ESA SCI Science Workshop #14
10–12 November 2021
Hybrid Meeting

Abstracts

Organising Committee:

Alba Alcol, Ines Belgacem, Johannes Benkhoff Isabel Caballero Domenech, Patricia Cruz, Matteo Guainazzi, Oliver Jennrich, Tereza Jerabkova, Erik Kuulkers, Álvaro Labiano Ortega, Andrew Lobban, Marcos López-Caniego, Jan-Uwe Ness, Theresa Rank-Lüftinger, Tim Rawle, Mylene Riemens, Jan Tauber.

The 14th SCI Science Workshop

10-12 Nov 2021, Aranjuez, Spain

Please note that the order of all talks within a given block will be randomised at the time.
Webex link for virtual participants:
https://esait.webex.com/esait/j.php?MTID=mee701d85bd87055c5af5d6de13334568

Wednesday 10th November

15:00-15:15: Welcome and Opening Remarks / Introduction of Newcomers

15:15-15:45: **Iris Nijman** (ESTEC) – *Storytelling for Scientists*

15:45-16:45: Science Talks (Webex) (Chair: Andrew Lobban; Co-chair: SOC member)

Nimisha Kumari
(STScI)
Using MaNGA to Probe Hardness of Ionizing Radiation Fields in Nearby Star-Forming Galaxies and Beyond

Andrew Fox
(STScI)
New Insights On the Magellanic Stream

Rickbir Bahia
(ESTEC)
Understanding the Evolution of Martian Topography Through Valley Networks

Elena Manjavacas
(STScI)
Revealing the Vertical Cloud Structure of a Young Low-Mass Brown Dwarf Analog to the Beta-Pictoris b Directly-Imaged Exoplanet

16:45-17:15: Coffee break

17:15-18:00: Science Talks (Webex) (Chair: Oliver Hall; Co-chair: Ines Belgacem)

Jack Wright
(ESAC)
NOAH-H: Deep Learning Terrain Classification of Jezero Crater, Mars

Sophie Musset
(ESTEC)
Multi-Spacecraft Observations of Solar Radio Emissions in the Solar Orbiter Era

Peter Kretschmar
(ESAC)
Surprises From a Well-Known Favourite – Insights From Writing a Review on Vela X-1

18:00-19:00: Poster Session (Webex + Teams) (Chair: Tereza Jerabkova; Co-chair: Ines Belgacem)

- **Belén López Martí** (ESAC) – *Building the Gaia Catalogue of Galactic AGB Stars*
- **Patricia Cruz** (ESAC) – *Identifying M Dwarfs in VVV Tile b294 Using Gaia*
- **Björn Grieger** (ESAC) – *A New Take on the CBL Test of the Copernican Principle and Implications for the Hubble Tension*
- **Simone Migliari** (ESAC) – *3D RMHD Simulations of Jet-Wind Interactions in High-Mass X-ray Binaries*
- **Peter Zeidler** (STScI) – *The Fate of Westerlund 2 – The Complex Dynamical State of a Young Massive Milky Way Star Cluster*
- **Ana M. Heras** (ESTEC) – *Identifying Transit Shape Anomalies in TESS Data with Deep Learning*
- **Daniel Mueller** (ESTEC) – *JHelioviewer: 3D Visualisation of Solar Data & Solar Orbiter Science Planning*
- **Sarah Boazman** (ESTEC) – *Landing Site Characterization and Hazard Mitigation for Luna 27*
- **Oliver Jennrich** (ESTEC) – *Will the Solar Wind Disturb LISA's Measurements?*
- **Alejandro Cardesin Moinelo** (ESAC) – *Mars Wind Maps and Gravity Wave Characterisation Using Ground Telescopes and Mars Express and Trace Gas Orbiter Observations*
- **Nils Janitzek** (ESAC) – *The First Year of Energetic Particle Measurements with Solar Orbiter's Energetic Particle Detector*
- **Bernhard Geiger** (ESAC) – *Radiometric Calibration of the Rosetta Navigation Camera*
- **Arnaud Masson** (ESAC) – *Improving the Indexing of ESA Science Datasets' DOIs*
- **Karen O'Flaherty** (ESTEC) – *Demonstrating the Feasibility of an ArtScience Programme in the Science Directorate*
- **Beatriz M. González Garcia** (ESAC) – *Conducting Scientific Research in Class with the CESAR TEAM: In Search of Our Origins*

19:00-20:00: Cocktail and Social Time

20:00: Dinner

Thursday 11th November

09:30-10:30: Science Talks (Webex) (Chair: Nils Janitzek; Co-chair: SOC member)

Sebastian Besse
(ESAC)
Mapping a Duck: Geological Features and Region Definitions on Comet 67P/Churyumov-Gerasimenko

