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Abstracts

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Contents

Oral Presentations

Listed alphabetically by 1st author last name

Nicolas Altobelli (ESAC) [Co-authors: Nicolas Altobelli]

Could the dinosaurs have observed Saturn's rings ?

Two main schools of thoughts are battling around the question of whether Saturn's rings are as old as the Solar System, if they formed together with Saturn, or were acquired more recently (young ring hypothesis). The Cassini mission acquired various measurements that need to be interpreted in a coherent way to find the correct answer. Radar and optical measurements constrain the amount of non-icy contamination by exogenous material accumulated over time by the rings, the current micrometeoroid infall has been characterised, as well as the total mass of the ring. Ring evolution models have been fed with those new measurements but still no consensus seems to emerge... we will present the latest status of the (sometime) heated discussions around the Age of the Rings.

Catarina Alves de Oliveira (ESAC) [Co-authors: et al.]

James Webb Space Telescope Unveils Faint Brown Dwarfs and an Unexpected Molecular Discovery

I will present the discovery of new brown dwarfs in the star-forming cluster IC 348 using the James Webb Space Telescope. Two of the brown dwarfs show the spectral signature of an unidentified hydrocarbon. The same infrared signature was detected by NASA's Cassini mission in the atmospheres of Saturn and its moon Titan. It has also been seen in the interstellar medium, the gas between stars. This finding, the first detection of this molecule in atmospheres outside of the solar system, challenges current atmospheric models of brown dwarfs and sheds new light on their formation and composition. Based on its luminosity and evolutionary models, the faintest new member of IC 348 has an estimated mass of 3–4 Jupiter masses, making it a strong contender for the least massive free-floating brown dwarf that has been directly imaged to date. Press release: https://www.esa.int/Science_Exploration/Space_Science/Webb/Webb_identifies_tiniest_free-floating_brown_dwarf Published article: https://iopscience.iop.org/article/10.3847/1538-3881/ad00b7

Stephan Birkmann (ESAC) [Co-authors: Stephan Birkmann, NIRSpec GTO Team (1224)]

Characterizing Exoplanets with JWST/NIRSpec

The study and characterization of exoplanets and their atmospheres is one of the most rapidly evolving fields in astronomy and astrophysics in the last decade. Transit, eclipse, and phase curve observations of these celestial bodies provide an avenue for understanding planetary diversity, investigating planetary system evolution, and ultimately advancing the search for extraterrestrial life. In this talk, I will present first results and findings of a JWST/NIRSpec program targeting four exoplanets ranging from hot Jupiters (WASP-52 b) and giant planets (WASP-107 b) down to more temperate super-Earths (L98-59 d) by means of transit and eclipse observations, as well as a full phase curve measurement of a single target (WASP-43 b).

Eleni Bohacek (ESTEC) [Co-authors: Eleni Bohacek, Rickbir Bahia, Lisanne Braat, Sarah Boazman, Elliot Sefton-Nash, Colin Wilson, Lucie Riu, Csilla Orgel]

Insights From Modelling How Aeolian-Fluvial Interactions Shape the Surface of Titan

Fluvial and aeolian surface processes have been observed on Titan. Methane precipitation feeds fluvial landforms (FLs), 50% of which exhibit rectangular drainage patterns (a much rarer pattern on Earth typically due to conjugate faulting). We developed the Titan Aeolian Fluvial Interactions model to simulate interacting fluvial and aeolian processes on Titan. This landscape evolution model is based on a coupled implementation of the Caesar-Lisflood fluvial model, and Discrete ECogeomorphic AeolianLandscape model (DECAL) dunes model. The Caesar-Lisflood fluvial model routes water over a digital elevation model and calculates erosion and deposition from fluvial and slope processes and changes elevations accordingly. The DECAL model is based on the Werner slab model of dunes, which simulates dune field development through self-organization. We show that although Titan dunes are potentially inactive, they are so much larger relative to rivers that dunes represent major topographic obstacles to rivers. Much like on Earth, we found that the nature of dune river interactions are dependent on the relative orientations of dune crestlines and the river channel. In some cases, where the river ran semi-parallel to dune crests, the river could be funnelled upslope along interdune corridors, forming rectangular drainage patterns. In other cases when the relative orientations were not parallel, the river would pool and then breach the lower area of a dune crest and flood deeper into the dune field, delivering sediment in the process. These findings help our understanding of FL drainage patterns, distribution, and planforms, and suggest a mechanism for fluvial sediment delivery into dune fields.

Lisanne Braat (ESTEC) [Co-authors: Muriel Z. M. Brückner, Elliot Sefton-Nash, Michael P. Lamb]

Gravity-driven differences in fluvial sediment transport on Mars and Earth

There is abundant evidence from fluvial landforms and deposits that early Mars had rivers that actively transported sediment and shaped its surface. Preserved ancient landscapes altered by water provide valuable insights into past processes on the planet's surface and the presence of water. To better understand these landforms, we rely on knowledge gained from systems on Earth. However, is it fair to do so when the gravity on Mars is much lower? How does gravity affect sediment transport and the landforms created by water? In this study, we isolate the effect of gravity on sediment transport by water with an analytical river model. We used 32 sediment transport formulas to compare sediment transport rates on Earth and Mars for the same conditions except gravity. The results show that larger grains are picked up by the flow on Mars and the transport rate of sediment travelling in suspension is higher, and therefore total transport as well. Because grains transported near and on the bed are less affected than the grains in suspension, the effect of gravity varies with the way of transport and hence grain size. Therefore, gravity-driven differences in sediment transport by water should produce differences in sediment sorting, morphology and stratigraphy between Earth and Mars.

Alejandro Cardesin-Moinelo (ESAC) [Co-authors: L. Montabone and international science consortium]

Mars Smallsat Mission & Instrumentation Studies for Global Meteorology & Space Weather Monitoring

We present here various scientific studies and efforts by the Martian atmospheric and magnetospheric science community, supporting the study and development of mission concepts with future small satellites and instrumentation that could be flown in orbit around Mars for meteorological and space weather monitoring, in line with the science and exploration priorities of ESA (SciSpaceE White Papers, Report & TerraNovae2030+) and NASA (MEPAG Future Program). Past and present Mars orbiters have provided great information on Mars surface and atmosphere, but focused mostly on targeted high-resolution measurements, lacking continuous global coverage. Mars atmospheric phenomena (clouds and dust storms in particular) and space weather (solar wind, aurorae, radiation, . . .) require global, continuous, and simultaneous observations to fully understand the dynamic variability of Mars climate and environment. Several mission concepts involving satellite constellations have been studied in past years [Cardesin 2023, Montabone 2022&2021, Parfitt 2021]. These include satellite networks in different high-altitude orbit configurations, with great advantages for meteorology, space weather monitoring, and extra communication and navigation capabilities that could pave the way for future human exploration, providing services to other orbiters and surface assets. We summarize here the science case study for a minimal mission concept, based on [Montabone 2021], defining scientific priorities and requirements for a network of 3 low-mass, low-cost small satellites in areostationary orbit (equatorial, circular at 17000km altitude). The small scientific payload would monitor atmospheric and surface parameters, aerosol (dust and ice) clouds, magnetic field and solar wind interactions. The nadir-viewing remote sensing payloads should at least include a visible camera (<5 km resolution), and a thermal infrared multi-band imager (<60 km resolution), potentially enhanced with a UV mapper or a near-IR high-resolution spectrometer. The basic space weather package would consist of a magnetometer, solar wind ion and/or electron detectors, and a space radiation monitor. References Cardesin 2023: Mars SmallSat missions: Spanish Science Consortium. Spanish Planetary Science Congress CPESS7 Montabone 2022: Continuous, Global, Simultaneous Mars Weather from Orbit, 7th MAMO Montabone 2021: A Paradigm Shift in Mars Meteorology, EPSC 2021, 625. Parfitt 2021: Small Mars Mission Architecture Study, Adv. Astron. 2021. NASA: Mars Exploration Program Analysis Group, Future Program, April 2023 ESA: SciSpaceE White Papers & Report, 2023; Strategy Roadmap TerraNovae2030+, 2022

Ashley Chrimes (ESTEC) [Co-authors: P. G. Jonker, A. J. Levan, D. L. Coppejans, N. Gaspari, B. P. Gompertz, P. J. Groot, D. B. Malesani, A Mummery, E. R. Stanway, K. Wiersema]

AT2023fhn (the Finch) and other animals

The extragalactic sky is full of transient phenomena, across the electromagnetic spectrum and beyond. These transients include cataclysmic events such as core-collapse supernovae, tidal disruption events, engine-powered transients (long gamma-ray bursts, super-luminous supernovae) and the detonations or mergers of stellar remnants (supernovae type Ia, short gamma-ray bursts). The advent of wide-field, deep, and high-cadence optical sky surveys has led to the discovery of rapidly evolving transients, which rise and fade on timescales of days. One example are luminous fast blue optical transients (LFBOTs), the prototypical example being AT2018cow ('the Cow'). These events are among the optically brightest transients ever observed, are accompanied by luminous X-ray and radio emission, and evolve too rapidly to be explained by standard supernova models. Since AT2018cow, only a handful more LFBOTs have been discovered, and their origins remain unknown. I present multi-wavelength observations of LFBOT AT2023fhn, 'the Finch'. In stark contrast with other LFBOTs so far, Hubble data reveals that AT2023fhn lies far away from the nearest sites of prominent star formation - challenging a massive star progenitor interpretation. I give an overview of the leading models put forward to explain LFBOTs, and evaluate them in the context of AT2023fhn.

Guillaume Cruz Mermy (ESAC) [Co-authors: F. Schmidt, F. Andrieu, T. Cornet, I. Belgacem]

Unveil the microphysical properties of Europa and Ganymede surfaces

Europa and Ganymede are two moons of Jupiter with strong evidence for the presence of deep reservoirs of liquid water beneath their icy crust. They are also exposed to intense space weathering due to the continuous bombardment of electrons and ions from Jupiter's magnetosphere. Their surfaces therefore appear to be the key witness for understanding endogenous and exogenous processes, and for characterizing the state and evolution of these moons. Using reflectance spectroscopy, the study of the amount of light reflected as a function of wavelength, numerous studies have already revealed a wide variety of chemical compounds associated with water ice, such as sulfates, oxidants and chlorinates, confirming that these moons are prime candidates in the search for habitability in the solar system. However, surface composition alone cannot distinguish between endogenous and exogenous processes. To do so, it is necessary to finely characterize the microphysics of the ice (volume abundance, grain size, surface roughness, porosity). Using accurate radiative transfer modeling and Bayesian inference framework, we aim at retrieving such properties. By combining the data from the Galileo/NIMS instrument at moderate spectral resolution but high spatial resolution with the recent JWST/NIRSpec very high spectral resolution data we want to produce maps of the surface microphysical properties to differentiate between endogenous and exogenous processes.

Emma De Cocker (ESTEC) [Co-authors: Victoria Grinberg]

Democratising Design: A Practical Guide to Creative Problem-Solving for All

Design appears ubiquitously—product design, web design, service design, fashion design—it is a term embraced by all. In your everyday work you may have to design a spacecraft, an interactive tool to allow your team to work together on the spacecraft or the public event where you will present your work on the spacecraft design. To give another example, I am currently working on the (re)design of the sci.esa.int pages.

So what is design? Attempting to pinpoint a definitive definition to such a versatile concept would be inconclusive. What remains open to discussion, however, is the design process. While dependent on team dynamics and available resources, the mindset designers adopt when approaching challenges, and the methodologies and tools they employ to develop solutions tend to align within a general pattern.

In this interactive talk, we will systematically dive into a typical design process illustrated by a simple but realistic use case. Together we will adopt the creative problem-solving mindset of designers. We will explore how gaining empathy involves not only understanding but actively involving all stakeholders in a co-creation journey. We will also demonstrate the delicate balance between applying established methodologies and following one's own intuition and expertise. Finally, the exercise will depict the iterative and flexible nature of the design process, emphasising on the importance of systematic reflection at each stage.

Marjorie Decleir (Baltimore) [Co-authors: Karl Gordon, Julia Roman-Duval, Karl Misselt, Burcu Günay]

MEAD: Measuring Extinction and Abundances of Dust

Interstellar dust has a significant impact on many astronomical research fields, as it absorbs and scatters a large fraction of the star light, and influences star formation and galaxy evolution at all cosmic times. Understanding the properties of the dust grains is thus crucial to derive precise knowledge of any object in the Universe that is obscured by dust, as well as to constrain the initial conditions for star and planet formation.

We can gain insight into the properties of the interstellar dust by studying its extinction effect on the star light. Multi-wavelength continuum extinction contains information about the average dust grain size along the line of sight, while extinction features reveal the composition of the dust grains. In addition, abundances of the elements that make up the dust grains enable us to quantitatively measure the chemical composition of the grains. With the MEAD (Measuring Extinction and Abundances of Dust) project we are combining these two methods to constrain the dust properties in our Galaxy. We obtained ultraviolet spectra with the Hubble Space Telescope to measure dust abundances in a sample of Milky Way sightlines, that span a range of environments. Furthermore, we will combine these abundance measurements with literature UV extinction curves, as well as new near- and mid-infrared extinction curves that we are measuring with our James Webb Space Telescope observations, for the same sightlines.

