetic reconnection can cause extreme heating of the local plasma in small (European country sized) regions, we still do not know whether this process occurs enough to sustain multi-million degree temperatures over entire the solar corona (known as the coronal heating problem). In this talk, we discuss recent work undertaken with the aim of tackling this problem, using data from the Interface Region Imaging Spectrograph (IRIS) and Solar Orbiter satellites. Our large-scale statistical analysis investigates the fundamental properties of the signatures of magnetic reconnection at temperatures ranging from the photosphere ($\sim$6000 K) to the corona ($>$1000000 K) at various positions across the solar surface (including in active regions and the quiet Sun). This comprehensive research allows us to make important inferences about the importance of magnetic reconnection in answering the coronal heating problem. We find that at any given time magnetic reconnection signatures are found to cover approximately 0.02% of the solar corona, an area around 239 times the surface area of the Earth, suggesting that this signature may play an important role in the constant energy deposition required in the upper solar atmosphere to account for corona heating. These results provide a basis for future research using data from Solar Orbiter during my fellowship.

The corona is the outer layer of the solar atmosphere. Intuitively, it should be cooler than the inner layers which sit below it, closer to the energy source at the solar core, but this is not the case. In fact, the temperature increases from a relatively cool 6000 K in the photosphere, the visible solar surface we see in the sky, to well above 1000000 K in the corona. How this temperature increase is sustained remains one of the key unanswered questions in solar physics. In this talk we explore whether magnetic reconnection, the explosive restructuring of the magnetic field which threads ubiquitously through the solar atmosphere, could hold the key to coronal heating through analysis of some of the highest spatial resolution data ever sampled for the solar atmosphere. Our analysis provides constrains about both the frequency with which magnetic reconnection occurs in the solar atmosphere and the thermal evolution of the plasma contained at these locations. This work will act as a basis for future research using data from Solar Orbiter during my fellowship.

Laurence O'Rourke [ESAC]; T.G. Müller, N. Biver, D. Bockelée-Morvan, S. Hasegawa, I. Valtchanov, M.Küppers, S. Fornasier, H. Campins, H. Fujiwara, D. Teyssier, T. Lim

The 3.1 μm NIR feature is not due to surface water ice on asteroids

Asteroids (24) Themis and (65) Cybele have an absorption feature at 3.1 μm reported in a Nature paper (Campins et al, Nature, 2010; Rivkin & Emery et al, Nature, 2010) to be directly linked to surface water ice. We searched for water vapour, linked to surface water ice, escaping from these asteroids with the Herschel Space Observatory Heterodyne Instrument for the Far Infrared (HIFI). While no H2O line emission was detected, we obtained sensitive 3σ water production rate upper limits of Q(H2O) $< 4.1 \times 10^{26}\,\mathrm{mol.\,s^{-1}}$ for Themis and Q(H2O) $< 7.6 \times 10^{26}\,\mathrm{mol.\,s^{-1}}$ for Cybele. Using a Thermophysical Model (TPM), we merge data from Subaru/Comics and Herschel/SPIRE with the contents of a multi-observatory database to derive new radiometric properties for these two asteroids. For Themis, we found a thermal inertia $\Gamma = 20^{+25}_{-10}\,\mathrm{J\,m^{-2}\,s^{-1/2}\,K^{-1}}$, a diameter 192^{+10}_{-7} km and a geometric V-band albedo pV $= 0.07 \pm 0.007$. For Cybele we obtained a thermal inertia $\Gamma = 25^{+28}_{-19}\,\mathrm{J\,m^{-2}\,s^{-1/2}\,K^{-1}}$, a diameter 282 ± 9 km, and an albedo pV $= 0.042^{+0.03}_{-0.02}$. Using all inputs, we estimate that water ice intimately mixed with the asteroids' dark surface material would cover <0.0017% for Themis and <0.0033% for Cybele of their surfaces, while an areal mixture with very clean ice (bond albedo 0.8 for Themis and 0.7 for Cybele) would cover <2.2% for Themis and <1.5% for Cybele, of their surfaces (O'Rourke et al, 2020). While surface (& sub-surface) water ice may exist in small localized amounts on both asteroids, there is no doubt that the 3.1 μm NIR feature observed is not due to surface water ice on these asteroids.

The planetary community has been publishing papers based on a Nature paper from 2010 that concluded that Water ice on asteroids can be identified with a 3.1 micron spectral feature. My paper shows the nature paper was wrong and proposes another explanation for this feature.

Jan Reerink [ESAC]

Data Science: The Good, the Bad and the Ugly

There is a new section in town! Let us take a look at what Data Science means in industry and figure out what it could mean for the science department. This talk will focus on the opportunities and risks of applying machine learning and the technologies that come along with it in science. We will try to cover the spectrum ranging from exciting new disciplines such as scientific machine learning to horrid examples of ML-powered cargo cult science. How should we position our department to take advantage of the opportunities while avoiding risks?

A look at the risks and opportunities of scientific machine learning.

Emily Rickman [Baltimore]; Elisabeth Matthews, Will Ceva, Damien Ségransan, Mirek Brandt, Hengyue Zhang, Tim Brandt, Thierry Forveille, Janis Hagelberg, Stéphane Udry

Precise Dynamical Masses of New Directly Imaged Companions from Combining Relative Astrometry, Radial Velocities, and Hipparcos-Gaia eDR3 Accelerations

Very little is known about giant planets and brown dwarfs at an orbital separation great than 5 AU. And yet, these are important puzzle pieces needed for constraining the uncertainties that exist in giant planet formation and evolutionary models that are plagued by a lack of observational constraints. In order to observationally probe this mass-separation parameter space, direct imaging is necessary but faces the difficulty of low detection efficiency. To utilize the power of direct imaging, pre-selecting companion candidates with long-period radial velocities, coupled with proper anomalies from Hipparcos and Gaia, provide a powerful tool to hunt for the most promising candidates for direct imaging. Not only does this increase the detection efficiency, but this wealth of information removes the degeneracy of unknown orbital parameters, like the inclination, leading to derived dynamical masses which can serve as benchmark objects to test models of formation and evolution. With new and upcoming missions like JWST and Roman, as well as ground-based facilities like the ELT, observing time is valuable and the strategy of direct imaging needs to be re-defined to pre-select targets. Looking further ahead, perfecting these strategies will be necessary as we look towards a large IR/O/UV mission, as recommended by the Astro 2020 decadal survey report, to pinpoint the location of terrestrial planets amenable to direct imaging. I present the detection of new directly imaged companions from VLT/SPHERE with derived model-independent precise dynamical masses from combining relative astrometry, radial velocities, and astrometry from Hipparcos-Gaia eDR3 accelerations. I also present the ongoing work towards hunting for the most amenable targets for direct imaging with upcoming and future instruments. Ultimately this will lead us to a catalogue of precisely characterized benchmark objects that can be used to test models of planet formation and evolution.

I present how we discover exoplanets using direct imaging, by using precursor information from other exoplanet measurement techniques to look for hints of their existence. Combining all of these techniques together is not only powerful for discovering exoplanets, but also for understanding the ones that we do find, like their atmospheres and perhaps how they formed.

Lucie Riu [ESAC]; Lucie Riu, John Carter, François Poulet, Alejandro Cardesín-Moinelo, Patrick Martin

A Martian investigation: Where did the water go and where is it now?