Jan-Uwe Ness
(ESAC)
Déjà vu? The 7th Outburst of a Famous Recurrent Nova in X-rays

Alexander James
(ESAC)
Evolution of the Critical Torus Instability Height and CME Likelihood in Solar Active Regions

Håkan Svedhem
(ESTEC)
The ExoMars Trace Gas Orbiter's Nearly Two Martian Years of Science Results

10:30-11:00: Coffee break

11:00-12:30: Science Talks (Webex) (Chair: Emilia Järvelä; Co-chair: SOC member)

Nuria Álvarez-Crespo
(ESAC)
Large-Scale Galactic Blazar Environments with XMM-Newton

Detlef Koschny
(ESTEC)
Lunar Impact Flashes – a Faculty-Funded Project

Maximilian Günther
(ESTEC)
Stellar Flares and Habitable(?) Worlds

Luciu Riu
(ESAC)
Global Abundance Distribution of Phyllosilicates at Mars

François Mernier
(ESTEC)
The Cycle of Metals in the Elliptical Galaxy NGC 1404

Felix Fürst
(ESAC)
How to Break the Eddington Limit with Magnetic Fields

12:30-14:00: Lunch

14:00-15:00: Science Talks (Webex) (Chair: François Mernier; Co-chair: SOC member)

William Alston
(ESAC)
A Compact Object Detected in the Aftermath of a Fast Blue Optical Transient

Ines Belgacem
(ESAC)
Uncovering the Icy Moons' Surfaces with Photometry

Enrica Bellocchi
(ESAC)
Local Luminous InfraRed Galaxies as the Most Compact Galaxies Among Low- and High-z Systems Observed at Sub-kpc Scale with ALMA

Oliver Hall
(ESTEC)
TESS-Gaia Synergy: Automating Rotation Measurements for New Hyades Stellar Stream

15:00-15:30: Coffee break

15:30-16:00: Science Talks (Webex) (Chair: Sarah Boazman; Co-chair: SOC member)

Anna Francesca Pala
(ESAC)
A Multiwavelength Perspective on Accreting White Dwarfs

Andrew Lobban
(ESAC)
Exploring the Accretion Process Near to a Supermassive Black Hole in Mrk 110 with XMM-Newton, NuSTAR, and Swift

16:00-17:00: Poster Session (Webex + Teams) (Chair: Ines Belgacem; co-chair: Tereza Jerabkova)

- **Nimisha Kumari** (STScI) – *Evidence for Both Gas Infall and Starvation by Extending the Fundamental Metallicity Relation Beyond the BPT STAR-Forming Sequence*
- **Marcos López-Caniego** (ESAC) – *Detection of Compact Sources in Maps of the Microwave and Sub-Millimeter Sky with Convolutional Neural Networks*
- **Tereza Jerabkova** (ESTEC) – *Tidal Tails of Open Star Clusters with Gaia*
- **Richard Saxton** (ESAC) – *Is a Diet of Black Holes Bad for Stellar Digestion?*
- **Johannes Sahlmann** (ESAC) – *Astrometric Orbits of Stars with Exoplanets*
- **Claire Vallat** (ESAC) – *Icy Moons' Surface Weathering Characterization in Preparation for the JUICE Mission: Simulations and Laboratory Experiments Results*
- **Hans Huybrighs** (ESTEC) – *JUICE Can Detect Europa's Water Plumes with its Particle Detector Instruments*
- **Lisanne Braat** (ESTEC) – *Comparing Sediment Transport Fluxes on Earth and Mars*
- **Dmitri Titov** (ESTEC) – *Mars Ionospheric Composition From ASPERA-MARSIS / Mars Express Sounding*
- **Alejandro Cardesin Moinelo** (ESAC) – *Maps of Venus Cloud Opacity, Particle Size and Cloud Top Temperature Seen by Venus Express/VIRTIS*
- **Sebastien Besse** (ESAC) – *Revealing Mercury's Surface Properties Through Data Mining of the MESSENGER Datasets with MeSS*
- **Saida Ramdani** (ESAC) – *First Measurements of Solar Wind Heavy Ions with Solar Orbiter*
- **Beatriz M. González Garcia** (ESAC) – *Conducting Scientific Research in Class with the CESAR TEAM: The Hidden Universe*
- **Antonia Vojtekova** (ESAC) – *Where in the Sky Are the ESASky Users Looking?*
- **Oriel Marshall** (ESTEC) – *Exoplanets in the Classroom: a CHEOPS Case Study*

17:00-17:30: Coffee

17:30-18:30: Equity, Diversity and Inclusion Session

- **Jarita Holbrook** – *It Can't Be Transformed Without Examining Astrophysicists' Limiting Beliefs and Discriminatory Actions*

20:00: Dinner

Friday 12th November

Important: All participants need to check out of their hotel rooms before the start of the programme.