In this talk, I will explain the goals of MEAD and walk you through the first results. I will also show how the synergy between multi-wavelength data from the HST and JWST, as well as other telescopes is advancing our understanding of interstellar dust properties and how they vary in our Galaxy.

Camille Diez (ESAC) [Co-authors: Victoria Grinberg, Felix Fürst, Ileyk El Mellah, Silvia Martínez-Núñez, Peter Kretschmar]

Exploring neutron stars' devouring nature through stellar wind studies

The spectral and timing behaviour of High-Mass X-ray Binaries (HMXBs) offers a unique opportunity for the investigation of accretion onto compact objects and of wind structure in massive stars. The bright and persistent neutron star HMXB Vela X-1 is one of the key systems for such studies with both current and future instruments. It has a complex clumpy stellar wind, prominent cyclotron resonant scattering features (CRSFs) and strong flares. Understanding the variability of the system on both short time scales of a few hundreds seconds and along its 9d orbit with current instruments enables us to make predictions for future observations with XRISM and Athena and to devise the best observational strategy for Vela X-1. Here, we analyse a new observation taken with XMM-Newton at orbital phase 0.5 and follow the evolution of spectral parameters down to the pulse period (300s) time-scale. The strong variability of absorption is associated with the presence of a large-scale wind structure combined with the variable line of sight as the neutron star moves along the orbit. In particular, we, for the first time, are able to trace the onset of the wakes with high time resolution and compare to predictions from simulations.

Henrik Eklund (ESTEC) [Co-authors: Miho Janvier, Chris Nelson]

Solar Orbiter and ALMA observations of small-scale brightening features in the solar atmosphere

Observations at millimeter wavelengths provide accurate measurements of the plasma temperature of the heavily dynamic chromosphere, and the Atacama Large Millimeter/sub-millimeter Array (ALMA) offers ground-breaking observations in terms of sensitivity and angular resolution. In particular, synergy-observations with the Solar Orbiter are very powerful in order to probe the solar atmosphere. We study so-far very perplexing small scale brightening features at both extreme ultraviolet wavelengths in Solar Orbiter data and at mm-wavelengths in ALMA data, to characterise and determine their formation process. Understanding their formation process increase our understanding of their possible contribution to the heating of the solar corona, the production of solar wind, violent eruptions and flares.

Willi Exner (ESTEC) [Co-authors: Willi Exner, Federico Lavorenti, Beatriz Sanchez-Cano, Daniel Teubenbacher, Mathias Rojo, Daniel Heyner, Léa Griton, Daniel Schmidt, Sae Aizawa, Lina Hadid, Yasuhito Narita, Johannes Benkhoff, Go Murakami]

Was BepiColombo's second swingby the first ever passage through the southern plasma ring?

Although the first three Mercury swingbys of BepiColombo had very similar trajectory configurations, plasma and magnetic field observations of the second swingby revealed a peculiar signature that had never been seen before. Just a few minutes before the outbound passage of the dayside magnetopause, the plasma density and temperature increased and magnetic field decreased. The previous and following swingbys did no show such features. To understand how these localized observations play into the context of the global magnetosphere, we employ the 3D hybrid model AIKEF that models the global magnetosphere and its interaction with the upstream solar wind. We compare our model results for plasma density, temperature and magnetic field with the maltitude of BepiColombo's instruments and find significant agreement. Our 3D results reveal that BepiColombo passed through Mercury's plasma ring in the southern dayside region, just before crossing through the magnetopause. We find that no other spacecraft had ever traversed this particular region, and so BepiColombo's second flyby is going to be an important subject to investigate in order to understand the plasma ring inside Mercury's magnetosphere.

Zoe Faes (ESAC) [Co-authors: Laura Hayes, Daniel Müller, Andrew Walsh]

Finding Hidden Conjunctions in the Solar Wind

This research aims to identify sets of in-situ measurements of the solar wind sampling the same volume of plasma at different times and locations in the heliosphere – referred to here as conjunctions. Observations of the same volume of plasma as it travels through the heliosphere allows for the characterization of the expansion of the solar wind. Specifically, this will enable us to test the current understanding of solar wind acceleration from the corona to the inner heliosphere using a greater sample of measurements than has been used in past research. Using in-situ measurements from Solar Orbiter, Parker Solar Probe, STEREO-A, Wind and BepiColombo, we identify a set of criteria from known conjunctions and search for other instances in which the criteria are satisfied. To improve the performance of our statistical detection algorithm, we will use a machine learning model trained on synthetic observations to identify candidate conjunctions. The initial statistical analysis shows that correlation and time lag between timeseries are the best predictors of conjunctions. Initial results show a limited set of conjunctions which we hope to expand using machine learning methods. The modular scientific software built over the course of this research will be released as an open-source Python package to ensure results can be easily reproduced and to facilitate further investigation of coordinated in-situ data.

Nelly Gaillard (ESAC) [Co-authors: Jose Luis Hernandez, Johannes Sahlmann, Pablo Gomez]

Machine Learning techniques application to astrometry in the Gaia Mission

The data processing task of the Gaia mission is large and complex. One of its central elements is the Astrometric Global Iterative Solution (AGIS), which produces and delivers the core astrometry data products. One of the most challenging tasks that we need to tackle in the software producing Gaia's astrometric solution is creating a calibration model accurate enough to consider the subtle effects, since they may have an impact on the quality of the solution at the micro-arcsecond level. Among AGIS related data, the first to be analysed are the post-fit residuals. These are the differences between the observations and the predictions obtained using the AGIS source, attitude and calibration model. Up to now, they have been manually explored, by plotting them in different partitions to identify anomalous clusters of points. This task is time consuming and lends itself to automated analysis by means of machine learning techniques, which could make the procedure more efficient and systematic. With the objective of performing anomaly detection on the residuals, the first task is to define what an anomaly is, which has been done exploring different data visualization and feature engineering techniques. In this poster we will present an overview of the project and its status, highlighting possible ways forward.

Pablo García Martín (UAM) [Co-authors: Sandor Kruk, Marcel Popescu, Bruno Merín, Karl R. Stapelfeldt, Robin W. Evans, Benoit Carry and Ross Thomson]

Hubble Asteroid Hunter III. Physical properties of newly found asteroids

Determining the size distribution of asteroids is key for understanding the collisional history and evolution of the inner Solar System. Aims. We aim at improving our knowledge on the size distribution of small asteroids in the Main Belt by determining the parallaxes of newly detected asteroids in the Hubble Space Telescope (HST) Archive and hence their absolute magnitudes and sizes. Methods. Asteroids appear as curved trails in HST images due to the parallax induced by the fast orbital motion of the spacecraft. Taking into account its trajectory, the parallax effect can be computed to obtain the distance to the asteroids by fitting simulated trajectories to the observed trails. Using distance, we can obtain the object's absolute magnitude and size estimation assuming an albedo value, along with some boundaries for its orbital parameters. Results. In this work we analyse a set of 632 serendipitously imaged asteroids found in the ESA HST Archive. These objects were obtained from instruments ACS/WFC and WFC3/UVIS. An object-detection machine learning algorithm (trained with the results of a citizen science project) was used to perform this task during previous work. Our raw data consists of 1,031 asteroid trails from unknown objects, not matching any entries in the Minor Planet Center (MPC) database using their coordinates and imaging time. We also found 670 trails from known objects (objects featuring matching entries in the MPC). After an accuracy assessment and filtering process, our analysed HST asteroid set consists of 454 unknown objects and 178 known objects. We obtain a sample dominated by potential Main Belt objects featuring absolute magnitudes (H) mostly between 15 and 22 mag. The absolute magnitude cumulative distribution logN(H $>$ H0) $\propto \alpha$ log(H0) confirms the previously reported slope change for 15 $<$ H $<$ 18, from $\alpha \simeq 0.56$ to $\alpha \simeq 0.26$, maintained in our case down to absolute magnitudes around H $\simeq$ 20, hence expanding the previous result by approximately two magnitudes. Conclusions. HST archival observations can be used as an asteroid survey since the telescope pointings are statistically ran- domly oriented in the sky and they cover long periods of time. They allow to expand the current best samples of astronomical objects at no extra cost on telescope time.

Pablo Gómez (ESAC) [Co-authors: Johannes Sahlmann]

Machine learning search for Gaia DR3 astrometric exoplanet orbits

The third Gaia data release (GDR3) contains 170,000 astrometric orbit solutions of two-body systems located within 500 pc of the Sun. The determination of the component masses of these systems usually hinges on incorporating complementary observations in addition to the astrometry, e.g., spectroscopy and radial velocities. Several GDR3 two-body systems with exoplanet, brown-dwarf, stellar, and black-hole components have been confirmed in this way. Using ESA Datalabs, we developed an alternative machine learning approach that uses only the GDR3 orbital solutions with the aim of identifying the best candidates for exoplanets and brown-dwarf companions. Based on confirmed substellar companions in the literature, we use semi-supervised anomaly detection methods in combination with extreme gradient boosting and random forest classifiers to determine likely low-mass outliers in the population of non-single sources. We employ and study feature importance to investigate the method's plausibility and produced a list of likely candidates for further study. Our preliminary findings suggest that this new approach is a powerful complement to the traditional and "manual" identification of substellar-companion candidates in Gaia astrometric orbits. It is particularly relevant in the context of GDR4 and its expected exoplanet discovery yield.

Laura Hayes (ESTEC) [Co-authors: Laura A. Hayes, Hannah Collier, Säm Krucker]

The Flaring Sun: 2 Years of Solar Flare Observations with Solar Orbiter/STIX

Solar flares are intense bursts of radiation caused by the release of magnetic energy in the solar atmosphere, and they play a pivotal role in influencing space weather. As we are approaching the solar maximum, observations from Solar Orbiter's Spectrometer/Telescope for Imaging X-rays (STIX) are providing new insights into X-ray emissions from solar flare events. STIX has observed over 40,000 flares to date, since January 2021. In addition to new X-ray observations of solar flares that Solar Orbiter/STIX provides, the distinctive trajectory of Solar Orbiter, diverging from the Sun-Earth line, affords us the ability to detect flares from viewing angles markedly different from those accessible from Earth, affording us new possibilities to do stereoscopic science. In this presentation, I'll present an introduction to X-ray flares, some new exciting results from STIX, and the importance of event lists and catalogs when doing coordinated science.

Svea Hernandez (Baltimore) [Co-authors: Svea Hernandez, Logan Jones, Linda Smith, Aditya Togi]

Dissecting the Mid-infrared Heart of M83 with JWST

Molecular gas is a critical ingredient in the recipe of star formation (SF) in galaxies. To fully understand the processes that govern SF, it is essential to accurately measure and characterize the distribution of H2 in star-forming environments. Since H2 is a weak rotational emitter, the molecular gas content in galaxies is typically inferred using indirect tracers such as the CO (1-0) transition. However, CO provides a partial census of the total H2 mass, particularly in regions with large quantities of CO-dark gas. A recent HST/FUV spectroscopic study suggested that S+ might be tracing large amounts of CO-dark gas in the core of M83. We have begun exploiting the unprecedented capabilities of JWST in the MIR, using the MIRI/MRS, performing a spatially-resolved study of the warm H2 gas in the heart of this face-on spiral galaxy. Our initial results indicate that 75% of the total molecular gas mass in the core of M83 is contained in the warm H2 component, hidden to the CO tracer. The combination of the FUV capabilities of HST with the MIR sensitivity of JWST have allowed us to confirm, for the first time, S+ as a tracer of CO-dark gas in this particular metal-rich and highly active environment. To understand the fueling SF history through time, it is imperative that we test and develop tools to accurately estimate molecular gas mass directly probing the H2 reservoirs. JWST, with its unrivaled resolution and sensitivity is allowing us to do exactly that.

Kate Isaak (ESTEC) [Co-authors: Catia Cardoso, Maximilien Guenther, Sandor Kruk, Davide Gandolfi, Sandra Benitez-Herrara]

Inspiration through space science: exoplanet themed education activities for secondary students

The topic of exoplanets is connected directly to the simple and profound question of whether we are alone in the Universe, capturing the imagination of scientists and the public alike. As such, it provides an excellent means through which to engage school students in some of the thrills of science and, critically, to teach science, technology, engineering and mathematics (STEM) core skills.

In this contribution we give an overview of a collection of exoplanet inspired classroom activities and resources that have been developed through a collaboration between ESA Education and scientists working in SCI and beyond. The emphasis of the activities has been on transit photometry and more specifically ESA's CHEOPS mission, with the underlying theme of using in-flight CHEOPS observations to engage young people. We combine the overview of the activities with an introduction to the ESA Education portfolio.

Sandor Kruk (ESAC) [Co-authors: Pablo Gomez, Jan Reerink, Vicente Navarro, Ernest Perkowski, Vicente Amado, Léa Zuili]

Machine Learning for Space Science: Projects and Community Building

In the past year, our Data Science team has dedicated efforts to foster a community centered on using machine learning in space science. We have actively involved young scientists at ESA in various activities on ESA Datalabs and are building knowledge and expertise through a range of projects, from natural language processing to computer vision. In this presentation, I will highlight some of our current projects, such as fine-tuning for the first time a large language model for astronomical research. I will discuss the role of infrastructures such as ESA Datalabs and discuss the scientific networks that have emerged throughout these ML initiatives, such as UniverseTBD.