Assessing the water content at the surface of Mars is key to understand the history of water and past climate of the planet but it also is very important for future exploration and potential In Situ Resource Utilization. Numerous locations on the surface, known to harbor hydrated minerals, have been detected and their mineralogical assemblages quantified. Based on previous analyses resulting from the modeling of OMEGA near-infrared spectra, we evaluated in this paper the amount of water that could still be stored in those hydrated minerals that were previously characterized. Overall, we find that on average at the surface the hydrated silicates are composed of $\sim$5 wt% of water with specific regions with >20 wt% localized in 100 m^2 areas, that could present a higher ISRU potential. We find that the global amount of water estimated in hydrated silicates corresponds to $\sim 10^{-4}$ Global Equivalent Layer (m) for deposits of 1 m in depth, which represents a lower bound but could still indicate that on the surface the hydrated silicates — as detected by OMEGA (<1% of the surface) — may not globally be an important sink of water.

Mars used to have liquid water at its surface, where did it go?
We are trying to understand here how much water could have been lost through the hydration of the Martian crust in its past using orbital data from the OMEGA/Mars Express instrument. Our investigation is two-fold: 1. we want to give insights on the climate/water history at Mars, 2. we hope to identified region(s) where a substantial amount of water is still present at the surface, region(s) that could be of interest for future exploration both for exobiology potential and in terms of resources (e.g., H2O) to be used once onsite.

Tineke Roegiers [ESTEC]

The power of combining science and visualisations

Through the promotion of Gaia science results, I've seen the different ways of connecting science and visualisations. Often scientists that start thinking early in the process on how to communicate the result, get the best coverage

for their science. That's no surprise, science visualisations can be very appealing. This talk will run through a few examples of how powerful this combination of science and visualisations can be. Explaining ways to connect with visualisation experts and enthusiasts, ways to make simple improvements to make material more accessible. I will not present science. I will present ways to get a better reach for science. None of the discussed is revolutionary new, but often people don't think about taking an active approach. This talk would be mostly to make people aware of the opportunities.
I will run through the following more or less:
* Be active in reaching out to get your science promoted
* The earlier the start, the better
* Journalists want graphics
* Connection with the institute visualisation expert
* Co-author with visualisation experts
* Connection with amateur astronomer
* Create your own visualisation with feedback from your outreach expert
* Simple guidelines to make visuals more attractive.

This talk will run through a few examples of how powerful the combination of science and visualisations can be. Explaining ways to connect with visualisation experts and enthusiasts, showing ways to make simple improvements to make material more accessible.

Alicia Rouco Escorial [ESAC]; Rudy Wijnands, Nathalie Degenaar, Jakob van den Eijnden, Alessandro Patruno, Wen-fai Fong, Tanmoy Laskar, Edo Berger, Raffaella Margutti, Genevieve Schroeder, Jillian Rastinejad

Fast & Furious: The time-domain richness of X-ray transient phenomena

Transient phenomena show diverse high-energy behaviour at different time scales. In the 'faster' regime — from seconds to hours — high-energy monitoring has facilitated the follow up of electromagnetic counterparts to gravitational waves and (short) gamma-ray bursts (GRBs), whereas in the 'slower' regime — from days to months — these kind of studies have yielded to the extension of our understanding of the X-ray binary phenomenology. None of this progress could have been made without the key role of the XMM-Newton, Swift, Chandra, INTEGRAL and MAXI observatories.
In the 'slow' time-domain scenario, I present the results of our X-ray monitoring campaigns focused on studying the low-luminosity state of Be/X-ray transients, which harbour highly magnetized ($B{\sim}10^{12}$–10^{13} G) neutron stars (NSs). We have observed that, at such luminosities, these systems show different transient behaviour, which is potentially linked to the neutron-star spin period. I will discuss our results in the context of the physical processes that could explain most of the observed phenomena. However, limiting our studies to high energies constrains our knowledge to the compact object and its surroundings, and ignores any feedback from the companion and its environment. Therefore, comprehensive multi-wavelength studies of these systems will broaden our understanding of the physical processes behind the observed emission and will help clarify the origin of the observed outflows. In the 'fast' time-domain scenario, I present the results of our latest systematic and comprehensive X-ray study of short GRB afterglows at late times. I will introduce the most updated jet opening angle distribution of short GRBs, which is determined utilising all the available broad-band (from X-rays to radio) afterglow information. This result has direct implications on the true energy scales of short GRBs, true event rates and possible progenitor (NS-NS or black hole-NS mergers) channels.

In this talk I will discuss the power of X-ray studies unveiling different time-domain transient phenomena. I will summarize what we have learnt about the different physical processes behind the transient behaviour of X-ray binaries and gamma-ray bursts thanks to X-ray missions.

Aurĺien Verdier [ESAC]; A.A. Nucita, L. Conversi

SSOs as Observed by Euclid

The ESA Euclid mission will survey 15,000 deg^2 in the visible and near-infrared, mapping the extra-galactic sky to constrain our cosmological model of the Universe. Although the survey focus on regions further than 15° from the ecliptic, it should detect more than 105 Solar System Objects (SSOs). The near-infrared photometry of Euclid will be highly valuable to study the composition of these SSOs, and motivate efforts to detect them. We aim at developing automated tools to identify SSOs among the millions of sources that will be imaged by Euclid. We focus here on a method adapted to objects moving with an apparent velocity in the range 0.1–10"/h, which typically corresponds to objects from the outer Solar System (from Centaurs to Kuiper-belt objects). We first develop a tool to simulate the signal from SSOs in Euclid images acquired with the visible camera (VIS). The detection scheme is then based on the Source Extractor and SCAMP softwares. A suite of filters to improve the purity of the sample by rejection of false-positive detections are then applied. We give the setting parameters to maximize the detection rate, and present the expected purity and completeness of the output Solar System catalogs. We also emphasize that identifying and correctly flagging these moving objects in both the visible and near-infrared images provided by the VIS and NISP instruments is of great importance to achieve the primary objective of the Euclid mission, that is to identify the shear signal in weak lensing

Asteroids (or Solar System Objects) can be detected in Euclid images with the VIS camera. This talk would present how to detect the slow SSOs quickly to be able to send alerts. The challenges are to detect and get the astrometry of the SSOs from level 1 data. During this talk, I will present the pipeline developed to detect the SSOs and the performance of different softwares used to find astrometric solutions of the Euclid's images.

Colin Wilson [ESTEC]

What lurks beneath the polar ice caps of Mars?

One of the most exciting recent discoveries from Mars Express was what appears to be liquid water lakes beneath the polar ice caps from the MARSIS subsurface sounder (Orosei et al., Nature, 2018, doi:10.1126/science.aar7268) This would be momentous, if confirmed, for two reasons. Firstly, for water at the polar cap to be liquid would probably require a heat source, which hints at active geological processes on this barren desolate planet. Secondly, a liquid water reservoir would give a glimpse of what an early, wet and potentially habitable Mars may once have looked like, so would be of significant astrobiological interest.
However, the interpretation is not so straightforward. The original paper, from 2018 has now been cited 127 in peer-reviewed literature. Some have tried to explain how strong basal reflectors could arise without liquid water, for example using specific compositions or layered structures of clays, saline ice, metal-bearing minerals, or ice-covered volcanic minerals. This in turn has spurred a new campaign of lab measurements of temperature-dependent dielectric properties of a wide range of possible materials, providing new data which has to be incorporated into the analytical models.
Meanwhile, the MARSIS team continues to build up ever more detailed maps of the Southern polar regions, in particular using a new mode which allows far more spatially extensive sounding in the high-sensitivity modes of the radar.
Where is this story leading? I'll give the latest...