09:30-10:30: Science Talks (Webex) (Chair: Laura Hayes; Co-chair: Ryan Cooper)

Xavier Dupac
(ESAC)
CUBIQU: a CubeSat for Calibration of Cosmic Microwave Background Polarization Ground-Based Telescopes

Bruno Merín Martin
(ESAC)
Discovering New Asteroids in the ESA HST Archive with Citizen Science and Deep Learning

Matteo Guainazzi
(ESTEC)
Dirty Dancing: Piercing the Dusty Environment of Merging Supermassive Black Holes

Michela Muñoz Fernández
(ESAC)
Mapping of the CO2 Deposits on the Martian Polar Caps Derived from Neutron Flux Variations

10:30-11:00: Coffee break

11:00-12:15: Science Talks (Webex) (Chair: Lucie Riu; Co-chair: SOC member)

Victoria Grinberg
(ESTEC)
Understanding Winds of Massive Stars Using Variability of High Mass X-ray Binaries

Eleni Bohacek
(ESTEC)
Aeolian Bedform Hunting on Mars Using Edge Detection

Nils Janitzek
(ESAC)
From the Solar Wind to Suprathermal and Energetic Particles: Utilizing Ion Composition Measurements to Understand Particle Acceleration at the Sun and in the Heliosphere

Héctor Cánovas
(ESAC)
Pushing the Gaia Brightest End to the Limit

Quentin Nenon
(ESTEC)
Anisotropy of Energetic Electron Fluxes in the Magnetosphere of Jupiter: From Galileo to JUICE

12:15: Memorabilia from the SSW#14 (Matteo Guainazzi) + Lunch

14:30: Departure of the ESTEC Bus

14:45: Departure of the ESAC Bus

Presenter	Page

Posters

Oral Presentations

Listed alphabetically by 1st author last name

Abstract: standard expert and *planetarium-audience*

William Alston [ESAC]; Dheeraj Pasham

A compact object detected in the aftermath of a Fast Blue Optical Transient

The brightest Fast Blue Optical Transients (FBOTs) are mysterious extragalactic explosions that may represent a new class of astrophysical phenomena. Their fast time to maximum brightness of less than a week and decline over several months and atypical optical spectra and evolution are difficult to explain within the traditional context of core-collapse of massive stars, which are powered by radioactive decay of Nickel-56 and evolve more slowly. AT2018cow (at redshift of 0.014) is an extreme FBOT in terms of rapid evolution and high luminosities. In this talk, we will present new work to be published in Nature Astronomy for a high-amplitude quasi-periodic oscillation (QPO) of AT2018cow's soft X-rays with a frequency of 224 Hz. This signal is found in the average power density spectrum taken over the entire 60-day outburst. The high frequency (rapid timescale) of 224 Hz (4.4 ms) argues for a compact object in AT2018cow, which can be a neutron star or black hole with a mass less than 850 solar masses.

Understanding supernova explosions and other rapid luminous transient events allows us to study the end points of stars and the formation of black holes and neutron stars (compact object). Fast Blue Optical Transients (FBOTs) are mysterious extragalactic explosions that may represent a new class of astrophysical phenomena. Their fast time to maximum brightness of less than a week and decline over several months are difficult to explain as supernova, which occur as the end point of massive stars. In this talk we will present a new study of one such FBOT event, named AT2018cow. By studying the X-ray light curves produced following the outburst we have detected particular oscillation signals that are only observed from neutron stars and black holes. For the first time, we have detected a compact object in the aftermath of such transient explosion event. These findings tell us more about the end points of stars and the formation of black holes and neutron stars.

Nuria Alvarez-Crespo [ESAC]; Ignacio De La Calle, Ivan Valtchanov, Adrián Aranda Oliva, Alejandro Fernández Centeno

Large-scale galactic blazar environments with XMM-Newton

Active galaxies present extremely bright regions in their centre, capable of emitting large amounts of energy in the entire electromagnetic spectrum. These regions are the Active Galactic Nuclei (AGN), consisting on a supermassive black hole (SMBH) fuelled by an accretion disc. Radio galaxies are active galaxies characterised by radio emission driven by jets, that originate in the active nucleus and form structures on scales that go from pc up to Mpc. The Unification Model implies that when seen with a small viewing angle, these objects are known as a blazars. According to such model, the large-scale environments in which each blazar class resides must be consistent with its misaligned counterpart. An understanding of the RLAGNs large-scale environment in the context of the new paradigm of the Unification Model is essential for realistic modelling of their evolution and environmental impact, understanding AGN triggering and life cycles and for calibrating galaxy feedback in cosmological models. It is currently accepted that radio galaxies are preferentially found in poor galaxy clusters and groups. However, there is still not a complete, systematic study of the large-scale environments of blazars, since only a handful of studies were devoted to this subject, showing contradictory results. Here we present a study of the environments of a sample of blazars at $z<1.5$, where we compare the X-ray radial profile observed with XMM-Newton with the theoretical PSF, to see whether or not they reside in galaxy clusters. About 30% of blazars where found associated with an extended X-ray emission, indicating they reside in rich environments, consistent to what found for radio galaxies.