Erik Kuulkers (ESTEC) [Co-authors: E. Kuulkers (ESA/ESTEC), A. Ingram (Newcastle University), V. Grinberg (ESA/ESTEC), J. Wilms (University of Erlangen-Nuremberg), K. Pottschmidt (CRESST, UMBC & NASA/GSFC), R.E. Rothschild (University of California at San Diego), Y. Mollard (Bordeaux INP)]

Never throw away old data! Cygnus X-1's fast X-ray variability behaviour in the 70s revisited

Apollo 15 (and 16) did not only bring people to the Moon, but also experiments to study our neighbour and its environment. Onboard the Command and Service Modules (CSM's) were X-ray experiments, to explore the Lunar surface chemistry. These data, covering about 10% of the Lunar surface has been extensively used to study Lunar formation history and geological evolution. However, when traveling back to Earth, the experiments were also used for X-ray astronomy. These data had to be retrieved from a tape dump binary file. One of the extra-Solar sources observed is the famous black-hole X-ray binary Cygnus X-1. X-ray states in X-ray binaries are mainly defined by their spectra and timing behaviour; these states correspond to different accretion regimes of the compact object. With the advent of high-throughput, high-time resolution experiments (such as onboard ASTROSAT, EXOSAT, Ginga, NICER, RXTE) emphasis has been shifting to study X-ray variability at high time resolution (typically less than milliseconds). For most of the earlier X-ray experiments in the 1960's and 1970's information is only available down to about milliseconds. We show that for Cygnus X-1, X-ray data taken with second to subsecond time resolution can uniquely help in defining its X-ray states. This is done by using digitized light curves and power density spectra as presented in the literature, from Uhuru (the 1st X-ray satellite), SAS-3 and HEAO-1, and various rocket experiments, in the 1970's, as well as newly analysed data from the X-ray experiment onboard Apollo 15 and the Netherlands Astronomical Satellite (ANS; the Netherlands 1st satellite).

René Laureijs (ESTEC) [Co-authors: R. Vavrek, G. Canas Herrera, V. Pettorino, on behalf of the Euclid SOC and the Euclid Collaboration]

Euclid Early Release Observations programme

The ERO programme comprises one day of Euclid observations to showcase the Euclid capabilities at an early stage of the mission. The targets were obtained from proposals submitted by groups in the Euclid Science Collaboration. The ERO dataset offers several interesting fields, enabling a variety of scientific studies. We present a description of the programme, the organization, the scope of the data processing, and the upcoming milestones. We will also mention the first scientific results. The aim is to make the ERO data public as soon as the first batch of scientific analyses are completed in February 2024.

Elena Manjavacas (Baltimore) [Co-authors: Elena Manjavacas, Pascal Tremblin, Stephan Birkmann, Jeff Valenti, Catarina Alves de Oliveira, Tracy L. Beck, G. Giardino, N. Luetzgendorf, B. J. Rauscher, M. Sirianni]

Medium Resolution 0.97-5.3 micron spectra of Very Young Benchmark Brown Dwarfs with NIRSpec onboard the James Webb Space Telescope

Spectra of young benchmark brown dwarfs with well-known ages is vital to characterize other brown dwarfs for which their ages are in general not known. These spectra are also crucial to test atmospheric models, in particular atmospheric retrieval models, which have the potential to provide detailed information about the atmospheres of these objects. However, to fully test atmospheric models, medium-resolution, long-wavelength coverage spectra with well-understood uncertainties are needed, such as the spectra provided by the NIRSpec instrument onboard the James Webb Space Telescope. In this paper, we present the medium-resolution JWST/NIRSpec spectra of two young brown dwarfs, TWA 28 (M9.0) and TWA 27A (M9.0), and one planetary-mass object, TWA 27B (L6.0), members of the TW Hydrae Association (10 Myr). We show the richness of the atomic lines and molecular bands present in the spectra. All objects show signs of a circumstellar disk, via near-infrared excess and/or via emission lines. We matched a set of cloudless atmospheric spectra (ATMO), and cloudy atmospheric spectra (BT-Settl) to our NIRSpec spectra, and analyzed which wavelength ranges and spectral features both models reproduce best. Both models derive consistent parameters for the three sources and predict the existence of CH4 at 3.35 microns in TWA 27B. Nonetheless, in contrast to other slightly older objects with similar spectral types, like PSO 318.5-22 and VHS 1256b, this feature is not present in the spectrum of TWA 27B. The lack of the CH4 feature might suggest that the L/T transition of very young dwarfs starts at later spectral types than for older brown dwarfs.

Julia Marin-Yaseli de la parra (ESAC) [Co-authors: michael kueppers]

Interstellar Harmony: Unraveling the Symbiotic Dance of Meteor and 67P Dust Particles

This research delves into the intriguing world of dust size distribution within comet 67P/Churyumov-Gerasimenko and its symbiotic relationship with meteors. Comets are time capsules, capturing the essence of the solar system's infancy, and thereby providing a window into the primordial composition and developmental processes of its constituents. Our study is anchored in the analysis of the dust particles ejected from comet 67P, with a goal to decode the size distribution mechanics and draw parallels to meteor data.

Pedro Mas Buitrago (ESAC) [Co-authors: Ana González-Marcos, Enrique Solano]

M dwarf stellar parameter determination with autoencoders and deep transfer learning

The estimation of stellar parameters for M dwarfs often involves the comparison of observed spectra with different synthetic collections. In this process, a major source of uncertainty is the "synthetic gap" (difference between theoretical and observed spectra), which must be addressed beforehand to know the reliability of the parameter estimation.

In this work, we propose a deep learning (DL) methodology to bridge the synthetic gap in stellar parameter estimation, using a sample of high S/N, high resolution, spectra from 286 CARMENES survey M dwarfs. For this purpose, we built a two-step process that involves different deep learning approaches. In particular, we used deep transfer learning (DTL), which focuses on transferring knowledge from one model to another.

First, we trained a sparse autoencoder to effectively compress synthetic spectra from the PHOENIX-ACES models into a low-dimensional latent space. Using this trained autoencoder as a base model, we adopted a DTL approach to adapt it to the target domain (CARMENES spectra) while keeping the features learned in the data-rich source domain (PHOENIX-ACES spectra) frozen.

Using the low-dimensional encoded latent space from the PHOENIX-ACES spectra as input features, we trained a convolutional neural network (CNN) to build a regression model and estimate the stellar parameters of the 286 M Dwarfs.

Thibaud Moutard (ESAC) [Co-authors: T. Moutard, O. Ilbert, P. G. Perez Gonzalez, P. Rinaldi, MIDIS Collaboration]

Witnessing Galaxies Fate since the End of Cosmic Dawn: a Star-Formation Quenching Story

Well documented over $\geq$12 billion years (e.g. Davidson et al 2017), the continuous increase of the fraction of quiescent galaxies (where star formation has stopped) is the statistic expression of the quenching —i.e. the permanent shutdown— of star formation in galaxies. Such permanent quenching of the star formation requires, however, mechanisms able to suppress and prevent the cold-gas infall, which one may expect to vary depending on galaxies properties and environment.

The diversity of quiescent galaxies (e.g. in terms of stellar mass and morphology) pleads indeed for the coexistence of different quenching channels since cosmic noon (Faber et al. 2007, Peng et al. 2010, Schawinski et al. 2014, Moutard et al. 2016b). At higher redshift, the physical processes which were at play in the early quenching of the very first quiescent galaxies a few 100Myrs after their formation (e.g. Chworowsky et al. 2023) are expected to be different again.

I will present unprecedented analysis of the connection between the star formation quenching and the morphological transformation of galaxies since z 7, drawing on the deepest, sharpest near- and mid-infrared observations ever conducted (even) with JWST (respectively, 29 and 31mag at 3.6 and 5.6µm), as part of JADES (NIRCam & NIRSpec GTOs) and MIDIS (MIRI GTO), combined with ultra-deep HST imaging over the HUDF. I will characterise the co-evolution between galaxies sSFR and morphology through the green valley, depending on their stellar mass, and discuss the different quenching scenarii that our results support across cosmic time over the last 13 billion years.

Raquel Murillo Ojeda (ESAC) [Co-authors: Francisco Jiménez Esteban, Enrique Solano, Alberto Rebassa Mansergas, Santiago Torres]

White dwarfs with infrared excess within 100 pc: Gaia and the Virtual Observatory

White dwarfs (WDs) are one of the most common objects in the universe. They are stellar remnants of low and intermediate mass stars, such as the Sun. WDs are compact objects, with typical masses around half a solar mass and planetary sizes. They are the key to understanding the composition and evolution of exoplanetary material around intermediate mass stars in their late stages of evolution. In this talk we will describe the work aimed at identifying nearby (< 100 pc) WDs with infrared excess. Starting from the so far most complete volume-limited WD sample built from Gaia DR3 data (Jiménez-Esteban et al. 2023, 10.1093/mnras/stac3382), we used Gaia DR3 spectroscopic coefficients and GaiaXPy to obtain JPAS synthetic photometry. Using VOSA, a Virtual Observatory tool, we complemented JPAS photometry with infrared photometry gathered from astronomical archives. Then, we compared the SEDs to different atmosphere models to identify flux excess at infrared wavelengths. Once we have got rid of the potential sources of contamination, the origin of the excess can be attributed to two causes: The presence of a low mass, cool companion or the existence of a circumstellar dust disk. Spectroscopic observations are required to discern between the two possible scenarios. This is why we started a follow-up program of the most promising candidates using the X-Shooter instrument at the Very Large Telescope. In this talk, we will show the first results obtained in this analysis.

Samuel Pearson (ESTEC) [Co-authors: Mark McCaughrean]

Jupiter Mass Binary Objects - JuMBOs

In recent observations of the Trapezium Cluster with the JWST, we have discovered and characterised a sample of 540 planetary-mass candidates with masses down to 0.6 Jupiter masses. In an unexpected twist we find that 9% of these planetary-mass objects are in wide binaries. The binary fraction of stars and brown dwarfs is well known to decrease monotonically with decreasing mass such that the binary fraction for the planetary-mass regime is expected to approach zero. The existence of substantial population of Jupiter Mass Binary Objects (JuMBOs) raises serious questions of our understanding of both star and planet formation. In this talk I will present the discovery of these JuMBOs, the 540 PMO candidates, and discuss the implications for our understanding of star and planet formation.

Isabel Rebollido Vázquez (ESAC) [Co-authors: Christopher C. Stark, Jens Kammerer, Marshall D. Perrin , Kellen Lawson, Laurent Pueyo, Christine Chen, Dean Hines, Julien H. Girard, Kadin Worthen]

The Beta Pic disk through the eyes of JWST

Since the first imaging observation of the Beta Pic disk in 1984, the astronomical community has thoroughly investigated this system, finding large amounts of dust and gas, exocomets, and two planets. All of this makes it the perfect laboratory to investigate the dynamics and chemistry of the late stages of planet formation. The JWST GTO 1411 program was designed to investigate the dust component at near- and mid-infrared wavelengths, providing new insights on the dust morphology, composition, and distribution. The combination of the high sensitivity of the on board instruments with the 4QPM and Lyot coronagraphs allows for the most detailed images of the Beta Pictoris disk so far at this wavelength range, revealing new features and details in the dust distribution. In this talk, I will present JWST NIRCam and MIRI coronagraphic images, ranging from 1.82 to 23 microns. I will also summarize the analysis of prominent disk features observed for the first time, and compare it to previous ground and space based observations at multiple wavelengths.

Rozenn Robidel (ESAC) [Co-authors: Rozenn Robidel]

Contribution of micrometeoroid impacts to the exospheres of the Galilean moons Ganymede and Europa

The exosphere is a thin atmosphere where the density is so low that atoms and molecules are unlikely to collide with each other. In the case of bodies with a substantial atmosphere (e.g. the Earth, Mars), the exosphere is the uppermost layer of the atmosphere, where it thins out and merges with outer space. In the case of airless bodies (e.g. the Moon, Mercury), the exosphere is the only atmosphere, in direct contact with the surface. The exosphere of an airless body is transient and is continuously supplied by incoming sources (e.g. solar wind) and particles released from the surface through different processes (e.g. sputtering, micrometeoroid impact vaporization, photon- and electron-stimulated desorption…). The processes that release atoms and molecules in the exosphere are various according to the element (volatile or refractory) but also according to the body, its physical and chemical properties and its environment (e.g. surface, gravity, heliocentric distance, magnetic field, plasma environment…). As micrometeoroids impact directly the surface of airless bodies, they release surface material into the exosphere by impact vaporization and ejection of dust grains. At Ganymede and Europa, micrometeoroid impact vaporization is often neglected as a source for neutral atmosphere models. However, micrometeoroid impacts result in eroding the surface and unveiling fresh material (the so-called impact-gardening). The contribution of micrometeoroid impacts is therefore important to understand the aging of surface and the relationship between endogenous and exogenous sources of surface material. Therefore, during my fellowship at ESA, I intend to study the contribution of micrometeoroid impacts on the formation of Ganymede and Europa

exospheres, as a proxy to constrain their surface history. It is essential in the context of the upcoming missions ESA/JUICE and NASA/Europa Clipper, to explore the Jovian system in the early 2030s.