Mars Express appears to have found evidence that liquid water lakes can be found underneath the ice caps at its South pole. But it's hotly debated! I will review the evidence for and against...

Olivier Witasse [ESTEC]; ... and many colleagues

Are spacecraft engineering data useful for science purposes?

Are spacecraft engineering data sets useful for carrying out scientific studies? Where to find these data sets? Are they easy to use? I will try to answer these questions with three examples: one successful study (study of galactic cosmic rays with Rosetta and Mars Express data); one unsuccessful (search for dust impact on Mars Express); one study ongoing and promising (space weather monitor with multi-spacecraft data [Mars Express, TGO, Gaia, Bepi-Colombo, Solar Orbiter]). Fun stuff!

Solar system science made with data that nobody know where to find them. It is a real detective work.

Jack Wright [ESAC]; Emma Caminiti, Auriol Rae, Sebastien Besse

What can impact ejecta from the Caloris basin tell us about Mercury's interior and formation?

Mercury, a planet with a disproportionately large iron core [1], has abundant evidence for volatile-driven activity (e.g., explosive volcanism [2]) on its silicate surface. Formation models for Mercury often invoke high-energy processes, such as giant impacts [3], to explain the large core, but such processes would also preferentially remove the volatiles from the silicates. It is currently unknown to what depth Mercury's silicate fraction is enriched in volatiles. The Caloris basin is the largest (1,550 km diameter), well-preserved impact structure on

Mercury [4]. Its impact ejecta represent a rare opportunity to study material from Mercury's deep interior using spacecraft data. The Odin Formation is a hummocky, knobby plains-type unique to Caloris' exterior, widely interpreted as Caloris impact ejecta [4]. It is host to numerous discrete, conical knobs (up to $\sim$10 km in diameter and 2 km high), which have previously been interpreted to be degraded ejecta blocks from the Caloris impact [5]. Interestingly, the degradation of initially arbitrarily-shaped blocks into cones might require a more rapid mass-wasting process than impact gardening, which smooths topography. At least some knobs contain hollows: pits where Mercury's surface appears to have been stripped away by the loss of some volatile component, which raises the possibility that volatile-loss might also have driven the collapse of blocks into the knobs observable today. In this work, we will use high-resolution MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) Mercury Dual Imaging System (MDIS) images to remap the extent of the Odin Formation, previously only mapped at low resolution. We will use MESSENGER Mercury Atmospheric and Surface Composition Spectrometer (MASCS) data to see if the Odin Formation and circum-Caloris knobs have any distinct spectral signature, for example, such as that identified at hollows, to test the involvement or not of volatiles in their formation. We will also use numerical impact simulations to estimate the depth of excavation of the original blocks, and hence the source depth of the volatiles within the knobs. If the impact simulations show that the knobs, and hence volatiles, are deeply sourced, then this strongly constrains formation models, because the planet must not heat up so much in its early history that volatiles are lost before the planet solidifies. On the other hand, if the blocks and volatiles are shallowly sourced, then perhaps a giant impacts and other high-energy models are permissible early in Mercury's history and then volatiles could have been delivered later in its evolution, perhaps as a (cometary?) veneer.

[1] Urey, H.C. (1951), Geochim. Cosmochim. Acta, 1, 209–277; `https://doi-org.libezproxy.open.ac.uk/10.1016/0016-7037(51)90001-4` [2] Kerber, L. et al. (2009), Earth Planet. Sci. Lett., 285, 263–271; `https://doi.org/10.1016/j.epsl.2009.04.037` [3] Benz, W. et al. (2008), in: Balogh, A., Ksanfomality, L., von Steiger, R. (eds), Mercury; `https://doi.org/10.1007/978-0-387-77539-5_2` [4] Murchie et al. (2008), Science, 321, 73–76; `https://doi.org/10.1126/science.1159261` [5] Wright et al. (2020), Earth Planet. Sci. Lett., 549, 116519; `https://doi.org/10.1016/j.epsl.2020.116519`

During my Research Fellowship I am going to map material excavated by the impact that formed the Caloris basin, the largest, well-preserved impact structure on Mercury. Together with my collaborators, I will investigate what this 'ejecta' might be made of and estimate the depth from which it was excavated. This will tell us about what Mercury's interior is made of, which in turn will give us clues to how the planet formed. This is because Mercury has a large iron core, which planetary scientists often have to explain with a giant impact early in the planet's history that removed much of Mercury's outer rocky layer, while leaving most of the iron core behind. However, Mercury's rocky surface has a lot of evidence for processes that require volatile compounds (things that readily turn into gases), such as explosive volcanism. A giant impact early in Mercury's history would remove such volatiles, so the question becomes how can Mercury have both a large iron core and a volatile-rich crust? My results should shed light on how deep in Mercury's interior the volatiles go. If they are deep, then the giant impact hypothesis looks unlikely. If they are only shallow, then maybe a giant impact is permissable, and Mercury's volatiles could have bee delivered to the planet afterward, for example by comet impacts.

Alice Young [ESAC]

From the center of the Milky Way to the most distant objects in the Universe

This talk will discuss the work I have been doing during the course of my Young Graduate Traineeship; both the continuation of the research from my MSc thesis and the development of data analysis tools for spectroscopic observations with the NIRSpec instrument aboard JWST. I will describe how the research I have completed detecting accelerations in stars surrounding Sgr A* using data from ESO instruments NACO and SINFONI led increasing in the number of known orbits within the Galactic Center by approximately 40%. Further, I will detail the development of a master background spectrum from NIRSpec MOS observations and how this subtraction method can be used to enhance multiplexing capabilities for observations utilizing the multi-shutter array. Altogether, I hope to demonstrate how exploring the technical abilities of Webb, combined with my experience studying the supermassive black hole at the center of the Milky Way have influenced my current interest in the co-evolution of SMBHs with their host galaxies. This will be explored in the context of Webb's capabilities within the field as well as providing insight into how a YGT project can shape the early research career of a young scientist.

This talk will replicate the journey of a young astronomer from the center of the Milky Way to the outer reaches of the observable universe through data analysis. Results from working with both ground-based observatories *studying the Galactic Center and the newly launched James Webb Space Telescope will culminate in a discussion of the future science that can be accomplished using JWST to explore how the black holes at the center of galaxies, near and far, influence their environment.*

Sascha Zeegers [ESTEC]; I. Abril Cabezas, C. Chen, Y. Chu, E. Costantini, I. Psaradaki, D. Rogantini, H. Shang and the WISCI JWST dust team

Exploring the properties of interstellar dust in the Galaxy using infrared and X-ray spectroscopy

Cosmic dust can be found everywhere in the universe. It plays a crucial role in the life cycle of stars and chemistry of galaxies. Dust grains cycle through different phases and environments of the interstellar medium (ISM). Although well studied, it is not clear how dust survives in the harsh environment of the Galactic diffuse ISM. By studying the dust properties, such as the chemical composition, lattice structure, and dust grain sizes, we can learn more about the evolution of these grains in the diffuse ISM. In this talk, I will show how spectroscopy provides us the tools to study the properties of the dust. Intervening dust grains absorb and scatter starlight. The wavelength dependence of this extinction is governed by the grain properties and cause distinctive spectral features in the infrared and X-ray band. In the infrared JWST will provide unprecedented details of infrared dust features. The X-ray band provides an independent method of analysis. Here we study the X-ray absorption fine structures in the X-ray spectra. We observe sightlines toward X-ray binaries using the current XMM and Chandra observatories and the future XRISM and Athena observatories.