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Rickbir Bahia [ESTEC]; Stephen Covey-Crump, Neil Mitchell, Merren Jones

Understanding the evolution of Martian topography through valley networks

The ancient surfaces of Mars are incised by vast dendritic valley networks, which provide strong evidence of liquid water flow and a hydrological cycle in the planet's past. The majority of these valleys are present within the southern hemisphere of Mars (0 to 30°S) and are hypothesized to have experienced peak formation during the Late Noachian to Early Hesperian (~3.8 to 3.6 Ga), indicating the atmosphere was thicker and warmer than its present state. Valley networks do not only reveal information about the past atmospheric conditions of Mars but also its topographic evolution. In the absence of lithological variation and tectonic features (e.g., faults and grabens), rivers, and the resulting valley networks they produce, will follow the surface slope direction. Hence, valley networks can be used to infer the surface slope direction at their time of formation. I shall be presenting a technique I have designed to compare valley network orientation with topographic surface slope direction, and the initial implications for the evolution of Mars' surface topography.

Mars is carved by numerous valley networks. The majority of these valleys are thought to have formed due to liquid water flows. Considering water flows downslope, valleys formed by rivers reflect the surface slope direction at the time of their formation. At the time that the majority of Martian valleys formed (~3.8 to 3.6 billion years ago) Mars was also much more tectonically active as a result of volcanic and impact cratering activity. I shall present how I compare the orientations of valley networks with topographic slope direction to understand how Mars' surface has evolved since the valleys were last active.

Ines Belgacem [ESAC]; Ines Belgacem, F. Schmidt, G. Jonniaux, A. Le Contellec

Uncovering the icy moons' surfaces with photometry

The icy moons of Jupiter and Saturn are prime candidates in the search for habitability in our solar system. Their subsurface oceans could be the perfect habitats for the emergence of life. As it is impossible (for now) to sample said oceans directly, we use remote sensing to identify possible signs visible at the surface. The study of photometry can help us better understand the processes at play at the surface. Photometry is the study of reflectance with respect to the geometry of observation (illumination and observing conditions). It is intimately linked to the surface microtexture (roughness, shape of particules, porosity, ...) and can affect all remote sensing observations. As a result, having a clear understanding of a surface photometry is both a proxy to better understand its physical state but also the first step for any other remote sensing application such as mapping or spectroscopy. We have been studying the photometry of Jupiter's icy moons and we have identified regions of interest on Europa and Ganymede that could be consistent with recent activity and be of great interest for future missions such as ESA's JUpiter ICy moons Explorer (JUICE) and NASA's Europa Clipper.

The icy moons of Jupiter and Saturn are promising candidates in the search for habitability in our solar system - or environments that have all the ingredients for the possible emergence of life. These worlds all have subsurface water oceans where the chemistry could allow the basic bricks of life to exist. As it is impossible (for now) to sample said oceans directly, we use data acquired with visiting spacecrafts to identify possible signs visible at the surface.

The study of photometry can help us better understand the processes at play at the surface. Photometry is the study of reflectance with respect to the geometry of observation (illumination from the Sun and observing conditions of the camera). It is intimately linked to the surface microtexture (roughness, shape of particules, porosity, ...) and can affect all other observations. As a result, having a clear understanding of a surface photometry is both a proxy to better understand its physical state but also the first step for a lot of other applications.

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ESA's JUpiter ICy moons Explorer (JUICE) and NASA's Europa Clipper that will be studying Jupiter's icy moons in detail.

Enrica Bellocchi [ESAC]; M. Pereira-Santaella, L. Colina, A. Labiano, M. Sánchez-García, A. Alonso-Herrero, S. Arribas et al.

Local Luminous InfraRed Galaxies as the most compact galaxies among low- and high-z systems observed at sub-kpc scale with ALMA

I will present new results of a representative sample of 24 local luminous infrared galaxies (LIRGs) at z<0.02 using high spatial resolution (<100 pc) data from ALMA. Our LIRGs lie above the Main-Sequence (MS), with typical stellar masses in the range 10^{10}-10^{11} $M_\odot$ and SFR$\sim$30 $M_\odot$ yr^{-1}. I study the CO(2-1) and 1.3 mm continuum emissions to derive their effective radii using the curve-of-growth method.