Laura Rodríguez García (ESAC) [Co-authors: Rodríguez-García et al.]

Acceleration and transport of solar energetic particles in the inner heliosphere

A new era of spacecraft probing the inner heliosphere make now possible the study of the spatial distribution of solar energetic particle (SEP) events closer to the Sun. Recent missions, such as Solar Orbiter, along with the constellations of spacecraft near 1 au facilitate the study of the radial dependence of SEP parameters, such as the peak intensity and spectrum. In this work, we use the solar energetic electrons (SEE) measured by the MESSENGER mission from 2011 to 2015 to derive statistical results about the radial dependence of some SEE parameters, which are compared with the results from Solar Orbiter near its first nominal perihelion in March 2022. The main conclusions are: (1) There is a wide variability in the radial dependence of the electron peak intensities, but on average and within uncertainties, the radial dependence can be expressed as R-3, being R the heliocentric distance to the Sun. (2) Between near 0.3 au and 1 au, the energy spectrum of the near-relativistic electrons becomes softer.

We also analyse the relations between the solar activity and the SEE peak intensities measured by MESSENGER, STEREO and ACE spacecraft during 2010-2015. A summary of the results, implications for the Space Weather research, and comparison with previous works is presented.

Johannes Sahlmann (ESAC) [Co-authors: I. Platais, L. Girardi, V. Kozhurina-Platais, S. Kamann, D. Pourbaix, F. Wragg, G. Lemson, A. W. Mitschang]

Astrometric binaries with dark companions in the globular cluster ω Centauri

We present the discovery of the first astrometric binaries in the globular cluster omega Centauri. This was made possible by analysing 13 years of regularly-scheduled Hubble Space Telescope calibration observations in the cluster core. We determined the astrometric orbits of four binaries and their Keplerian parameters suggest periods of 9-19+ years and dark companions in the mass range of 0.7-1.4 solar masses, including at least one neutron-star candidate. We discuss the potential of astrometric binary searches in globular clusters in the context of the recent Gaia Focused Product Release and future Gaia data releases.

Victor See (ESTEC) [Co-authors: Lucy Lu, Louis Amard, Julia Roquette]

How does stellar metallicity affect the rotation evolution of low-mass stars?

In recent years, there has been a growing body of evidence that the metallicity of a star affects how efficient its dynamo is. The central idea is that a star's metallicity affects the depth of its convection zone and, therefore, the dynamo process. Metal-rich stars are expected to generate stronger magnetic fields and have stronger activity than metal-poor stars. From theoretical considerations, a star's metallicity is also expected to affect its rotation evolution since angular momentum loss is ultimately a result of the dynamo. In this talk, I will present observational evidence that this is indeed the case.

Nicole Shearer (ESTEC) [Co-authors: Nicole Shearer, Anne Daniels]

Captivating communications: catching and keeping your audience's wandering eye

Your audience matters more than you do. You have only a few seconds to grab their attention, and they can look away at any time. If you want to be heard, you have to keep them at the centre of everything you write, say and create. What's the best way of getting them to read an article, watch a video, or pay attention during your presentation? How can we compete with funny cat videos, clickbait-y space drama and *ahem* bigger space agencies? This is a big, complex subject; two ESA Science editors will squeeze what they can into this 30 minute slot.

Matthew Standing (ESAC) [Co-authors: Matthew R. Standing]

The search for circumbinary planets

Circumbinary planets, those which orbit both stars of a binary system, challenge our understanding of planet formation and orbital evolution. Planet formation around binary stars was thought to be difficult, and therefore these circumbinary planets were confined to the realm of science-fiction. Yet during its lifetime, Kepler discovered several of these objects. Since the discovery of Kepler-16b in 2011, 14 circumbinary planets have been discovered in 12 systems by transit missions. Future transit missions such as PLATO, will likely double the number transiting circumbinary planet candidates, and radial velocities would be required to confirm them. Despite the radial velocity method being the most established technique for planet detection, only recently has it become possible to detect circumbinary planets using radial velocity measurements. I will present a recent radial velocity discovery of a second circumbinary planet in the TOI-1338/BEBOP-1 system, where TESS had identified a 95-day circumbinary planet. This makes TOI-1338/BEBOP-1 the second multiplanetary circumbinary system ever discovered. I will also present an efficient method to calculate detection limits for radial velocity datasets with minimal assumptions, preliminary occurrence rates from the BEBOP and DMPP surveys, and describe plans for detection of circumbinary planets with PLATO. Understanding how these planets form and how common they are can provide us with a unique insight into planet formation in these extreme systems.

Andy Shu Ho To (ESTEC) [Co-authors: David H. Brooks, Shinsuke Imada, Ryan J. French, Lidia van Driel-Gesztelyi, Deborah Baker, David M. Long, William Ashfield IV]

Plasma Composition Evolution in a Solar Flare - The Effect of Reconnection Outflow

We analyse the coronal elemental abundances of the X8.2 flare on 2017 September 10 using spatially resolved measurements from Hinode/EIS (EUV Imaging Spectrometer). Using both the Ca XIV 193.87 Å/Ar XIV 194.40 Å and Fe XVI 262.98 Å/S XIII 256.69 Å composition diagnostic ratios, we show that the flare loops exhibit a large variation of coronal abundances, with the loop tops showing enhanced coronal abundances that decrease to photospheric values toward the footpoints. We propose that this variation is caused by two physical processes. The highly fractionated abundance at the loop top is likely associated with plasma downflow from the plasma sheet, which has coronal abundances. Meanwhile, upflows caused by chromospheric evaporation/ablation fill the loop footpoints with unfractionated photospheric composition. Mixing between these sources produces the observed gradient along the loops. Our findings provide a novel explanation for the composition discrepancy observed between Sun-as-a-star and spatially resolved flare composition measurements, and have significance for understanding loop top brightenings also known as bright knots. Spatially resolved spectroscopy proves critical for revealing these complex abundance structures.

Emma Vellard (ESTEC) [Co-authors: Olivier Witasse]

Empowering researchers with comprehensive data access for the ESA's JUICE Mission

Now that JUICE is on its cruise, the first datasets of the nominal mission are expected in 2032. A need for an integrated and user-friendly data environment to support the research community and their analysis efforts was identified a few years ago. In response to this demand, we have been working on the development of an extensive data environment tailored for the JUICE mission. This environment is designed to streamline and enhance the research process by offering researchers a centralized platform containing a wealth of information. Our platform will encompass a diverse array of data, including details about the spacecraft itself, such as trajectory, instrumentation and 3D models. In addition, it will provide technical data and specifications necessary for researchers to effectively interpret the mission's observations. It will also house valuable information on the scientific aspects of the JUICE mission, such as workshop presentations, latest published papers or relevant databases. By providing comprehensive, easily accessible information, we aim to empower researchers within the scientific community to conduct in-depth analysis and gain valuable insights into the JUICE mission's data.

Sascha Zeegers (ESTEC) [Co-authors: Sascha Zeegers, Stefan Bromley, Jean Chiar, Laurie Chu, Elisa Costantini, Marjorie Decleir, Thavisha Dharmawardena, Tom Geballe, Karl Gordon, Joel Green, Burcu Günay, Thomas Henning, Olivia Jones, Ciska Kemper, Aigen Li, Joan Mariñoso Guiu, Jonathan Marshall, Melissa McClure, Karl Misselt, Mayank Narang, Gilles Otten, Yvonne Pendleton, Giulia Perotti, Klaus Pontoppidan, Alexey Potapov, Manoj Puravankara, Julia Roman-Duval, Peter Scicluna, Alexander Tielens, Himanshu Tyagi, Rens Waters, Eleonora Zari]

Early results from the WISCI project: Webb Investigation of Silicates, Carbons and Ices

The diffuse interstellar medium plays an essential role in regulating the energy balance of galaxies, by processing starlight and driving molecule formation. It contains the input ingredients of dense star forming clouds and, consequently, of new stars and planets. Therefore, it is important to understand the properties, formation, and evolution of this dust. However, we lack a fundamental understanding of the dust cycle in galaxies and its main elemental building blocks: H, C, O, Si, Mg, and Fe. The imprints of dust on the spectra of stars reveal information about the composition and structure of the dust grains, which in turn can explain what happens to the grains as they travel through the interstellar medium (ISM). In this talk I present the Webb Investigation of Silicates, Carbons and Ices (WISCI) project in which we study dust along the line of sight of twelve OB stars in the Milky Way, using JWST MIRI and NIRCam (GO cycle 1 program id 2183), HST STIS (cycle 30 program id 17078) and VLT XSHOOTER spectroscopy. The wavelength coverage, sensitivity, and spectral resolution of JWST at near- and mid-infrared wavelengths in combination with HST and VLT observations enables us to study dust in the diffuse ISM in unprecedented detail. In this talk I will present the first exciting results from this study.

Poster Presentations

Listed alphabetically by 1st author last name

[Poster #1] Nicolas Altobelli []

Ice Impacts Experiments

The contribution of micro-meteoroids impacts to both, alteration of the surface properties and volatile release is experimentally (and theoretically) poorly known. Understanding in details the effect of micro-meteoroids impacts on Jovian ices analogues is therefore an important preparatory step for the future analysis of JUICE and CLIPPER icy moons surfaces and exosphere data. We will address both topics experimentally (ice weathering and volatiles release) via hyper-velocity impact experiments on analogues of Jovian ices. Such experiments have not been performed so far because of the highly specialized laboratory equipment required. The experimental set-up requires having, at the same location, the capacity to produce ice targets, whose composition and temperature match in composition and structure our current best knowledge of those of Callisto, Ganymede and Europa and a particle accelerator (typically, a Van De Graaff electrostatic accelerator), to shoot the targets with silicate particles (representative of the micro-meteoroids impactors) at tens of kilometers per seconds. This set-up is now available at the University of Stuttgart that will handle the ice target fabrication and shooting experiments. We present the latest status of the work that was kicked-off in November.

[Poster #2] Rickbir Bahia [Co-authors: Rickbir Bahia, Eleni Bohacek, Lisanne Braat, Sarah Boazman, Elliot Sefton-Nash, Ines Torres, Colin Wilson, Lucie Riu, Csilla Orgel]

Where Environments Collide: Aeolian-Fluvial Interactions on Ancient Mars

Mars is carved by thousands of valley networks, which are evidence of ancient flowing rivers 3.7 Byr ago. These rivers are thought to have been primarily fueled by rainfall or snowfall, leading researchers to suggest that during the period in which rivers were primarily active (the Late Noachian to Early Hesperian period 3.8-3.6 Byr ago) Mars was 'warm and wet'. However, recent analysis of Martian valley network branching angles and lake deposits has revealed that the climate was similar in aridity to terrestrial deserts.

In deserts on Earth, fluvial and aeolian (wind-blown) (AF) processes display considerable interactions, which have an impact on dune and river trajectories, morphologies, geometries, and distributions. These interactions can lead to water loss to the subsurface and the formation of sabkhas, which are interdune ponds that transform into salt flats. These pools are where primordial continental life on Earth is hypothesized to have emerged, evidenced by microbial mats. Lithified dunes and interwoven inverted river channels, and the discovery of aqueously altered lithified dunes by the Curiosity rover, indicates synergy between AF interactions on ancient Mars.

Here I report the results of the pilot study examining the effects of these processes in synergy under ancient Martian conditions, using a combination of modelling and geomorphological analysis. To perform this analysis, we established the Working group on Aeolian-Fluvial Terrain Interactions (WAFTI) at ESA, comprising of 9 members from ESTEC and ESAC, SCI and HRE, Project Scientists, Research Fellows and Young Graduate Trainees. Our study shows that just like on Earth, A-F interactions play a massive role in shaping the surfaces of Mars. There are a number of salient impacts for Mars: meandering inverted channels, the sediment size and distribution of Martian rivers, the formation of interdune pools, and the preservation of Martian valley networks.

[Poster #3] Mark Bentley [Co-authors: Léonard Martinez, François Andrieu, Frédéric Schmidt, Hugues Talbot]

Automatic crater detection and classification using Faster R-CNN

Impact craters are one of the most ubiquitous geological features observed on planetary bodies, and their study can yield information on their chronology and composition as well as the flux and size distribution of the impactors. A number of techniques have been used to count and characterise craters from imagery and derived properties such as surface age, however results can be inconsistent and easily biassed. The work presented here applies the Faster R-CNN algorithm to detect and classify craters. Initially trained on MRO/CTX data and ground-truth from a published crater database, the method shows promising results in producing a comprehensive database of Martian craters and their characteristics. Next steps will apply this method to the MEX/HRSC dataset, and test its applicability to other Solar System bodies. The source code is open source and published on GitHub and the final software should be installed on ESA DataLabs such that it can be easily (re-)run on the relevant datasets in the Planetary Science Archive.