Cosmic dust can be found everywhere in the universe. It plays an important role in the life cycle of stars and forms the building blocks for planets. These grains, produced by stars, are blown into in the interstellar medium and eventually end up in planetary systems. Although the dust is well studied, it is not clear how it survives in the harsh environment of the Galactic interstellar medium. By studying properties of the dust particles, such as the chemical composition, crystallinity and grain sizes, we can learn more about the evolution of these grains in the diffuse ISM.

Poster Presentations

Listed alphabetically by 1st author last name

Abstract: standard expert and *planetarium-audience*

[Poster #1] Deborah Baines [ESAC]; B. Merín, G. De Marchi, M. López Caniego, H. Norman, M. Wångblad, P. Matsson, J. Espinosa, E. Puga

ESASky: Data Glorious Data!

ESASky is a science-driven discovery portal providing full access to the entire sky as observed by space-based and ground-based astronomy missions and observatories. Since its concept, access to science ready from as many missions as possible has been a top priority from the scientific community. With this aim, the ESDC ESASky team has been collaborating with and adding more and more missions and data centres such that ESASky today provides access to science ready data from more than 75 space-based and ground-based missions and observatories. Most recently added include: JWST and CHEOPS public observations; the latest Gaia, XMM-Newton and LAMOST catalogues; gravitational wave (GW) and neutrino multi-messenger events from the LIGO-Virgo-KAGRA collaboration and the IceCube Neutrino Observatory respectively; access to all of the 900+ background skies (HiPS: Hierarchical Progressive Survey) in the International Virtual Observatory Alliance (IVOA) HiPS registry; and access to metadata and data from the following major astronomical data centres: the European Southern Observatory (ESO), the Canadian Astronomy Data Centre (CADC), the Mikulski Archive for Space Telescopes (MAST), the Netherlands Institute for Radio Astronomy (ASTRON) and the High Energy Astrophysics Science Archive Research Center (HEASARC). And it doesn't stop there, in the next six months the team plan to provide access to eROSITA observations; all VizieR catalogues; the NASA/IPAC Infrared Science Archive (IRSA); all TAPs (Table Access Protocol) in the IVOA registry; and real-time access to multi-messenger events from GRBs and from the next LIGO-Virgo-KAGRA observing run (O4: which may detect as many as one GW event per day)! With the increase of data access comes the increase of users, and averaging at more than 6000 users per month this year, ESASky is steadily becoming a reference tool for the scientific community.

As of today, ESASky provides access to science ready data from more than 75 space-based and ground-based missions and observatories, and we're not stopping there! This poster will show what data is already accessible and what is about to become available.

[Poster #2] Mark Bentley [ESAC]; M. Kim, T. Mannel, R. Moissl

Primitiveness of cometary dust collected by MIDAS on-board Rosetta

The MIDAS atomic force microscope flew onboard the Rosetta orbiter and collected and studied dust from comet 67P. In this work an attempt was made to characterise the dust in different ways to determine if a metric related to particle pristinity could be found. The particle catalogue provided in the archive was first re-analysed and updated and was used to produce enhanced dust coverage maps for each exposed target. A clustering algorithm was applied to try to identify particles deposited individually, as opposed to those fragments of larger impacting dust grains.

Next, a number of shape descriptors were studied and the results of their application to the MIDAS data compared with previous laboratory and instrument data to evaluate if they were useful indicators of pristinity. The most promising combination of metrics was used to rank the particles and identify the most pristine MIDAS particles, which are relatively un-flattened, un-fragmented particles in the few micrometres to sub-micrometre size range.

Comets contain some of the most pristine material in our Solar System, but even the material collected by Rosetta at low speed was inevitably altered. This study re-analysed the data from the MIDAS atomic force microscope to see if it was possible to identify which particles were most pristine and can be used for future analysis.

[Poster #3] Eleni Bohacek [ESTEC]; A.M. Barrett, M.R. Balme, E.A. Favaro, E. Sefton-Nash

Transverse Aeolian Ridges at the ExoMars Rover landing sites

Introduction

Apart from the Earth, no planetary body is mapped more extensively and to such fine resolution as Mars. The increasing volume of remote sensing data means we are better equipped than ever to answer the fundamental questions about the history of the planet. However, the volume of data grows much faster than the number of scientists who can use it. Machine Learning (ML) is a powerful tool for automating the analysis of ever-increasing volumes of remote sensing data. Aeolian bedforms exhibit varied morphologies at different scales in remote sensing imagery, therefore, automated detection is a complicated problem. Linear dune fields have been successfully characterized at regional scales using edge detection on Titan from synthetic aperture radar images [1]. Within the field of Earth observation, an edge detection algorithm has been proposed that is optimized for recognizing linear dune fields in panchromatic Landsat 8 data and digital elevation models [2]. Fingerprint minutiae extraction software designed for forensic applications has also successfully detected dune crests and their bifurcations and terminations for linear dunes in the Namib Sand Sea and Strzelecki Desert, and for Transverse Aeolian Ridges (TARs) on Mars [3]. A method for mapping aeolian ripples has been demonstrated using HiRISE imagery from Gale crater [4]. Similarly to earlier studies, this uses a two-step algorithm that segments the bedforms from the surrounding terrain and then detects the crestlines [5]. This study uses the same approach but with a segmentation step that classifies bedforms according to scale and morphology as opposed to foreground-background. The aim of this study is to create a more general bedform detector that can be applied over larger and more texturally diverse areas of Mars. Moreover, it should perform as well as classic methods employed by geologists such as manually mapping crestlines. This will be assessed in terms of orientations and crest line maps produced but also in terms of the inferred wind regime. The secondary goal of this study is to demonstrate how ML terrain classifications designed for rover navigation can be repurposed for science.

Method

A machine learning system called the Novelty or Anomaly Hunter – HiRISE (NOAH-H) has been developed to classify terrain in HiRISE images from Oxia Planum and Mawrth Vallis according to texture. It was designed to assess terrain for rover traversability but also demonstrates great potential to be used for science [6]. Each pixel of an input HiRISE image is assigned one of 14 classes. These classes represent every type of terrain that can be found at the Oxia Planum and Mawrth Vallis landing sites, summarized in Table 1. Classes 8 through to 13 are the six types of ripple morphology that are recognized by NOAH-H.

Table 1: Ontological classes used by NOAH-H. Large refers to decimeter scale features and small refers to meter scale features.

1	Non-bedrock	Smooth, Featureless
2		Smooth, Lineated
3		Textured
4	Bedrock	Smooth
5		Textured
6		Rugged
7		Fractured
8	Large Ripples	Simple form, Continuous
9		Simple form, Isolated
10		Rectilinear form
11	Small Ripples	Continuous
12		Non-continuous, Bedrock substrate
13		Non-continuous, Non-bedrock substrate
14	Other Cover	Boulder fields

Class 9, 'large simple form isolated ripples', corresponds to the larger-scale TARs in these regions and we use the NOAH-H output to segment the TARs from the surrounding terrain. Some of these classified regions contain more than one TAR, therefore the next step splits these into separate regions. Now that we can assume that every region corresponds to a single TAR, we calculate an orientation for each region using second order central image moments.