I found that LIRGs are characterized by an extremely compact molecular gas distribution ($<R_{CO}>\sim 0.7$ kpc), factor X2 smaller than the ionized gas ($<R_{H\alpha}>\sim 1.4$ kpc), and X4 smaller than the stellar host ($<R_{star}>\sim 2.2$ kpc). Therefore, LIRGs deviate from local Spirals for which the molecular and stellar distributions have similar sizes ($R_{CO} \sim R_{star} \sim 3.9$ kpc). In particular, the molecular size of LIRGs is similar to that of early-type galaxies (ETGs; $R_{CO} \sim 1$ kpc), but about a factor of 6 more compact than Spirals of similar stellar mass. The presence of an active galactic nucleus (AGN) does not seem to strongly affect the (mean) molecular size in local LIRGs, although larger median radii by a factor of 2 are derived when considering galaxies with an AGN, as a result of the different range of R_{CO} characterizing the two subsamples. According to the results obtained for high-z (2<z<6) MS SFGs and (above the MS) SMGs using different tracers, high-z systems are characterized by more extended stellar, molecular and ionized gas emissions than local LIRGs (by a factor of ~5). Their derived stellar size and stellar mass values support the idea that high-z SMGs might be the 'scaled-up' version (both in size and stellar mass) of local LIRGs.

Up to date the molecular size of local LIRGs is poorly constrained. In this talk I want to shed more light on this topic using high resolution (sub-kpc scales) ALMA data comparing our results with those previously derived in the stellar and ionized phase in the same LIRG sample and also comparing the sizes of the different LIRG phases with those derived in local and high-z systems.

Sébastien Besse [ESAC]; Mireia Leon-Dasi, Bjorn Grieger, and Michael Küppers

Mapping a Duck: Geological Features and Region Definitions on Comet 67P/Churyumov-Gerasimenko

The data from the Rosetta mission enabled the reconstruction of the shape of comet 67P/Churyumov-Gerasimenko (hereafter 67P) and the identification of the terrains and features forming its surface. The highly irregular shape of the comet poses a challenge for the depiction of these geological features on two-dimensional maps. We present individual maps for 17 of the 26 regions of 67P, mostly located in the northern hemisphere. The new maps combine features published in previous studies with newly identified features. We discuss the distribution of geological features and the characteristics of the regions. In order to align region boundaries with geological features, we propose two modifications of region definitions.

Standard global map projections cannot display the complete surface of 67P because different points on the surface can have the same longitude and latitude. As a consequence, the geological maps published to date are created on top of comet images, making them dependent on the viewing angle and image coverage and resolution.

Here, we make use of the recently published Quincuncial Adaptive Closed Kohonen (QuACK) map [Grieger, 2019]. It projects the complete surface of 67P unambiguously onto a square and makes it possible to define generalized longitudes and latitudes. These can be used within any global map projection in order to obtain an unambiguous QuACK version.

The mapping of geological features is carried out in three dimensions employing the Small Body Mapping Tool (SBMT). We use images from the OSIRIS Narrow Angle Camera aboard Rosetta which have been projected onto the shape model of the SBMT. The three-dimensional coordinates are then projected onto two-dimensional maps, either in the QuACK map projection or in the QuACK version of the equidistant cylindrical projection.

We present individual maps for 17 of the 26 regions of 67P, mostly located in the northern hemisphere. The new maps combine features published in previous studies with newly identified features. We discuss the distribution of geological features and the characteristics of the regions. In order to align region boundaries with geological features, we propose two modifications of region definitions.

We developed and applied a new technique to map the complex shape and geology of comet 67P/Churyumov-Gerasimenko. With this new approach, we are significantly improving the accuracy of mapped geological features and the re-usability by the scientific community. Our results highlight the geology of comet 67P in a new way. This visualisation open very important questions on the distribution of features on the surface of the comet and the link to its evolution.

Eleni Bohacek [ESTEC]; Alexander Barrett, Elena Favaro, Matt Balme, Elliot Sefton-Nash

Aeolian Bedform Hunting on Mars Using Edge Detection

The Aeolian environment of the site of the ExoMars 'Rosalind Franklin' Rover has been characterised using manual observation techniques of 10,753 aeolian bedforms [1]. A machine learning system called the Novelty or Anomaly Hunter - HiRISE (NOAH-H) has been developed to classifify terrain in HiRISE images at Oxia Planum and Mwarth Valles according to texture for rover traversability. Of the fourteen classes of terrain NOAH-H has been trined to recognise, six are types of ripple features. We run Canny edge detection on terrain segmented by NOAH-H as 'large isolated ripples', which correspond to features called Transverse Aeolian Ridges (TARs). Preliminary results show the algorithm can pick out portions of TAR crests but also unwanted features. The next steps are tuning the edge detection thresholds so that it works around the whole HiRISE image, potentially using an adaptive method, and suppressing the signals from the edges of the mask and features that are not TARs.