[Poster #4] Sarah Boazman [Co-authors: David Heather, and Landing site working group]

Detailed analysis of the landing site for ESA's PROSPECT instrument

ESA's PROSPECT instrument is one of the payloads onboard the NASA Commercial Lunar Payload service (CLPS) 22 mission and is targeting the lunar south pole. PROSPECT is designed to drill into the lunar surface up to a depth of 1 m, sampling volatiles including water ice. A landing site with a 100 m diameter ellipse has been selected, located at 31.588°E, -84.496°S. Detailed analysis of the landing site has been conducted to investigate the features present within the landing ellipse, thermal conditions, and the illumination and Earth visibility. Boulders, craters and morphological units have been mapped to characterize the landing site and to observe if there are any hazards which may affect the mission. Understanding the landing site in detail will ensure the safety of the landing site and provide context to the volatiles sampled during the mission.

[Poster #5] Eleni Bohacek []

Volumetric Calculation of Quantization Error in 3-D Vision Systems

We investigates how the inherent quantization of camera sensors introduces uncertainty in the calculated position of an observed feature during 3-D mapping. The error of the object position is typically thought of as a confidence interval in the x, y, and z directions, ϵ_x, ϵ_y, ϵ_z. The magnitude of the three components can be very different and this dimensionality information is lost when only considering ϵ, as this effectively this models the uncertainty volume as a sphere. It is typically assumed that pixels and scene features are points, however, a pixel is a two-dimensional area that maps onto multiple points in the scene. This uncertainty region is a bound for quantization error in the calculated point positions. Earlier studies calculated the volume of two intersecting pixel views, approximated as a cuboid, by projecting pyramids and cones from the pixels into the scene. In this paper, we reverse this approach by generating an array of scene points and calculating which scene points are detected by which pixel in each camera. This enables us to map the uncertainty regions for every pixel correspondence for a given camera system in one calculation, without approximating the complex shapes. The dependence of the volumes of the uncertainty regions on camera baseline length, focal length, pixel size, and distance to object, shows that earlier studies overestimated the quantization error by at least a factor of two. For static camera systems the method can also be used to determine volumetric scene geometry without the need to calculate disparity maps.

[Poster #6] Guadalupe Cañas Herrera [Co-authors: Euclid Consortium InterScience Taskforce Likelihood & Non-linear]

Cosmology Likelihood for Observables in Euclid (CLOE): Inference and Forecasts

The second version of the 'Cosmological Likelihood for Observables in Euclid' has been released. CLOE is the official pipeline to compute the theoretical predictions for Euclid's main primary probes and the likelihood, and it will be used to produce constraints on cosmological parameters once Euclid data is ready. CLOE v.2.0 has a more robust theoretical model to predict Euclid's observables, which includes the modelling of non-linearities, non-gaussian contributions to the likelihood computation, and new user-friendly features, among others. I will briefly show the main updates of the code, the current development and validation status, and preliminary forecasts.

[Poster #7] Hector Canovas [Co-authors: M. Vioque, M. Cavieres, M. Pantaleoni Gonzalez, Á. Ribas, R. D. Oudmaijer, I. Mendigutía, L. Kilian, M. A. Kuhn]

Clustering Properties of Intermediate Young Stellar Objects

The intermediate-mass (4-10 $M_\odot$) young stellar objects (YSO) are a suitable population to understanding the different formation mechanisms that apply to low- and high- mass stars. In addition, the complex structures observed in their surrounding accretion discs, and their derived disc masses, suggest that giant planet formation happens at a higher rate in this mass regime. Until recently, the study of the general properties of intermediate-mass YSO was hampered by the low-number statistics and the lack of a well-defined, homogeneous sample. This situation has changed thanks to the vast amount of data provided by the Gaia mission and the use of machine learning techniques. In this talk I will present a novel analysis of the association (clustering) properties of these objects when observed at optical wavelengths. Our results suggest that the intermediate-mass YSO form in less clustered environments when compared to their low- and high- mass counterparts. We also find that intermediate- and high- mass YSOs become less clustered with decreasing disc emission and accretion rate.

[Poster #8] Quentin Changeat [Co-authors: Changeat, Skinner, et al.]

Atmospheric variability in an exoplanet

Observations of exoplanet atmospheres have not yet been able to infer weather patterns. This is typically due to the low signatures from past instruments and the lack of repeated observations. In a recent study, we utilize repeated observations of an ultra-hot Jupiter to study the variability of its atmosphere. Crucially, we detect significant differences between the observations. The observed variability manifests as: i) shift of the 'hotspot' offset between two phase-curves and ii) varying spectral signatures in the transits and eclipses. We combined the constraints inferred from modern atmospheric retrievals to perform high-resolution dynamics calculations tailored to simulate the atmosphere of this planet, showing that the observed variability is consistent with quasi-periodic weather patterns.

Conventional atmospheric retrieval techniques for transiting exoplanets extract physical properties, such as chemical abundances, thermal structures and cloud properties, from reduced spectra. Reduced spectra, however, are a form of 'summary statistics' of the observations, which by definition do not encode all the available information. Here, we present a new extraction method that acts on the panchromatic light-curves (i.e., closer to the data), enabling us to extract more informations from transit, eclipse, and phase-curve observations of exoplanets. This new method is implemented in ExPLOR, a new class of atmospheric retrievals that adds time new axis in exoplanet observations.

[Poster #9] Chiara Circosta [Co-authors: Chiara Circosta]

5000 eyes on feedback from active galactic nuclei

Accreting supermassive black holes (aka active galactic nuclei, 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 host galaxies. This process, the so-called AGN feedback, is thought to be key in shaping the life-cycle of galaxies. AGN feedback is a necessary ingredient of theoretical models of galaxy evolution, although proving its role observationally remains a challenge. The Dark Energy Spectroscopic Instrument (DESI) survey is collecting 5000 spectra at a time over a large area of the sky, therefore providing an unprecedented sample of thousands of targets to investigate diagnostics of ionized winds such as [OIII] up to redshift 1 (when the Universe was about 6 Gyr old). In this talk I will present recent work aimed at characterizing ionized winds through multi-component line fitting using DESI data, which offer an ideal avenue to build a statistical understanding of AGN feedback across the galaxy population.

[Poster #10] Thomas Cornet [Co-authors: G. Cruz-Mermy, I. Belgacem, F. Andrieu, F. Schmidt]

A database framework to explore the surface of Jupiter's icy moons in the infrared

The NASA Galileo spacecraft explored the Jupiter system between 1995 and 2003. The mission was equipped with the Near-Infrared Mapping Spectrometer instrument (NIMS), able to probe the Jupiter's atmosphere and the icy moons' surface composition in the near-infrared with its 17 detectors operating between 0.7 to 5.2 microns [1]. The Galileo NIMS data were collected during flybys, which resulted in diverse data cubes viewing geometries and spatial resolutions. In addition, depending on the instrument mode used to collect the data, and on the instrument own health status, the NIMS infrared spectra were collected with a varying spectral sampling (between 15 and 408 wavelengths), and a varying absolute wavelength calibration over the course of the mission. Despite its heterogeneity and complexity of use, the Galileo/NIMS data set represents, to date, one of the most valuable data set to model and mapping the surface composition of Jupiter's moons, which are the prime targets of the Europa Clipper [2] and ESA JUICE [3] missions in this decade.

We are currently re-investigating the spectroscopic and photometric properties of the Jovian moons using the Galileo/NIMS data set publicly available on the PDS Imaging Node (as g-cubes) and decomposed into a MySQL relational database. Radiance factors data can be retrieved using queries on the viewing geometry (incidence, emission, phase, and azimuth), and the location (pixel geographic latitudes and longitudes, spatial resolution, target), integrated over the entire NIMS data set in a matter of seconds. This allows the rapid extraction of phase curves and spectra as prime inputs to spectrophotometric data modeling studies [4, 5, 6].

References [1] Carlson et al., Space Science Reviews, 60, 457-502, 1992. [2] Howell and Pappalardo, Nat Commun 11, 1311, 2020. [3] Grasset et al., Plan Spac Sci 78, 1-21, 2013. [4] Cruz Mermy et al., Icarus 394, 115379, 2023. [5] Belgacem et al., EPSC, 2022. [6] Andrieu et al., EPSC 2022.

[Poster #11] Marc Costa Sitja [Co-authors: Paula Betriu, Manel Soria, Jordi Gutierrez]

Optimization of the Juice Ganymede phase scheduling with genetic algorithms

The Juice mission science planning is divided in two phases: the Jupiter Tour and the Ganymede phase. Both phases present different challenging approaches to strategic and detailed science planning. Whilst the Juice SOC core system is focused on the Jupiter Tour science planning, which is more similar to a multi-flyby mission like Rosetta, there is a need to address the design and strategy of the Ganymede Phase planning. The challenges of the Ganymede phase can be potentially addressed with a semi-automated planning approach involving the optimal skeleton scheduling of science observations.

As part of this work we study and develop methods and tools for automated planning and scheduling —using single- and multi objective genetic algorithms— of remote-sensing observation activities in planetary exploration missions. The main objective is to understand whether if the research performed so far is adept to optimize the science return of the Juice Ganymede phase, considering the geometric and (potentially) operational constraints of the instruments and the spacecraft and to build up a first use-case with different optimization parameters for the JANUS framing camera.

[Poster #12] Patricia Cruz [Co-authors: Patricia CruzCo-authors: Miriam Cortés-ContrerasCo-authors: Enrique SolanoCo-authors: Carlos RodrigoCo-authors: Dante MinnitiCo-authors: Javier Alonso-GarcíaCo-authors: Roberto K. Saito]

Identifying M dwarf stars towards the Galactic bulge using VVV, Gaia DR3, and Virtual Observatory tools

M dwarf stars are the dominant stellar population in the Milky Way, and they are important for a wide variety of astrophysical topics, for instance, as prime targets in the search for life outside our Solar System. The Gaia mission has delivered a superb collection of data, nevertheless, ground-based photometric surveys are still needed to study red, faint objects. In this work, we have identified and characterised M dwarfs in the direction of the Galactic bulge by using photometric data and with the help of Virtual Observatory tools. The studied region is the b294 tile from Vista Variables in the Via Lactea (VVV) survey, which is a deep near-infrared survey towards Galactic Southern plane. We used parallax measurements and proper motions from Gaia Data Release 3, in addition to different colour cuts based on VISTA filters, to identify 7925 M dwarf stars in V tile b294. We performed a spectral energy distribution fitting to derive the effective temperature for all objects using broad-band photometry available at Virtual Observatory archives, which varies from 2800 to 3900 K. As a secondary outcome, we also searched for periodic signals in WV light curves with up to 300 epochs. Our sample has increased significantly the number of known M dwarfs in the direction of the Galactic bulge and within 500 pc, showing the importance of ground-based photometric surveys in the near-infrared and the need for future space-based IR surveys.

[Poster #13] Guido De Marchi [Co-authors: Guido De Marchi, Ciaran Rogers, Bernhard Brandl]

Measuring the extinction in the massive cluster NGC 3603 with NIRSpec

Using NIRSpec onboard JWST we have studied the spectra of a large number of sources in the young massive cluster NGC 3603 in the Milky Way. The spectra are used not only to study the physical properties of the stars, but also those of the interstellar medium that surrounds them. In particular, we have determined a new extinction law towards this giant HII region, sampling the inner 50' from the cluster centre. We have done this by exploiting the strong Brackett recombination lines present in over 600 nebular spectra throughout the region. The recombination line intensity ratios were used to determine independent values of the selective extinction E(B-V). A wide range of extinction curves were tested, and the finally adopted curve is the one that produced the least amount of scatter in E(B-V) for each spectrum. The resulting extinction characteristics in NGC 3603 are similar to other galactic HII regions like Orion, as well as extragalactic starburst regions such 30 Doradus, in that we find a high value of R(V) = 5.2 +/- 0.8. This corresponds to a reddening of E(B-V)=0.7 +/- 0.2, which is about half the value published in previous works. The large value of R(V) underlines the existence of an important grey component to the extinction, due to a larger fraction of big grains in the mix, compared to the diffuse interstellar medium. Furthermore, we find that the extinction curve, i.e. R(V), varies across the field, with higher values of R(V) corresponding to regions with brighter dust emission. The likely cause of the larger R(V) values and larger fraction of big grains is localized fresh injection of new big grains by supernova explosions.

[Poster #14] Xavier Dupac [Co-authors: X. Dupac, J. Gallegos, M. López-Caniego]

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

CUBIQU (CubeSat for I,Q,U calibration, pronounced queue-bee-queue) is a project developed at ESA-ESAC, mostly from the work of ESA trainees and a fruitful collaboration with Universidad Politécnica de Madrid, whose aim is to build a CubeSat with two polarized antennas as payload (11 GHz and 30 GHz), in order to point at the ground to allow Cosmic Microwave Background polarization ground-based experiments, such as QUIJOTE, to calibrate their instruments on these sources. Several aspects of the CubeSat have been worked on over the past years, such as the Attitude Determination and Control System (a proof of concept was demonstrated using an air-bearing test bed), the design of a 1-unit CubeSat and the integration of its subsystems, the design and manufacturing of patch antennas for communication (S-band), the design and manufacturing of the payload patch antennas (11 and 30 GHz), the building of a ground station at ESAC for receiving signals from CubeSats in space, and the creation of a Helmholtz cage to simulate magnetic field conditions in space. In this presentation, we will describe the goals of the project, how the work has been proceeding so far and the expected future of the project.