Planned Analysis

This method will be applied to HiRISE images already classified by NOAH-H in Oxia Planum. We will compare the spatial distribution and orientation of TARs using the proposed method with those measured from a study that measured 10,753 TARs by manually digitizing crestlines [8]. They will also be compared in terms of inferred wind regime and compared with a global climate model to see if they give the same conclusions. The next step to build on this work is to implement existing or new methods for the remaining 5 bedform classes detectable by NOAH-H, in order to make a more general bedform characterization method.

References: [1] Lucas A. et al. (2014) JGR, 41, 6093–6100. [2] Telfer M.W. et al. (2015) Aeolian Research, 19, 215–224. [3] Scuderi L. (2019) Aeolian Research, 39, 1–12. [4] Vaz D.A. and Silvestro S. (2014) Icarus, 230, 151–161. [5] Pina P. et al. (2004) LPS XXXV, Abstract #1621. [6] Barrett A.M. et al. (2022) Icarus, 371, 114701. [7] Canny J. (1986) IEEE TPAMI, PAMI-8, 6, 679–698. [8] Favaro E.A. et al. (2021) JGR Planets, 126, e2020JE006723.

Sand organises itself into ripples when the wind blows fast enough.

[Poster #4] Lisanne Braat [ESTEC]

Isolating effects of gravity on fluvial geomorphology

Fluvial landforms on Mars are important for resolving paleo-environments, as their morphology and sedimentary record are testimony to past activity of liquid water. Fluvial geomorphology on Mars has the potential to provide information about historic environmental and climate conditions and the potential for past life. For much geomorphic research we make use of terrestrial studies and Earth analogues. However, to confidently apply this knowledge, it is important to understand differences between Earth and Mars, especially in sediment transport. In this study, we investigate the effects of gravity on fluvial sediment transport with parameterized equations. Sediment transport fluxes can differ significantly on Mars, leading to potential errors in estimating the duration of fluvial activity. In addition, the gravity effect on suspended sediment differs from the effect on bedload transport, with implications for sediment sorting. These differences in sediment fluxes likely have affected delta geomorphology and stratigraphy on Mars and should be considered when interpreting in situ observations. Preliminary morphodynamics modeling of deltas in 2D suggests that this change in sediment transport fluxes results in faster growing deltas with lower slopes, bigger depositional lobes and wider channels.

I investigate how gravity affects the movement of sediment by liquid water and how this in turn influences the landscape. With modeling I compare transport on Earth and Mars. By better understanding the differences between the planets, we can more confidently apply our knowledge from Earth to Mars and make use of Earth analogues. I discovered that sediment transport rates are higher for the same water discharge on Mars. Smaller sediment sizes (clay/silt) are affected more by gravity than larger grain sizes (gravel/boulders), which creates differences in sediment sorting. This in turn creates differences between landforms on Earth and Mars.

[Poster #5] Marc Costa [ESAC]; Estela Fernández-Valenzuela, José Luis Ortiz, Nicolás Morales, Pablo Santos-Sanz, Mónica Vara-Lubiano

Long-term photometric analysis of the trans-Neptunian object 2008 OG19

We have carried out a long term photometric analysis of time series images of the trans-Neptunian object (TNO) 2008 OG19 with which we have refined its physical properties from its long-term variability.

<u>Photometric Analysis</u>

The first detailed analysis of 2008 OG19 was carried out by [1] using rotational light-curves from 2014 and 2016 from which a volume-equivalent diameter, a rotation period (P), a triaxial ellipsoidal shape model, and a density were estimated.

We have used 1,314 images covering a time-span of six years (2014–2021), obtained with the Sierra Nevada 1.5-m telescope and the Calar Alto 1.2-m telescope, both in Spain, in order to build yearly rotational light-curves for 2008 OG19. To refine the rotation period estimation of 2008 OG19, we have combined the whole set of data and applied the Lomb periodogram [2] and the Phase Dispersion Minimization techniques [3] resulting in $P = 8.72565 \pm 0.0008$ hr.

<u>Long-term variability</u>

By folding the light-curves with the refined period, we have been able to see an increase of the amplitude of the rotational light-curve. This increase is due to a change in the aspect angle, that allows to estimate the orientation of 2008 OG19 rotational axis. Using the largest rotational light-curve amplitude and assuming hydrostatic equilibrium we have updated its triaxial ellipsoid model and its density.

Searching for a close-in satellite
We have analyzed the data in order to determine whether if 2008 OG19 has a close-in satellite or not.

We have carried out a long term photometric analysis of time series images of the trans-Neptunian object (TNO) 2008 OG19 with which we have refined its physical properties from its long-term variability.

[Poster #6] Patricia Cruz [ESAC]; Micah Navia, Luan Ghezzi

Relationship between the atmospheric properties of hot Jupiters and chromospheric activity of host stars

To better understand the properties of exoplanets, it is necessary to comprehend how their atmospheres are affected by their host stars. In this scenario, we set out to analyze how the stellar activity may affect the thermal profile of Hot Jupiters' atmospheres. Thereby, we performed a search in the literature and we selected a number of Hot Jupiters that have secondary eclipses observed in the infrared bands, because in this region of the spectrum, the thermal emission of the planet is greater (in comparison with shorter wavelengths). Therefore, it's easier to derive the brightness temperature by using the secondary eclipse data, which can be obtained with observations from the ground. With a sample of measured brightness temperatures at 2MASS Ks band, and at Spitzer's $3.6\,\mu$m and $4.5\,\mu$m bands, we observed a linear correlation between the chromospheric activity of planet-host stars and the brightness temperature. To classify the Hot Jupiters in our sample with respect to the presence or absence of thermal inversions and the activity of host stars, we adopted two empirical indices. However, we did not find yet a clear relationship between the presence of a thermal inversion in the atmospheric temperature-pressure profile and the activity index of their host stars. We are currently working to improve these analyses and to confirm our results. As future steps, we intend to extend the analysis to different photometric bands available in the literature, ranging from 2MASS's J band to Spitzer's $8\,\mu$m band. Studying Hot Jupiters atmospheres may help to understand the effects of stellar activity and star-planet interactions, a subject that is of great importance for future space missions like ESA's Ariel.

Does stellar activity affect planetary atmospheres? In this work, we explored if more active stars have a greater impact on the atmospheres of close orbiting exoplanets than less active stars, based on infrared photometric data.

[Poster #7] Chris Evans [Baltimore]; Marcolino, Bouret, Garcia

A ground-UV reconnaissance of metal-poor massive stars

We use synthetic model spectra to investigate the potential of near-ultraviolet (3000-4050A) observations of massive O-type stars. We highlight the He I 3188 and He II 3203 pair as a potential temperature diagnostic in this range, supported by estimates of gravity using the high Balmer series lines. The near-ultraviolet also contains important metallic lines for determinations of chemical abundances (oxygen in particular) and estimates of projected rotational velocities for O-type spectra. Using the model spectra we present performance estimates for observations of extragalactic massive stars with the Cassegrain U-Band Efficient Spectrograph (CUBES) now in construction for the Very Large Telescope. The high efficiency of CUBES will open-up exciting new possibilities in the study of massive stars in external galaxies.

A new spectrograph is under construction for the Very Large Telescope in Chile that will give a tenfold gain in sensitivity compared to existing facilities. One of the exciting fields that this will enable is observations of massive, hot stars in galaxies at distances of several million light years. From these new observations we will learn about the physical properties and compositions of these massive stars, gaining insights into the properties of their host galaxies, and similar young galaxies in the early Universe.