[1] Favaro, E. A., Balme, M. R., Davis, J. M., Grindrod, P. M., Fawdon, P., Barrett, A. M., & Lewis, S. R. (2021). The aeolian environment of the landing site for the ExoMars Rosalind Franklin Rover in Oxia Planum, Mars. Journal of Geophysical Research: Planets, 126, e2020JE006723. https://doi.org/10.1029/2020JE006723

Aeolian bedforms are a family of ripple-like features on the surface of Mars that have been formed by wind. The orientation of the crest of the bedform tells us about the present or past wind regimes and climate. Traditionally they have needed a geologist to identify them and manually draw the dune crest in mapping software. Who has time for that? Edge detection algorithms can extract edges in images. When you apply this to Mars images it picks up bedform crests but also crater rims, boulders, fractured bedrock, more or less everything else, so it is not useful on it's own. We need a way to isolate the ripples, which is where the terrain classification algorithm called NOAH-H (Wright et al.) comes in. This talk shows preliminary results of running edge detection algorithms on the ripple areas isolated by NOAH-H.

Héctor Cánovas [ESAC]; J.M. Martín-Fleitas, A. Mora, J. Sahlmann, and J. Fernández-Hernández

Pushing the Gaia brightest end to the limit

The Gaia mission has produced the most comprehensive stellar catalogue to date, with astrometric and photometric measurements for more than 1.8 billion stars. This impressive dataset contains stars as faint as 21 mag in the optical regime. However, the brightest stars that can be easily observed with the naked eye fall beyond the nominal detection range of Gaia. This subset of stars comprises some of the most important sources for stellar physics, including several spectrophotometric standards, spatially resolved supergiants, and age-benchmark stars. In this talk I will present the VOsync program: a technique developed by the Gaia SOC at ESAC that allows to observe the 50 brightest stars with Gaia. I will highlight its first results and future prospects.

Gaia observations of bright stars.

Xavier Dupac [ESAC]; 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 with the work of ESA trainees and a Science Operations Department contract with Universidad Politécnica de Madrid. The final aim is to create a CubeSat with two polarized patch antennae 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. In this presentation, we will describe the goals of the project, how the work has been done so far and the expected future of the project.

CUBIQU (CubeSat for I,Q,U calibration, pronounced queue-bee-queue) is a project developed at ESA-ESAC with the work of ESA trainees and a Science Operations Department contract with Universidad Politécnica de Madrid. The final aim is to create a CubeSat with two polarized patch antennae 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.

Andrew Fox [Baltimore]; Elena D'Onghia, Scott Lucchini

New Insights on the Magellanic Stream

Extending for over 200 degrees across the sky, the Magellanic Stream together with its Leading Arm is the most spectacular example of a gaseous stream in the Local Group. The Stream is an interwoven tail of filaments trailing the Magellanic Clouds as they orbit the Milky Way. Thought to be created by tidal forces, ram pressure, and halo interactions, it holds many clues to the assembly history of the Milky Way. Recently, considerable progress has been made in our understanding of the origin and fate of the Stream. I will present hydrodynamical simulations that include a warm halo around the LMC (a "Magellanic Corona"), which can explain many properties of the Stream, including it's total gas mass, spatial extent, and Leading Arm. Our latest simulations (Lucchini et al. 2021, submitted) indicate that the Stream may be much closer to the Milky Way than previously thought, at a distance of only 20-30 kpc from the Sun instead of 50-100 kpc. This would have several important implications on the Stream's mass, ionization, and lifetime, which I will discuss. Overall, the Stream helps us to understand how large galaxies like the Milky Way acquire new gas to fuel their star formation over long (Gyr) timescales.

The Milky Way's two closest major satellite galaxies are the Large and Small Magellanic Clouds (LMC/SMC). The LMC and SMC are interacting as they fall toward the Milky Way, and through their interaction they are losing enormous amounts of gas. This has left an extended gas trail behind them, like a vapor trail behind an airplane. From our vantage point in the Milky Way, this trail (known as the Magellanic Steam) covers over 200 degrees on the sky. The Stream can be seen with both radio and ultraviolet telescopes, and can also be modeled with computer simulations. In this talk, I will describe how recent observations and simulations have advanced our understanding of how the Stream forms and evolves over time. Overall, the Stream helps us to understand how large galaxies like the Milky Way acquire new gas supplies to fuel their ongoing star formation.

Felix Fuerst [ESAC]; D. Walton, M. Heida, M. Bachetti, for the ULX working group

How to break the Eddington limit with magnetic fields

Nearby galaxies often host a large amount of X-ray sources. Some of the brightest and most interesting point sources in these galaxies are so-called ultra-luminous X-ray sources (ULXs). ULXs are accreting compact objects in binary systems which are much brighter than any binary we know in the Milky Way. They seem to accrete above the so-called Eddington limit, where radiation pressure balances the pressure from the in-falling, accreted material. The strongest offenders of the Eddington limit are the ultra-luminous X-ray pulsars, i.e., accreting neutron stars powering an ULX. The big open question is, how these neutron stars can be so bright. Leading theories involve a very strong magnetic field or geometric beaming, both of which I will discuss in my talk. I will also show new results on the long-term behavior of a few selected ULX pulsars and discuss how studying their variability helps us understand their physical properties.