[Poster #15] Willi Exner []

Determining the Influence of the IMF and Planetary Magnetic Field Models on Mercury's Magnetosphere along Spacecraft Tarjectories of MESSENGER, BepiColombo and MPO

Determining the internal planetary magnetic field moments of planet Mercury is one of the major goals of the late MESSENGER and upcoming BepiColombo mission. Due to the northerly biased spacecraft coverage of the MESSENGER mission, the available planetary magnetic field models (PMFMs) are well equipped to describe the northern magnetosphere. However, these PMFMs differ significantly in their predicted magnetic field strengths in the southern magnetosphere due to the subtractive behaviour of the higher orders of the multipole moments. Hence, comparing magnetic field observations outside of the previously covered regions, i.e., trajectories passing through the southern magnetosphere, with global 3D modeling of the magnetosphere will be an important indicator to determine the more applicape PMFM. Such trajectories are the MESSENGER M1 and M2 flybys, BepiColombo's MSB1 and MSB2 swingbys and the Mercury Planetary Orbiter (MPO) after its orbit insertion. To estimate the influence of the upstream interplanetary magnetic field (IMF) on the local field topology, we increase our parameter space with the most prevalent IMF directions at Mercury, obtained from the Parker spiral. Our results indicate that the PMFMs result in significantly different magnetic field strengths within the southern magnetosphere of about a third of the local magnetic field magnitude at the closest approaches of M1 and MSB1. Consequently, the southern section of the magnetopause boundary shows different altitudes, locations of the southern cusp, and, in the case of MPO orbits, result in extended passages through the dayside magnetosheath. In addition to analysis of future MPO observations, our results can be used to directly determine the PMFM of Mercury.

[Poster #16] Katja Fahrion [Co-authors: Guido De Marchi]

Peering into the 30 Doradus star forming region with JWST

The 30 Doradus region in the Large Magellanic Cloud is the most energetic star forming region in the Local Group, powered by a young massive star cluster at its centre. Given the low metallicity of the Large Magellanic Cloud, this region has often been considered as a local analogue to the sites of star formation in the high redshift Universe. I will present our work on 30 Doradus using JWST NIRCam imaging that allows us to peer deep into the complex dust structures of this region to study how and where star formation proceeds in 30 Doradus. Combining JWST with Hubble Space Telescope data, we are able to constrain how dust extinguishes light in a broad wavelength range from the ultra violet to the near infrared. Then applying this dust extinction law, we identify stellar populations of varying ages in the region, including low-mass pre-main sequence stars of only 0.1 solar masses. We also detect populations that have excess emission in either emission lines or dust as signatures of young pre-main sequence objects. Studying the spatial distribution of the populations of different ages, we find evidence of the still-ongoing hierarchical formation of this region.

[Poster #17] MariCruz Galvez Ortiz [Co-authors: Paticia Cruz, Johannes Sahlmann]

COMPANIONS FOR GAIA LOW-MASS OBJECTS

We adopted a sample of 1843 sources listed as astrometric binary systems, composed of possibly late-type components, published by the Gaia Collaboration et al. (2022). We used tools from the Virtual Observatory (VO) in combination with data from Gaia DR3 and other archive data to search for the signature of potential companions as an infrared excess in the sources' spectral energy distributions. We have identified 7 candidates that may have a lower-temperature/mass companion. We have started a spectroscopic follow up to confirm the low-mass nature of the companion candidates. We will present the project and discuss the results obtained so far.

[Poster #18] Pedro Garcia-Lario [Co-authors: Sandor Kruk (ESAC), Bruno Merín (ESAC), Krzys Nienartowicz (Sednai), Milena Ratajczak (Science Now), Laurent Eyer (U. Geneva) and Gaia Coordination Unit 7 @ University of Geneva]

GaiaVari: classifying variable sources in Gaia DR3 using citizen science

GaiaVari is a faculty-funded citizen science project to inspect the epoch photometry of variable sources identified as such in Gaia DR3 and critically review/verify their variability classification. Given the large dataset of variable sources provided in Gaia DR3 (more than 10 million) it is impossible for the experts to perform a systematic detailed analysis of individual sources and assign classifications. A comprehensive exploration of the epoch photometry data with human eyes can help verifying the classifications provided by the automated tools and identify misclassified sources and/or weird sources displaying unusual properties, which may result in new science and improvements in the classification software. In this talk we will present our experience developing and implementing this project in the context of the Zooniverse.org citizen science platform and the main outcome of the project, not only in terms of the science return to the Gaia mission, but also including the high potential of this and similar projects based on the contents of the ESA science archives for outreach and education of the general public.

We present the main results of this multi-year Faculty funded project intended to build a 'Gaia DR3 Galactic Catalogue of Asymptotic Giant Branch (AGB) stars' and characterise their photometric colours, variability properties and absolute luminosities as measured by Gaia, in connection with their overall spectral energy distribution and chemical composition, derived from photometric and spectroscopic information, respectively, retrieved at other wavelengths from other resources using Virtual Observatory tools. Due to the lack of accurate distances to galactic AGB stars, studies have been made in the past mainly using the Magellanic Cloud population of AGB stars. Now, thanks to the astrometric information provided by the Gaia mission, we are able to explore the galactic AGB population on a larger scale, taking advantage of the distances derived from Gaia data.

[Poster #19] Björn Grieger [Co-authors: Fiet Vujagig]

Spooky Action: A Brief Proof of Quantum Reality

Quantum mechanics tells us that the outcome of a measurement of a quantum system is truly random. We can exactly predict probabilities, but we cannot in general predict the outcome of an individual measurement. Moreover, the quantum system does not even have a certain state before the measurement.

Albert Einstein and some other scientists were thinking that quantum mechanics is incomplete and misses hidden parameters. Therefore, a more comprehensive theory would enable us to predict the outcome of an individual measurement. Einstein and his colleagues advocated this approach in a paper which presented a Gedankenexperiment which is now called the Einstein-Podolsky-Rosen (EPR) paradox. Einstein's view would imply that the system does already have a certain state before the measurement and that it even has this state if the measurement is not carried out.

It may appear as if this is a rather esoteric debate, like the question whether the Moon disappears if you close your eyes, but it can be proofed that Einstein was wrong on this subject. Here, we try to present this proof as concise as possible. The mathematical description of a simple quantum systems - like, e. g., a hydrogen atom - by quantum mechanics is already quite complicated. In order to explore the EPR paradox, we employ the most basic quantum systems, quantum bits, or qubits. This keeps the mathematical effort manageable and Qiskit, an open-source Software Development Kit for quantum computing, provides convenient simulation and visualization tools. The results are confirmed by experiments on real quantum hardware that clearly rule out the existence of hidden parameters.

[Poster #20] Maximilian Günther [Co-authors: Mariasole Agazzi, Nicol Caplin, Quentin Changeat, Willi Exner, Salma Fahmy, Laura Hayes, Ana Heras, Gaitee Hussain, Markus Kissler-Patig, Theresa Lüftinger, Bruno Merín, Daniel Pardekooper, Isabel Rebollido Vázquez, Emily Rickman, Elliot Sefton-Nash, Jorge Vago, Olivier Witasse]

ESA Brainstorming on Astrobiology

The ESA Brainstorming on Astrobiology, realised via a Science Faculty grant, was a successful pilot for a series of open, informal, and multidisciplinary workshops on astrobiology. The experimental concept was built on a hybrid between a classical top-down conference and modern bottom-up 'unconference' approaches, featuring expert discussions, peer-to-peer learning, and public talks. The event united nearly 60 scientists from ESA and the community - including exoplanets, planetary science, and solar/stellar physics - for a full week at ESTEC from 16 to 20 October 2023. Our ambitious goals were fostering transparency and collaboration, connecting scientists from ESA and the community with the Zeitgeist of the rapidly growing astrobiology field, brainstorming outside-of-the-box ideas for interdisciplinary approaches, and disseminating our findings via public lectures and a scientific publication. Our vision was to form a diverse group in terms of research expertise, gender, seniority, background, institute country, and professional functionality. After very positive feedback from the community, we anticipate to grow the event in an impactful and sustainable way, driven by community-led working groups (axes) and future events in the series.

[Poster #21] Ana María Heras [Co-authors: Marylyn Rosenqvist, Ana M. Heras, Maximilian Guenther, Kate Isaak, Theresa Lueftinger]

Multi-band photometric observations of exoplanet transits

The transit method is key to characterising exoplanet atmospheres, but the presence of spots and faculae on the stellar disk can affect the measurements of the transit depth and therefore the interpretation of spectral features. We will present an analysis on multi-band observations of transiting exoplanets aimed to determine the wavelength dependences of transit depths and study their association with stellar activity. In particular, we have performed the data reduction and aperture photometry for a sample of exoplanets observed with ESA's Optical Ground Station, and analysed data of the targets observed with the Transiting Exoplanet Survey Satellite (TESS) and with the MuSCAT2 instrument on the Carlos Sánchez Telescope. For each target and observation, we have derived the planet-to-star radius ratios in each wavelength band by transit fitting with a MCMC model, and then estimated the temperatures and filling factors of spots and faculae. Our results are generally consistent with the stellar variability model from Rackham et al. (2018), favouring that both spots and faculae must be accounted for to explain the observed trends. Possible deviations concern the faculae filling factors in stars with Teff $>$ 5500 K, which are larger in our study than previously estimated.

[Poster #22] Fran Jiménez-Esteban [Co-authors: Enrique Solano, Patricia Cruz, Raquel Murillo-Ojeda, Santiago Torres, Alberto Rebassa-Mansergas]

White dwarf star studies from Gaia and the Virtual Observatory

As everybody already knows, Gaia mission has revolutionized our knowledge in many fields of Astronomy. Since the beginning, Gaia and the Virtual Observatory have demonstrated to be a pairing of great value. At the Spanish Virtual Observatory group we have extensively used this pairing for the study of white dwarf stellar evolution. We were the first in published a catalogue of white dwarf stars from Gaia-DR2, or the first in exploiting Gaia-DR3 BP/RP spectra to characterize the white dwarf population in the solar neighbourhood, among others. In this talk, we will review the studies we have done so far and the results obtained, focusing on those based on Gaia data.

[Poster #23] Jari Kajava [Co-authors: Celia Sanchez-Fernandez, Erik Kuulkers]

Structure of the disc-star boundary around weakly-magnetized neutron stars

Neutron stars are stellar remnants that are formed when massive stars collapse at the end of their evolution. Some thus-formed neutron stars have sun-like binary companions, and when in close contact mass transfer can start taking place onto the neutron star. Many aspects of the accretion processes are not understood at present, particularly regarding the geometry of the boundary between the accretion disc and the stellar surface. In this presentation, we will present an overview of how we are utilizing the INTEGRAL and XMM-Newton science archives, as well as data from NASA missions, to shed light on how the accreted gas settles onto the neutron star surface, and how the star and the disc interplay when the accreted gas fuses rapidly in a thermonuclear runaway.

[Poster #24] Peter Kretschmar [Co-authors: Felix Fürst, Victoria Grinberg, Isabelle Caballero]

X-ray lighthouses observed through a relativistic looking glass – what we can learn from the pulse profiles of accreting X-ray pulsars

Neutron stars harbor the strongest magnetic fields known in the universe. These fields dominate the physical processes and lead to the existence of pulsars. In accreting X-ray pulsars, matter captured from a companion star is captured by the field far away from the neutron star and funneled to the magnetic poles leading to strong X-ray radiation being emitted from these poles. As the neutron star rotates, this emission will be pulsating with the rotation period. The emission patterns are intrinsically complex. In addition, neutron stars are so compact that spacetime is markedly curved close to the surface, meaning that photons may go quite complex paths to reach an observer. The resulting energy-dependent pulsating emission – the pulse profile – is usually very specific for an individual source, kind of a 'fingerprint'. Studying these profiles can, in principle, yield a lot of diagnostic information about the physics of accretion, X-ray emission, or the neutron star's mass-radius relation. The presentation will give a brief overview of X-ray observations, as well as the theoretical efforts to understand the observed emission, highlighting challenges and possible ways forward. The collaboration behind this work was supported by a Science Exchange Programme (Disentangling Pulse Profiles

[Poster #25] Nimisha Kumari [Co-authors: This talk is based on 6 papers, with different co-authors on different papers. I will list them on the slides in my talk.]

3D view of emission line galaxies

Galaxy formation and evolution are regulated by a complex interplay between star formation, chemical abundance and gas dynamics. This intricate ballet of gas flows in, out, and within galaxies can lead to chemical inhomogeneities in the gas across the star-forming galaxies (and manifests itself in the form of ordered/disordered kinematics and photo/shock-ionization of the interstellar medium. Detailed spatially resolved kinematic and chemical studies of star-forming galaxies/regions can unravel some of the secrets of the key mechanisms involved in galaxy formation and evolution. Integral field spectroscopy (IFS) is a powerful technique to perform such detailed spatially-resolved studies. In this contribution, I will present my efforts on studying various aspects of galaxy formation and evolution by performing detailed studies of emission line galaxies - dwarfs and spirals - by using data from several ground IFU facilities such as GMOS, MUSE and SDSS-MANGA thus demonstrating the significant impact of IFS in the broad field of extragalactic astronomy.