[Poster #8] Zoe Faes [ESAC]; Andrew Walsh (ESAC) and Daniel Müller (ESTEC)

Exploring conjunctions of virtual spacecraft with simulated data for heliophysics in Python

We present a Python library with a suite of methods to identify conjunctions between spacecraft observing the Sun and extract time-series from 3D magneto-hydrodynamic heliosphere simulations for analysis. The class-based library can identify conjunctions from SPICE kernels for individual spacecraft by computing the Vincenty angle between these spacecraft, as well as using the Parker model of the heliospheric magnetic field to find events when spacecraft are estimated to sample the same volume of plasma at different times and distances from the Sun. This library can also create plots for each conjunction in 2D or 3D, as well as animations of the spacecraft orbiting and conjunctions occurring for easy reference. CDF and FITS files are supported, but the methods have been designed to handle output from ENLIL simulations. Time-series extracted from ENLIL simulations for each spacecraft can be stored and plotted, and slices of simulation data can be overlayed with 2D conjunction plots for context. This library currently supports the following spacecraft: Solar Orbiter, Parker Solar Probe, STEREO-A, and BepiColombo, as well as Earth. The ESA GitLab project for this library can be found at `https://gitlab.esa.int/Zoe.Faes/solar-orbiter-alignment-ygt`.

We present a Python library with a suite of methods to identify conjunctions - favorable relative positions of spacecraft - between spacecraft observing the Sun, and extract time series from heliosphere simulations for analysis. This library can identify conjunctions based on the separation angle between spacecraft, create plots for each conjunction in 2D or 3D, as well as create animations of the spacecraft orbiting and conjunctions occurring for easy reference. The library can also read CDF and FITS files, but is designed to handle output from a specific heliosphere simulation (ENLIL). It can store and plot time-series extracted from ENLIL simulations for each spacecraft. The simulation data can also be overlayed with 2D conjunction plots for context. This library currently supports the following spacecraft: Solar Orbiter, Parker Solar Probe, STEREO-A, and BepiColombo, as well as Earth. The ESA GitLab project for this library can be found at `https://gitlab.esa.int/Zoe.Faes/solar-orbiter-alignment-ygt`.

[Poster #9] Giovanna Giardino [ESTEC]; P. Ferruit, T. Rawle and the JADES collaboration

The dawn of galaxies – the deepest Webb observations are coming ...

The Webb telescope NIRCam-NIRSpec galaxy assembly GTO program – JADES – is an ambitious imaging and spectroscopic deep-field survey to study the formation and evolution of galaxies from $z \geq 12$ to $z \sim 2$. Complemented by MIRI, alongside the deepest data from HST, Chandra, ALMA, and JVLA, it aims to produce an unprecedented view of high-redshift galaxies and the early stages of their development. Some of the observations have just been executed, with more coming at the beginning of 2023. What shall we expect?

The JADES program includes among the most sensitive observations to be executed with the Webb Space Telescope and will observe the furthest objects in the universe. This will help scientist to address fundamental questions about the formation and evolution of galaxies.

[Poster #10] Matteo Guainazzi [ESTEC]; Brigitte Pruijt

In the life of black holes, size does not matter (almost)

Astrophysical black holes exist in different flavors. They can be isolated, or hosted in binary or multiple system; they cover a range of masses from ∼10 to about a billion times the mass of the Sun; and shine an energy output comparable or larger than that of their host galaxy, if they efficiently accrete matter from a star or from the surrounding material. Despite this immense variety, are there underlying common physical processes regulating the accretion and ejection of matter (disks, outflow, winds, jets)? What do they tell us about the cosmological evolution of the most massive specimen at the core of galaxies (including our own)? In this poster, I will present the results of a project aiming at addressing these questions using multi-wavelength photometric and spectroscopic data extracted from the XMM-Newton archive. The punch line answer is: yes, but ...

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[Poster #11] Maximilian Guenther [ESTEC]; Tansu Daylan

Studying exoplanet orbits & dynamics with ALLESFITTER

The orbits and dynamics of exoplanet systems can unveil their tales of formation, migration, star-planet interactions, and atmospheric properties. Kepler, TESS, and soon PLATO deliver an unprecedented wealth of new photometric data on this matter, while ground-based follow-up and radial velocity instruments add valuable insights. Here, I will present how we can unite and untangle all this data on exoplanets' orbits and dynamics using ALLESFITTER. This open-source python software enables flexible and robust inference of stars and exoplanets from photometric and radial velocity data. ALLESFITTER offers a rich selection of orbital and transit/eclipse models, accommodating multiple exoplanets, multi-star systems, transit-timing variations, and phase curves. It can also help mitigate and/or study stellar variability, starspots, and stellar flares. I will highlight some of ALLESFITTER's science output on examples of exoplanet dynamics (e.g., TOI-270 and TOI-216) and orbital phase curves (e.g., WASP-18 and WASP-121). With TESS' extended mission, CHEOPS in full swing, and PLATO on the horizon, a wealth of new data face us, allowing TTV and phase curve studies of dozens of such systems over many years.

The orbits and dynamics of exoplanet systems can unveil their tales of formation, migration, star-planet interactions, and atmospheric properties. All-sky satellite missions and ground-based telescopes deliver an unprecedented wealth of new data on this matter. Here, I will present how we can unite and untangle all this data on exoplanets' orbits and dynamics using ALLESFITTER*, an open-source software.* ALLESFITTER *enables analysing multiple exoplanets, multi-star systems, dynamic interactions, and phase curves. It can also help mitigate and/or study stellar variability, starspots, and stellar flares. I will highlight some of* ALLESFITTER*'s science output on examples of exoplanet dynamics and atmosphere studies. With TESS, CHEOPS, and PLATO on the horizon, a wealth of new data face us, allowing detailed studies of dozens of such systems over many years.*

[Poster #12] Laura Hayes [ESTEC]; On behalf of the SunPy community

The SunPy Project: A Python Package for Solar Physics

The SunPy project facilitates and promotes the use and development of a community-led, free and open-source solar data-analysis software based on the scientific Python environment. Consisting of both the sunpy core library and an affiliated package ecosystem, the SunPy Project provides critical science enabling functionality such as data search and download, data structures for remote sensing and in-situ observations, solar-specific coordinate systems, and a variety of image processing techniques. As such, a wide variety of science analysis workflows and instrument data pipelines depend on the SunPy ecosystem. Here, an overview of the functionality within the SunPy project will be outlined, together with a prospective for the future and a demonstration how SunPy can facilitate coordinated science with Solar Orbiter!

SunPy and its affiliated packages provides an ecosystem of python software to preform solar physics analysis. In the era of a multitude of solar physics missions, with space based (e.g., SDO, Solar Orbiter, PSP), and ground-based (e.g., DKIST, EOVSA, SST) observatories, SunPy provides the functionality to create a workflow to analyse coordinated observations, including data search, retrieval, containing data, and coordinate transformations among others. Here, an overview of the SunPy project will be given.

[Poster #13] Detlef Koschny [ESTEC]; Moissl, R, Zender, J., Sefton-Nash, E., Witasse, O., Svedhem, H.