Accreting neutron stars are very bright in X-rays as they effectively transfer mass from their companion star into radiation. Ultra-luminous X-ray pulsars are the brightest known accreting neutron stars but we still don't know how they manage to do that. One important aspect is very likely the extremely strong magnetic field some neutron stars are known to have. To learn more about their physical properties and measure the magnetic field, we are studying how fast they rotate and how their brightness changes with time.

Maximilian Günther [ESTEC]; et al.

Stellar Flares and Habitable(?) Worlds

On our search for habitable worlds, we have to account for explosive stellar flaring and coronal mass ejections (CMEs) impacting exoplanets. These stellar outbursts are a double-edged sword. On the one hand, flares and CMEs are capable of stripping off atmospheres and extinguishing existing biology. On the other hand, flares might be the (only) means to deliver the trigger energy for prebiotic chemistry and initiate life. This talk will highlight our study of all stellar flares from the TESS primary mission, driven by a convolutional neural network. I will discuss our new insights on flaring as a function of stellar type, age, rotation, spot coverage, and other factors. Most importantly, I will link our findings to prebiotic chemistry and ozone sterilisation, identifying which worlds lie in the sweet spot between too much and too little flaring. With future extended missions and increased coverage, flare studies and new exoplanet discoveries will ultimately aid in defining criteria for habitability.

Our search for habitable worlds is leading us more and more outside our solar system. By now, we have discovered over 4,500 exoplanets (planets around other stars). Even our nearest neighbour, Proxima Centauri, hosts an Earth-sized world with the right temperature for life. Curiously, Proxima Centauri is a red dwarf star, only 15% the radius and half as hot as our Sun. We now know that such systems are the most common, holding the answer to whether life is ubiquitous in the universe.

The problem is, red dwarfs often show stellar flares (explosive outbursts), reshaping their exoplanets' habitability. On the one hand, flares might deliver the necessary UV energy to trigger prebiotic chemistry and initiate life. On the other hand, they can strip off atmospheres and extinguish existing biology.

This talk highlights our study of stellar flares and temperate worlds from the TESS primary mission, using convolutional neural networks. I will discuss our new insights on flaring versus stellar type, age, and rotation. Most importantly, I will link our findings to prebiotic chemistry and ozone sterilization, identifying which worlds lie in the sweet spot for life.

Victoria Grinberg [ESTEC]; I. El Mellah, F. Fürst, L. Härer, N. Hell, M. Leutenegger, P. Kretschmar, M. Nowak, M. Parker, J. Sundqvist, J. Wilms

Understanding winds of massive stars using variability of high mass X-ray binaries

The strong winds of hot, massive giant stars drive their interaction with their environment, influence their final fate as (failed) supernovae and define the mass of the final compact object, left over after the death of the star. Yes, these winds are still poorly understood. Optical and X-ray measurements of the wind mass loss strongly disagree and can only be reconciled if the winds are highly structured, with colder, dense clumps embedded in a tenuous hot gas. In (quasi-)single stars, however, wind properties are inferred for the whole wind ensemble only; no measurements of individual clumps or clump groups are possible, limiting our understanding of wind properties. Luckily, nature provides us with perfect laboratories to study clumpy winds: high mass X-ray binaries that consists of a neutron star or a black hole and a massive star. The radiation from close to the compact object is quasi-point like and effectively X-rays the wind, in particular the clumps crossing our line of sight. I will use this talk to highlight the methods we have developed for such studies in the recent years. In particular, I will focus on how we can use the short-term (kiloseconds to seconds) variability that is caused by the clumps passing through the line of sight to decipher the structure of the wind of massive stars.

I will use this talk to highlight the methods we have developed for such studies in the recent years. In particular, I will focus on how we can use the short-term (kiloseconds to seconds) variability that is caused by the clumps passing through the line of sight to decipher the structure of the wind of massive stars.

Stars, including our sun, have stellar winds - streams of material that leave the star. In the most massive stars, the winds are so strong that they can carry away a significant amount of mass - they thus can influence the evolution of the star, including their final demise as supernovae that leave behind so-called compact objects, that is neutron stars or black holes. The winds are also 'clumpy', consisting of small, dense clouds embedded in much thinner very hot gas. Understanding these winds is crucial for understanding the life and death of massive stars.