[Poster #26] Marcos Lopez-Caniego [Co-authors: Miguel Doctor, Miguel Angel Diego, Javier Espinosa]

Enhancing object-type based searches in ESA's astronomical archives extending ESASky's AI capabilities with Large Language Models and Retrieval Augmented Generation

The realm of Large Language Models (LLMs) stands as one of the most thrilling frontiers in today's Artificial Intelligence (AI) exploration. Since ChatGPT emerged in late 2022, these models have ignited a profound transformation across various industries, serving as the bedrock of groundbreaking advancements in many fields including astronomy.

Taking advantage of the platform developed in the context of ESA's Virtual Assistant, and, in particular, its integration in the ESASky web application, we want to explore the possibility of using LLMs to facilitate the exploitation of ESA's scientific archives in an innovative way.

At the moment the users of ESASky are given the possibility to identify objects within a given field of view that have scientific articles associated to them using information compiled by Simbad (CDS-Strasbourg Observatory).

This is possible because ESASky queries two very specific tables in the Simbad astronomical database of objects that link objects in the sky with publications that mention or analyze these objects.

But, what if we could ask EVA in ESASky to find observations, catalogues and spectra across multiple wavelengths for specific types of objects? For example, we could ask EVA to find for us observations of brown dwarfs, X-ray binaries, blazars, etc., hosted in ESA's astronomy archives? Such object-type oriented search is not possible in ESASky and scientists would greatly benefit from such search capabilities.

We propose to use AI to make the link between scientific publications titles, object coordinates, object id's, object types, and other physical magnitudes contained in Simbad tables in such a way that the users of ESASky can search for specific types of objects.

For this purpose we have set up an LLM model based on Mistral 7b that could empower ESASky with yet another layer of AI. EVA in ESASky already uses natural language processing to "operate" ESASky via its extended API. Now we go one step beyond combining the existing EVA in ESASky capability with Retrieval Augmented Generation (RAG) applications that augment LLM's generation capabilities by retrieving relevant information from an external knowledge base (in this case specific publicly available tables in the Simbad astronomical object database) without having to retrain the foundational model.

In this presentation we will show the current status of this exploratory project.

[Poster #27] Arnaud Masson [Co-authors: Arnaud Masson]

Heliophysics/Space weather science information architecture and innovative solutions: progress report

Over the past decade, radical changes have happened in the world of science and information technology. Open science is now recommended by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021). In parallel, artificial intelligence (AI) and machine learning (ML) technologies are profoundly impacting most fields of science and space weather in particular. These key aspects did not exist when the 2015-2025 COmmittee on SPAce Research (COSPAR)/International Living With a Star (ILWS) Space weather roadmap was published by Schrijver et al. (2015).

Hence, when the COSPAR International Space Weather Action Teams (ISWAT) initiated community-wide efforts, back in 2020, to join forces in order to advance space weather predictive capabilities, four ISWAT overarching activities were created: assessment, information architecture and data utilization, innovative solutions and education/outreach. These topics are indeed transversal activities across all subfields of space weather research, focusing on either the variability of heliospheric regions or physical phenomena and their specific space weather impacts.

Here, we present a progress report on the outcome of the information architecture and innovative solutions working groups. We will first present the key building blocks of the space weather information architecture. We will then present (open science) tools and infrastructures (e.g., ESA DataLabs, NASA Heliocloud). We will highlight examples of AI/ML solutions applied to the data available through this information architecture and how, sometimes, they can improve forecast. Key recommendations will be then presented showing how powerful this open science ecosystem is, but also requiring continuous and sustainable support. Finally, the start of an on-going coordination between COSPAR/ISWAT, the UN World Meteorological Organisation (WMO) and the International Space Environment Services (ISES) will be evoked.

[Poster #28] Felix Meeker-Fuerst [Co-authors: Walton, D.JCo-authors: Israel, G.L.Co-authors: Bachetti, M.Co-authors: Belfiore, A.Co-authors: et al]

Magnetic field and orbital period of NGC 5907 ULX-1

NGC 5907 ULX-1 is the brightest known ultra-luminous X-ray pulsar (ULXP), with luminosities exceeding 1e41 erg/s during the high state. However, it shows large variability, and was in an off state between 2017-2020. Based on precise measurements with XMM-Newton of the pulse period just before and immediately after the off state, we show that the pulsar slowed down in this period. This is the first time a strong spin-down is seen during a low flux state in a ULXP. We interpret this as a spin-down due to the propeller effect, where accretion is magnetically inhibited, and the large magnetosphere slows the pulsar down. Based on this interpretation, the dipole magnetic field of the neutron star is larger than 1e13G. At the same time the precise pulse period measurements allow us to infer the orbital period of the system, which is around 5.6d. Our results therefore shine a light on the intrinsic properties of the system, showing that a small orbit and very strong magnetic field seems to be necessary to explain the extreme luminosity.

[Poster #29] Alcione Mora [Co-authors: Regina Temiño]

Remote Sensing of Coastal Upwelling. An astronomer observing the Earth

I will present my Artificial Intelligence Master thesis on coastal upwelling characterized using remote sensing Copernicus data. Apart from its scientific merit, I have found notable parallelisms between Astronomy and Earth Observation, including data formats, science archives, Python libraries and code-to-the-data platforms. I believe cross-fertilization between such closely related fields could be very beneficial.

Sea upwelling systems are key ecosystems where deep water rich in nutrients arises to the sea surface. They constitute the most fertile oceanic regions, providing the richest fisheries in the world. This work explores and characterizes sea upwelling based on sea surface temperature and chlorophyll density maps. Level 4 Copernicus data have been used. Three prototypical coasts have been analyzed: Portugal, Peru and Chile. The temporal baseline is 41 years for the temperature and 24 for chlorophyll.

Three different Artificial Intelligence algorithms (unsupervised classification) have been applied to the images to detect (segment) upwells, group them temporally and finally divide them between two spatial regions: internal reasonably stable (core) and external and variable (shell). For each epoch, image and segmentation, different magnitudes have been analysed in terms of seasonality, long term evolution and bi-variable relationships.

The most important results are as follows. First, there is seasonality in all coasts both for the temperature and the chlorophyll. Second, the chlorophyll content is strongly correlated with the temperature gradient between the upwell and its environment. Third, the global warming is clearly identified in Portugal, but not in the other coasts. However, the upwell-environment temperature contrast has increased in all areas. This is compatible with the upwell intensification hypothesis. Forth, Chlorophyll has increased in Portugal and Chile, with the changes in Portugal being much higher than previously reported. These increments are opposite to the general trend of upwell biomass content getting smaller as the global temperature rises.

[Poster #30] Daniel Müller [Co-authors: D. Müller, Y. Zouganelis, M. Janvier, A. De Groof, D. Williams, A. Walsh, L. Hayes, S. Musset, C. Nelson, P. Osuna, L. Sanchez]

Solar Orbiter: Science highlights and mission status

This contribution will summarise recent science highlights of the Solar Orbiter mission. Solar Orbiter started its nominal mission phase in December 2021, with perihelia around 0.29 au occurring every six months. The ten instruments onboard provide high-resolution imaging and spectroscopy of the Sun and corona, as well as detailed in-situ measurements of the surrounding heliosphere. Together, these observations enable us to comprehensively study the Sun in unprecedented detail and determine the linkage between observed solar wind streams and their source regions on the Sun. Solar Orbiter's science return is significantly enhanced by coordinated observations with other space missions, including Parker Solar Probe, SDO, SOHO, STEREO, Hinode and IRIS, as well as new ground-based telescopes like DKIST. Starting in 2025, Solar Orbiter's highly elliptical orbit will get progressively more inclined to the ecliptic plane, which will enable the first detailed observations of the Sun's unexplored polar regions.

[Poster #31] Sophie Musset [Co-authors: Sophie Musset, Louis Siebenaler, Olivier Witasse]

Multi-spacecraft study of solar radio bursts with heliospheric and planetary missions

Solar energetic electrons, accelerated during solar flares or coronal mass ejection, will be responsible for radio emission as they propagate in the heliosphere: the so-called solar radio bursts. The current fleet of heliospheric and planetary missions measuring the radio flux in the solar system, enable us for the first time to measure radio bursts simultaneously from multiple positions in the heliosphere. Two years ago, I presented some preliminary results of solar radio bursts observed by four heliospheric missions. In this presentation, I will report on an extensive study of these radio bursts and the comparison of these observational results with simulations of radio-wave propagation in the heliosphere. I will then demonstrate that planetary missions also produce observations of solar radio bursts, by presenting observations from the MARSIS instrument on Mars Express and conclude on how to incorporate data from planetary missions in future studies of solar radio bursts.

[Poster #32] Chris Nelson [Co-authors: M. Janvier, D. Mueller]

Solar Orbiter coordinated observations: Planning and science exploitation

Combining datasets from the powerful suite of instruments carried by Solar Orbiter allows massive advances in understanding of our closest star to be made. However, some of the most impactful results come from combining Solar Orbiter data with observations sampled by other telescopes, including the Interface Region Imaging Spectrograph (IRIS) satellite and the Daniel K. Inouye Solar Telescope (DKIST) ground-based telescope. In this talk, we will discuss how coordinated observations are conducted, the science results that comes from them, and why we need further coordinated observations in the future. Essentially, this talk covers both the scientific and functional work that I have been conducting during my fellowship.

[Poster #33] Joana S. Oliveira [Co-authors: Foteini Vervelidou, Mark A. Wieczorek, Marina Diaz Michelena]

Constraints on the spatial distribution of lunar crustal magnetic sources from orbital magnetic field data

Spacecraft measurements show that the crust of the Moon is heterogeneously magnetized. The sources of these magnetic anomalies are yet not fully understood, with most not being related to known geological structures or processes. Here we use an inversion methodology that relies on the assumption of unidirectional magnetization, commonly referred to as Parker's method, to elucidate the origin of the magnetic sources by constraining the location and geometry of the underlying magnetization. This method has been used previously to infer the direction of the underlying magnetization but it has not been tested as to whether it can infer the geometry of the source. The performance of the method is here assessed by conducting a variety of tests, using synthetic magnetized bodies of different geometries mimicking the main geological structures potentially magnetized within the lunar crust. Results from our tests show that this method successfully localizes and delineates the two-dimensional surface projection of subsurface three-dimensional magnetized bodies, provided their magnetization is close to unidirectional and the magnetic field data are of sufficient spatial resolution and reasonable signal-to-noise ratio. We applied this inversion method to two different lunar magnetic anomalies, the Mendel-Rydberg impact basin and the Reiner Gamma swirl. For Mendel-Rydberg, our analysis shows that the strongest magnetic sources are located within the basin's inner ring, whereas for Reiner Gamma, the strongest magnetic sources form a narrow dike-like body that emanates from the center of the Marius Hills volcanic complex.

[Poster #34] Ricardo Pérez Martínez [Co-authors: Ana María Pérez García (CAB), Jesús Vega (U Valladolid), Helena Domínguez (CEFCA), Fernando Buitrago (U Valladolid), Sandor Kruk (ESA), Jan Reerink (ESA)]

Machine learning techniques applied to cluster galaxies

The production of large catalogs of galaxies belonging to clusters with high levels of purity and completeness is key for several open questions in astronomy, from cosmology to galaxy evolution. The optimal way of assigning membership is based on spectroscopic redshifts, but they are difficult to obtain in terms of exposure time and data quality. Other means, like color selection, isophotal profiles or photometric redshifts, alone or combined, imply selection biases and uncertainties that often result in conflicting conclusions when using different methodologies and datasets. We present here a new methodology to determine membership of galaxies to clusters based on convolutional neural networks using HST and XMM Newton images together with ancillary data such as projected surface densities and clustercentric distances. We have applied this method to 16 clusters from the Hubble Frontiers Field Survey, significantly extending the member catalogue. We will also discuss the main difficulties and caveats of this approach and the plans for improving the tool in the near future.

[Poster #35] Valeria Pettorino [Co-authors: Valeria Pettorino]

Distinguishing Dark Energy theories

As I have just arrived at ESTEC, I will introduce myself. I will recall the status of Dark Energy and Modified Gravity and some of the challenges involved in testing different theoretical models and gravitational interactions. I will present some recent results that investigate how different choices in the statistics used in the analysis can make a difference in the result which we obtain: for example, statistics beyond power spectrum can help to distinguish different theories.

[Poster #36] Tim Rawle [Co-authors: N. Lutzgendorf, E. Curtis-Lake, A. Bunker, J. Witstok and the JADES Collaboration]

JADES: Science highlights from the GOODS deep-fields

We present an overview of recent results from the James Webb Space Telescope (JWST) Advanced Deep Extragalactic Survey (JADES), using 770 hours of guaranteed observations in the GOODS deep fields. The programme is intended as a comprehensive study of galaxy evolution from the highest redshifts to 'cosmic noon', combining 8-10-band tiered-depth NIRCam near-infrared imaging, extensive 0.6-5.3 micron NIRSpec multi-object spectroscopy targetting over 5000 faint sources, and coordinated parallel imaging in the mid-infrared using MIRI. Fourteen JADES papers have been published, with a further 25 submitted, accruing almost 800 citations. Scientific highlights include: detection of carbonaceous grains in large dust reservoirs within the first billion years of cosmic time, implying rapid production; remarkable extended Lyman-alpha emission at epochs previously expected to have highly neutral intergalactic medium; and discovery of a metal-poor galaxy at $z=13.2$, the current record-holder for a spectroscopically-confirmed redshift.