The lunar impact 'Flash Detection Software' - a faculty-funded project

Meteoroids and asteroids hitting the Moon will generate an impact flash, which can be observed on the unilluminated part of the Moon (the dark side). Observing these flashes allows to constrain the flux density of objects in the size range of decimeters to meters, which is poorly known. If the corresponding impact crater is found, it will provide a valuable contribution to understanding cratering processes.
These impact flashes have been observed in a previously SCI-funded project called NELIOTA. With a 1.2 m telescope at the Greek observatory Kryoneri, the dark side of the Moon is being observed whenever possible. Since Aug 2021, the Planetary Defence Office (OPS-PD) is funding this project.
The project has started in 2015. Since then, it has observed the Moon for a bit over 200 hours, recording 150 impact flashes. For the given time period, the observing time is not very much, due to geometrical and

straylight constraints. To expand the observational coverage, amateur astronomers could be involved - also smaller telescopes will see these flashes. What has been missing so far is an easy-to-use, modern impact flash detection software. At the beginning of 2022, ESA's Science Faculty agreed to fund a project to develop an Open Source software for this. A contract was awarded to the Greek team operating NELIOTA. At the end of the contract, the tool and its source code will be made publicly available.
The software, called Flash Detection Software (FDS), has already been distributed in a beta version at the '3rd International EuroPlanet Fireball Workshop' in Aug 2022. At the time of writing this abstract, the software is undergoing testing. To support these tests, an impact flash simulation tool has been developed via a Master student at the University of Oldenburg.
At the time of the SSW, the contract should have ended. We will report about the testing with the simulator, but hopefully also with real telescope setups. We will also report about our experiences following this contract for an Open Source tool.

Why is the observation of lunar impact flashes important? And what is the status of the Faculty-funded project for a lunar impact flash detection software?

[Poster #14] Detlef Koschny [ESTEC]; Zender, J., Witasse, O., Svedhem, H, Toni, A., Smit, H, Visser, I., Van der Luijt, C.

10 years CILBO - A Faculty-funded project to observe meteors from the Canary islands

Dust coming from comets and asteroids will generate a meteor when it enters the Earth's atmosphere. Observing these meteors is a 'poor man's comet mission'. We have used Faculty funding to build up and operate a ground-based double-station meteor camera system operating from the Canary Islands in 2011/2012. The lifetime for the stations have come to an end, they are being removed from the islands while this abstract is written.
Observing meteors from two stations simultaneously allows to compute their trajectories in the atmosphere. Via backward propagation this allows to determine their orbit in the solar system. We have operated on camera with an objective grating, which produced spectra of at least the brightest meteors. The main science results were: The determination of the flux density of meteoroids as a function of size; their directional and velocity distribution; and we could constrain the elemental composition for the brightest of these objects.
In this poster, we will summarize the scientific achievements of this project.

ESA's Meteor Research Group has operated a double-station meteor camera system on the Canary Islands for the last 10 years. The system is currently being shut down. This poster will show which scientific results were obtained with this Faculty-funded project.

[Poster #15] Peter Kretschmar [ESAC]; Luis Abalo Rodríguez (1st author), Felix Fürst, Victoria Grinberg, Matteo Guainazzi

MAXI Analyzer: a command-line software for extracting information in long-term monitoring studies

The Monitor of All-sky X-ray Image (MAXI) experiment is mounted to the Japanese Experiment Module on the International Space Station and uses several wide field of view X-ray detectors to monitor astronomical X-ray sources for variability, scanning the sky every 92-minute ISS orbit. We have used data in the 2–20 keV energy band from the Gas Slit Camera to conduct a long-term study of absorption variability. In our project, we focus on the well-known High-Mass X-ray Binary system Vela X-1, aiming to complement detailed observations with X-ray telescopes like XMM-Newton or in the future Athena. In the course of our work, we were faced with a set of data processing tasks that slowed down the progress of the research and we decided to work on the automation of the data processing. Here we present MAXI Analyzer, a command-line software for data analysis and extracting information on the time scale of individual binary orbits. We illustrate MAXI Analyzer taking as an example our study source (Vela X-1) as well as with other X-ray sources to show the possibilities of this new software.

We present helpful software to combine data from MAXI, an X-ray monitor instrument for the study of absorbing structures and example results for Vela X-1, a well-studied X-ray binary source.

[Poster #16] Peter Kretschmar [ESAC]; Felix Fürst, Victoria Grinberg, Isabel Caballero, Ekaterina Sokolova-Lapa, Carlo Ferrigno, Jörn Wilms

Disentangling Pulse Profiles

We present the ongoing work and plans up to March 2023 for the approved Science Exchange Programme 'Disentangling Pulse Profiles', which connects researchers in the Faculty at ESAC and ESTEC with experts in academia on the analysis of the pulsed emission of accreting X-ray pulsars. The project includes describing the current observational knowledge and state of the art in modeling as well as the discussion of fruitful avenues for further research.

We want to better understand the physics of X-ray emission in the columns or hotspots of magnetic poles of accreting neutron stars, combining systematically observational information with the latest efforts in modeling this emission.

[Poster #17] Alvaro Labiano [ESAC]; J. Álvarez-Márquez, A. Labiano, P. Guillard, D. Dicken, I. Argyriou, P. Patapis, D.R. Law, P.J. Kavanagh, K.L. Larson, D. Gasman, M. Mueller, S. Alberts, B.R. Brandl, L. Colina, M. García-Marín, O.C. Jones, A. Noriega-Crespo, I. Shivaei, T. Temim, G.S. Wright

The Seyfert galaxy NGC 6552 as seen with the JWST Mid-infrared Instrument

During the commissioning of the James Webb Space Telescope (JWST), the Mid-Infrared Instrument (MIRI) observed NGC 6552 with the MIRI Imager and the Medium-Resolution Spectrograph (MRS). NGC 6552 is an active galactic nucleus (AGN) at 120 Mpc, classified as a Seyfert 2 nucleus in the optical, and Compton-thick AGN in X-rays. We obtained the nuclear, circumnuclear, and central mid-IR spectra of NGC 6552. They provide the first clear observational evidence for a nuclear outflow in NGC 6552. The outflow contributes to 68% of the total emission line flux, showing an average blue-shifted peak velocity of -126 ± 44 km/s and an outflow maximal velocity of 689 ± 37 km/s. Nine pure rotational molecular Hydrogen lines are detected and spectrally resolved, and exhibit symmetric Gaussian profiles, consistent with the galactic rotation, and with no evidence of outflowing molecular Hydrogen. We detect a warm Hydrogen mass of 1.7×10^7 M_{Sun} in the central region (1.8 kpc in diameter) of the galaxy, with almost 20% of that mass in the circumnuclear region. Line ratios confirm that NGC 6552 has a Seyfert nucleus with a black hole mass estimated in the range of 0.8 to 8 million Solar masses. Even though these observations were not optimized for scientific studies, this work demonstrates the performance and power of the MIRI instrument to study the physical conditions and kinematics of the interstellar medium around the dusty nuclear regions of nearby active galaxies.

During the commissioning of the James Webb Space Telescope (JWST), the Mid-Infrared Instrument (MIRI) observed the active galaxy NGC 6552. These observations provide the first clear observational evidence for a nuclear ionised gas outflow in this galaxy. We also measure the properties of the warm molecular gas, and estimate the mass of the central black hole in the range of 0.8 to 8 million Solar masses. Even though these observations were not optimized for scientific studies, this work demonstrates the power of the JWST MIRI instrument to study the physical conditions and properties of the interstellar medium of nearby active galaxies.