[Poster #37] Patricio Reller [Co-authors: Rafael Brahm, Antónia Vojteková, Bruno Merín, Ingo Waldmann, Maximilian Günter, Anna Francesca Pala, Tristan Guillot, Amaury Triaud, Keivan G. Stassun, Nicolas Crouzet, Kate Isaak, Ana Heras, Theresa Lüftinger, Lyu Abe, Djamel Mékarnia, François-Xavier Schmider, Olga Suarez, Philippe Bendjoya, Abdelkrim Agabi, Georgina Dransfield, Domenico Mura, Thomas Gasparetto, Marco Buttu, Jan Eberhardt, Thomas Henning, Melissa J. Hobson, Andrés Jordán, Felipe I. Rojas, Marcelo Tala Pinto, Trifon Trifonov, Johanna Teske, R. Paul Butler, Jeffrey D. Crane, Stephen Shectman, Ian Thompson, David Osip, Gaspar Á. Bakos, W. Bhatti, Zoltan Csubry, Gavin Boyle, Rodrigo Leiva, Vincent Suc]

Transit Timing Variations and Radial Velocity of the long-period exoplanetary system TOI-4409

Long-period exoplanets are scientifically compelling as edge cases within the known exoplanet population and are challenging to observe due to the strict scheduling requirements they impose on the observations. Here we present a combined photometric transit and Radial Velocity analysis of data on the transiting exoplanet TOI-4409 b obtained with TESS, the ASTEP Antarctica-based telescope, CHAT, OMES, FEROS, HARPS and PFS confirm the exoplanet's presence around the star and refine its TESS-derived physical properties. A significant Transit Timing Variation signal detected in the measured transits indicates the potential presence of further exoplanets in the system and will be also discussed. The data-intensive pipeline developed for this project has broader applications beyond this particular study; thus, we will also present its development status and seek feedback from users on desired features that would be most useful for their scientific use cases.

[Poster #38] Tineke Roegiers [Co-authors: Roegiers, T.]

A billion ways of using Gaia data

Gaia data is used in many ways by many scientists and the diversity of the research topics is dazzling, making it sometimes seem like there could be a billion ways of using Gaia data. While Gaia's impact mapping the Milky Way might be obvious, Gaia's data has been used closer to home as well, and further out beyond the Milky Way. A full overview of the many results Gaia data helped with is impossible to make, but a taste of the diversity of topics affected by Gaia is aimed at here. Starting from the Sun we will move out into the Solar System, further out into the Milky Way, and then beyond, all the while exploring the different ways Gaia data has been used so far and pointing to existing outreach resources to learn more about these topics.

[Poster #39] Alicia Rouco Escorial [Co-authors: Alicia Rouco Escorial, Julia Alfonso Garzón, Rudy Wijnands, Nathalie Degenaar, Jakob van den Eijden, Peter Kretschmar, Felix Fuerst, Carlota Prieto Jiménez]

The versatility of XMM-Newton investigating the extreme accretion regimes of Be/X-ray binaries.

In 2023, two Be/X-ray transients, LS V +44 17 and 4U 0115+63, showed their brightest giant outbursts ever observed. Two systems showing their brightest outburst in the same year is extremely unusual, and gives us the unique opportunity to monitor and characterise the physical scenarios across the different luminosity states of the sources. We have monitored the LS V +44 17 and 4U 0115+63 outburst behaviours of the binary systems with Swift/XRT, and obtained unique XMM-Newton observations at high- and low X-ray luminosities. In this talk, I present the preliminary results of our X-ray monitoring and XMM-Newton observations of LS V +44 17 and 4U 0115+63 during and after their giant outbursts. We also compare our new datasets to the archival XMM-Newton observations that were obtained for these sources. We strive to obtain a better understanding of how accretion works at different luminosity states and, most importantly, to unveil the conditions that are in play to make the LS V +44 17 and 4U 0115+63 low X-ray luminosity state behaviours so different from each other.

[Poster #40] Richard Saxton [Co-authors: Giovanni Miniutti, Margherita Giustini]

Quasi-periodic eruptions from super-massive black holes

The discovery of giant quasi-periodic flares in a small number of active and non-active galactic nuclei has caused great excitement in the community and sparked off a cottage industry searching for more examples in archival data. Despite intensive efforts, less than ten examples have so far been uncovered. Of the many theoretical explanations that have been proposed, the leading idea is that flares are generated when a star or compact object crashes through a disk of material rotating about the central black hole. If this proves to be correct then the irregularity of the flares would be caused by the precession of both the disk and the secondary impactor. As these processes occur well within the range of general relativistic effects, careful observations have the potential to measure the mass and spin of the black hole.

In this talk, we summarise the state of the field and look at the prospects for future progress with the soon-to-be-launched Einstein Probe.

[Poster #41] Enrique Solano Márquez [Co-authors: E. Solano, B. Villarroel, C. Rodrigo, et al.]

Discovering vanishing objects using the Virtual Observatory

In this presentation we report the results of a search which aims at finding POSS I sources not present in any other Virtual Observatory (VO) archive. After applying a number of filtering criteria, we ended up with a list of 5399 unidentified transients. These sources, available from a VO compliant archive, can be of interest in searches for strong M-dwarf flares, high-redshift supernovae, asteroids, or other categories of unidentified red transients.

Particularly interesting is the discovery of three optically bright, $\simeq$16th mag, point sources within 10 arcsec of each other that vanished within 1 h, based on two consecutive exposures at Palomar Observatory on 1952 July 19. We obtained two deep exposures with the 10.4-m Gran Telescopio Canarias on 2023 April 25 and 27 in r and g band, both reaching magnitude 25.5 (3σ). The three point sources are still absent, which implies that they have bee absent in telescope exposures during more than 70yr. The explanation for these three transients remains unclear. Models involving background objects that are optically luminous for less than 1 h coupled with foreground gravitational lensing seem plausible.

[Poster #42] Paule Sonnentrucker [Co-authors: Friedman, Chayer, Jenkins, Tripp, Williger, Hebrard]

The D/H ratio in the nearby ISM and the Big Bang!

The Big Bang theory of Nucleosynthesis (BBN) predicts that deuterium (D) is mostly produced in the first minutes after the Big Bang and gets subsequently destroyed in stars via a process called astration. The deuterium abundance (D/H) in the ISM is therefore expected to decrease with time. Its measurements serve to constrain the chemical evolution models of galaxies and allow to probe the early universe. Over the past few decades, a number of FUV space missions measured the D/H ratio toward galactic and extra-galactic sight lines to test both the BBN and our understanding of the Milky Way chemical evolution. The resulting ensemble of D/H spectroscopic measurements showed an approximately constant D/H ratio within the Local Bubble (LB) but significant variability beyond it. This was somewhat unexpected and causes tension between the BBN and models of galactic evolution. A number of physical processes have been put forward to account for these variations, from local infall of pristine or D-rich gas onto the galactic disk to depletion of D onto dust grain. To-date the amplitude of these variations remains puzzling and is somewhat challenged because of large uncertainties attached to the H I column density (N(H I) determinations outside the LB.

To address the N(H I) measurement suspicion, we obtained Cycle 18 HST/STIS observations of the H I Lyα absorption line (1215Å) for 16 galactic sight lines within and beyond the LB. Our analysis demonstrates that the measured D/H variability does not result from HI measurement shortcomings, but is intrinsic to the ISM gas. We confirm the D/H variability beyond the LB and tightened the amplitude of the variations ($\sim$factor 5). We discuss how our results affect models of Galactic chemical evolution and we explore what mechanisms could account for the D/H variability and how we can further test those mechanisms observationally with JWST.

[Poster #43] Roland Vavrek []

Euclid: from space telescope to dark matter surveyor

This talk addresses the key performances that enables Euclid not only to observe the optical and IR sky, but required to survey dark matter in the coming period of 6 years routine operations. We present the early mission status of Euclid with focus on optical, guiding, and thermal performances as well as the science program currently being executed under constrained operating conditions.

[Poster #44] Eva Verdugo [Co-authors: Ana Pérez, David Barrado Navascués, Nuria Huélamo]

JWST and synergies:comprehensive taxonomy of planetary systems

This research consists of scientifically exploiting of JWST data of exoplanets, providing a comprehensive and coherent knowledge of planetary systems as a unit, putting together the data of the planets and host stars.

[Poster #45] Antonia Vojtejová [Co-authors: Ingo Waldmann)UCL), Kai Hou Yip (UCL), Bruno Merín (ESA)]

Exploration of exoplanet atmospheres with machine learning

In the current era of exoplanetary research, we are witnessing an unprecedented wave in acquiring exoplanet-related data. The field is gradually transitioning into the domain of big data science. Consequently, there is a growing imperative to explore novel data analysis techniques, particularly those involving machine learning.

It is widely recognized that unravelling the complexities of exoplanet atmospheres demands substantial computational resources, which may pose future computational bottlenecks. Machine learning offers a promising way to accelerate these computations without necessarily replacing existing models.

In this presentation, we introduce a project to enhance the efficiency of modelling disequilibrium chemistry in exoplanet atmospheres. Our project's objective is the development of a machine learning algorithm capable of speeding the calculation of species abundances within exoplanetary atmospheres, enabling the transition from equilibrium chemistry (equilibrium model - ACE, Agundez et al. 2012) to disequilibrium chemistry (kinetic model - FRECKLL, Al-Refaie et al. 2022). Before delving into the intricacies of deep learning, we have conducted an in-depth analysis of our dataset to uncover inherent patterns and insights.

Our presentation will delve into the scientific methodologies and strategies employed to achieve faster calculations, thereby contributing to our understanding of exoplanetary atmospheres.

[Poster #46] Jack Wright [Co-authors: Francesca Zambon, Cristian Carli, Francesca Altieri, Claudia M. Pöhler, David A, Rothery, Carolyn H. van der Bogert, Angelo Pio Rossi, Matteo Massironi, Matthew R. Balme, Susan J. Conway]

Using all the pieces of the puzzle: integrating geomorphology and reflectance spectra in Mercury Rachmaninoff basin

Geological maps of Earth typically incorporate field observations of rock lithology, structure, composition, and more. In contrast, conventional planetary geological maps are often made using primarily qualitative morphostratigraphic remote sensing observations of planetary surfaces. However, it is possible to define independent quantitative spectral units of planetary surfaces, which potentially contain information about surface composition, grain size, and space weathering exposure. Here, we demonstrate a generic method to combine independently derived geomorphic and spectral units, using the Rachmaninoff basin, Mercury, as an example to create a new geostratigraphic map. From this geostratigraphic map, we can infer some compositional differences within geomorphic units, which clarifies and elaborates on the geological evolution of the region. This work is under review in Earth and Space Science.

[Poster #47] Peter Zeidler [Co-authors: Elena Sabbi, Beena Meena, Anotnella Nota]

From the cluster to the clouds – a journey from the massive OB stars to the youngest, disk-bearing objects of the young star cluster NGC 602

We present a multi-instrument (HST, JWST, VLT/MUSE), multi-wavelength (FUV to mid-IR) study of NGC 602, the Small Magellanic Cloud low-metallicity counterpart of Trumpler 14. NGC 602 is a unique example for star formation in isolation. Located in the 'wing' of the Small Magellanic Cloud, a very low metallicity environment, it formed through the interaction and collision of three HI shell structures. The cluster's mass budget is comparable to well-studied Milky Way young star clusters (YSCs) and with numerous centrally concentrated O and B stars it makes it a low-metallicity equivalent to Trumpler 14 in the Carina Nebula. We quantify the far-ultra-violet (FUV) fluxes and stellar winds of the massive cluster stars using Hubble STIS spectra, characterize the stellar and gas kinematics with optical multi-epoch Hubble photometry and MUSE IFU spectroscopy, while with Webb we investigate the disk-bearing pre-main-sequence (PMS) stars and reveal the young stellar objects (YSOs) deeply embedded in the surrounding HII region. With this remarkable dataset, we show how massive OB star FUV radiation and stellar winds impact the evolution of PMS star protoplanetary disks in the cluster center and even hamper (rocky) planet formation, in an environment similar to the cosmic noon, when star formation in the Universe peaked. By detecting deeply embedded Class 0/I YSOs, the Webb data reveals how efficiently OB stars drive star formation into the surrounding gas and dust clouds, thus triggering a new generation of stellar and planetary systems, even small subclusters. Furthermore, the stellar and gas kinematics of this region not only shed light on their current interactions but also reveal the channel through which this cluster formed.

All together we paint the full evolutionary and kinematic picture of NGC 602, a YSC in a relatively isolated region of space, where feedback and evolution processes are regulated primarily by its early-type stars in the center we demonstrate the power of combining state-of-the art space and ground-based telescopes.

[Poster #48] Léa Zuili []

MLOps integration on Datalabs

The presentation will deal the possibility of adding MLOps (Machine Learning Operations) capabilities on ESA Datalabs. This platform, among other capability, provides datalabs to process and analyze data from ESA which can often include machine learning approach.