[Poster #18] Marcos López-Caniego [ESAC]; X. Dupac, J. Gallegos, F. Mart ın-Porqueras, M. Salas-Natera

CUBIQU: a CubeSat for calibration of Cosmic Microwave Background polarization ground-based telescopes

Nowadays, the focus from the new generation of Cosmic Microwave Background (CMB) experiments is on the polarization of the CMB, and have been designed to detect or set limits to the so-called primordial B-modes, the imprint on the CMB polarization from gravitational waves produced in the very early Universe. Experiments measuring the polarization of the CMB typically calibrate their observations with well known astrophysical sources. These experiments need better calibrations in polarization and the usual approaches have limitations. At ESAC, the CUBIQU Collaboration, in collaboration with the Telecommunications Engineering School of the Technical University of Madrid (ETSIT-UPM), is developing a prototype CMB polarization calibration cubesat based on patch antennas that would emit well characterized linearly polarized signals to be used by ground experiments to calibrate their instruments. At the moment the study is focused on designing and manufacturing the antennas and building a prototype at the frequencies of the QUIJOTE experiment that can be tested flying a drone above its telescopes in the Canary Islands. Here we present the status of the project.

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[Poster #19] Daniel Mueller [ESTEC]; B. Nicula, A. Rouillard, V. Reville, F. Verstringe, B. Bourgoignie, B. Fleck, A. De Groof, A. Walsh, D. Williams, C. Watson, Y. Zouganelis, L. Sanchez

Solar Orbiter science target planning with JHelioviewer and the Magnetic Connectivity Tool

The Solar Orbiter mission focuses on exploring the linkage between the Sun and the heliosphere. To achieve this, coordinated observations of the mission's six remote-sensing and four in-situ instruments are carried out during three dedicated 10-day periods per orbit. Choosing the targets of individual observing campaigns in these periods is under the responsibility of the scientific coordinator of the respective Solar Orbiter Operations Plan, typically external to ESA, and requires assimilating recent image data from several space missions orbiting the Sun, as well as models of the Sun's large-scale magnetic field to forecast which areas on the Sun's surface are most likely magnetically connected to the spacecraft (Magnetic Connectivity Tool, `http://connect-tool.irap.omp.eu/new-home`). In this contribution, I will present how the ESA JHelioviewer software (`https://doi.org/10.1051/0004-6361/201730893`, developed with SCI-S research funds), has been augmented to enable this, and how science-driven target selection was successfully achieved using this new functionality.

This poster describes software tools developed and used for Solar Orbiter science target planning.

[Poster #20] Ines Torres [ESTEC]Elliot Sefton-Nash, Jorge Vago, Csilla Orgel, Rickbir Bahia, Eleni Bohacek

Quantifying Biosignature Potentials for future targets of the ExoMars rover mission

The ExoMars rover mission, whose primary objective is the search for signs of past and present life on Mars, is an astrobiology focused mission with a suite of nine instruments (Pasteur payload) and a two-metre drill. The rover will land in Oxia Planum, a location chosen for its high potential for biosignature preservation: ancient, clay-rich outcrops of Oxia Planum may have formed in aqueous conditions that could have hosted micro-organisms and the fine-grained sediments could have preserved evidence of their existence. Three tools were designed to evaluate the science potential of targets that Rosalind Franklin will encounter once it lands on Mars. These metrics will be used during operations to aid decision-making for science targets and maximize their scientific value. - The ExoMars Biosignature Score (EBS): The EBS is based on two broad classes of biosignatures that the Pasteur payload is able to detect: morphological and biochemical. Chemical biosignature scores will be modulated with a quality factor, depending on the outcome of a first blank chemical check – prior to any sample analysis. Chemical scores are currently being refined in order to take into account other criteria such as molecular complexity, for example. The geological context will also add up to the final EBS score, as Rosalind Franklin will be capable of exploring the landing site and establishing the geological environment at the time of deposition and its evolution. - The Past and Present habitability and Preservation site assessment (PPP): The PPP metric quantifies the extent to which a site could have supported and preserved signs of life based on evidence from initial observations of the site. Criteria are based on the chemical and physical needs for life, as well as the preservation potential of biosignatures (some records of habitability may not be preserved or detectable anymore). - The Target Science Potential (TSP): The TSP metric evaluates a target in terms of the hypotheses that are deemed to be addressable by observation or analysis of that target. A table of hypothesis is being defined by the Rosalind Franklin Science Working Group (RSOWG) in the Strategic Science Plan of the mission. This document gathers a list of questions that we would like to answer and a table of testable hypothesis that we will try to assess during the mission operations. The TSP tool will help identify which targets could yield the highest science return in order to optimise planning decisions.

The ExoMars rover mission, whose primary objective is the search for signs of past and present life on Mars, is an astrobiology focused mission with a suite of nine instruments and a two-metre drill. The rover will land in Oxia Planum, a location chosen for its high potential for biosignature preservation: ancient, clay-rich outcrops of Oxia Planum may have formed in aqueous conditions that could have hosted micro-organisms and the fine-grained sediments could have preserved evidence of their existence. I will present three tools developed to quantify the science potential of targets that Rosalind Franklin will encounter once it lands on Mars. These three metrics *will be used during operations in order to optimise planning decisions and identify which targets could yield the highest science return.*

[Poster #21] Alice Young [ESAC]

This poster will present the primary results of my Young Graduate Traineeship project developing data analysis tools for the NIRSpec instrument aboard the James Webb Space Telescope. In particular, I detail the methods used to define a 2D master background spectrum which can be used to increase the multiplexing abilities of Multi-Object Spectroscopy with JWST. Further, it will discuss the implementation of this master background subtraction into the new platform: ESA Datalabs, in order to progress towards the mission's goal of creating a digital library of the universe.

How can subtraction allow you to see more with the James Webb Space Telescope? This poster will describe how different background emission subtraction methods can be selected to maximize the scientific return of spectroscopic observations using NIRSpec. It will also describe how data analysis tools for the JWST mission will be available to the scientific community on the new platform: ESA Datalabs, in order to progress towards the mission's goal of creating a digital library of the universe.

[Poster #22] Peter Zeidler [Baltimore]; Elena Sabbi, Antonella Nota

The Spiraling Stars of NGC 346 – A Window into the Early Universe

We present our kinematic study of the young star forming region NGC 346 in the Small Magellanic Cloud, combining VLT/MUSE radial velocities and Hubble multi-epoch proper motions, showing that the outer spiral might be feeding the formation of stars in the central regions in a river-like flow. We discovered multiple stellar velocity groups with a coherent inward spiraling motion of both, the massive upper-main-sequence, and lower-mass-pre main sequence stars. Many of NGC 346's sub-clusters and massive young stellar objects are found at the interface of significant change of the stellar kinematic field, suggesting that turbulence is the main star formation driver, consistent with various proposed cluster formation models. Furthermore, the ionizing gas of the innermost region has lost any natal kinematic imprint but shows clear expansion, driven by the far-ultraviolet fluxes and stellar winds of the numerous O and B stars. This in excellent agreement with the latest star formation episode the occurred about two million years ago. NGC 346 is also part of the Webb GTO programs, which will uncover the full extent of the lower-mass stellar population and most young stellar objects using NIRCam, MIRI, and NIRSpec photometry and spectroscopy. This lower than solar metallicity environment in the SMC is one of our best chances to understand how star and cluster formation happened in the earlier Universe.

We present our kinematic study of the young star forming region NGC 346 in the Small Magellanic Cloud showing that the outer spiral might be feeding the formation of new stars in the central regions in a river-like flow. The SMC and its regions are more similar to the earlier Universe, when heavy elements were less abundant, and less like our own Milky Way. NGC 346 is one of our best chances to understand early star and cluster formation, at an Epoch when our Universe underwent a "baby-boom" forming many new stars. This amazing region is also part of the Webb GTO programs to uncover the full extent of the lower-mass stellar population and newly forming young stellar objects.