In this talk, I will explain how we use special binary systems that consists of a massive giant star and a black hole or a neutron star to learn more about the wind of the companion star. To do so, we use X-ray emission from close to the compact object as a backlight to reveal the clumpy structure of the wind.

Matteo Guainazzi [ESTEC]

Dirty Dancing: piercing the dusty environment of merging supermassive black holes

It is a posit of modern astrophysics that most galaxies host a super-massive black hole (millions to billions of times more massive than the Sun). These black holes affect the evolution of galaxies well beyond their gravitational sphere of influence (which does not extend wider than 1/1000th of a typical galaxy linear size). In turn, the evolution of galaxies affects the growth of black holes through, e.g., galaxy merging. Interacting galaxies, or galaxies with a multiple (active) nuclei are key laboratories to investigate these processes.

While the extragalactic astrophysical community share a broad consensus on each of the above statements taken individually, how these feed-back loops work in the Universe, and the relative importance of various feed-back channels remain largely not understood. Furthermore, the existing samples of dual/binary/multiple active galaxies are remarkably scarse and incomplete.

My talk will offer a glimpse of the recent efforts that a group of scientists in the MAGNA ('Multiple AGN Activity'; 'Eat!' in Roman dialect) Collaboration have been undertaking to acquire large observational samples of dual/binary AGN, and to use them to inform the cosmological and 'local' simulations aiming at predicting the concurrent galaxy/black hole evolution. This talk will allow you to pierce your (X-ray) view through the dusty environment of these systems.

Eventually the supermassive black holes merge and produce grativational waves. I will also disclose a sneak preview on the exciting perspectives that simultaneous observations of merging black holes with Athena and LISA will yield.

Parental guidance not needed.

It is a posit of modern astrophysics that most galaxies host a super-massive black hole (millions to billions of times more massive than the Sun). These black holes affect the evolution of galaxies well beyond their sphere of influence due to their mass (which does not extend wider than 1/1000th of a typical galaxy linear size). In turn, the evolution of galaxies affects the growth of black holes through, e.g., galaxies merging together.

Astronomers believe that all that is true, but do not understand well why and how these processes occur in the real Universe. Galaxies that are close enough to interact, at whose center black holes are dangerously swirling around each other prior to catastrophically merging are a privileged place to learn more. Even if we know millions and millions of galaxies, the number of interacting galaxies with swirling black holes is, however, still rather small. This is also because the regions around the black holes pairs are rich in gas and dust, and therefore hard to observe because light is absorbed or scattered away before reaching us.

My talk will show the recent efforts by the MAGNA ('Eat!' in Roman dialect) Collaboration to overcome these difficulties, collect larger observational samples, and help the whole community understanding how galaxies and black holes evolve together.

Oliver Hall [ESTEC]; Tereza Jerabkova, Jason Curtis, Isabel Colman, Ruth Angus, Benjamin Montet, Soichiro Hattori, Adina Feinstein, Nicolas Crouzet

TESS-Gaia synergy: automating rotation measurements for new Hyades stellar stream members

Tidal tails of stellar clusters are important laboratories for the evolution of stellar populations and the Milky Way at large. Recent data from the Gaia mission has allowed the identification of new tidal tail structures thanks to its high-precision astrometric data. One such tidal tail belongs to the Hyades, recently detected by Jerabkova et al. (and confirmed using Gaia EDR3 data). However, Gaia data alone is not enough to robustly confirm tail membership. In this work, we aim to conform the coeval status of stars in the newly identified Hyades tidal tail through the use of gyrochronology, which infers stellar ages from their rotation rates.

We construct an automated method for measuring rotation rates using the all-sky TESS Full Frame Image (FFI) data. Using multiple tried and tested techniques, we measure rotation rates and gyrochronological age for the Hyades tidal tail stars and compare these to observations of the Hyades cluster itself. We also test these techniques on previously studied tidal tails, in order to confirm their potential for application to other targets of interest identified by Gaia.

Using dark spots on the surface of stars, we can measure how quickly they rotate. This rotation is also related to the age of stars. We are working on new methods to make it easier to measure rotation for stars observed by the TESS mission. This lets us determine the ages of stars which we suspect were born together, but are now scattered across the Milky Way due to gravitational forces.

Alexander James [ESAC]; David Williams, Jennifer O'Kane

Evolution of the critical torus instability height and CME likelihood in solar active regions

Working towards improved space weather predictions, we aim to quantify how the critical height at which the torus instability drives coronal mass ejections (CMEs) varies over time in a sample of solar active regions. We model the coronal magnetic fields of 43 active regions and quantify the critical height at their central polarity inversion lines throughout their observed lifetimes. We then compare these heights to the changing magnetic flux at the solar surface and identify CMEs in these regions. We find higher rates of CMEs per unit time during periods when the critical height is falling rather than rising, and when magnetic flux is increasing rather than decreasing. Furthermore, we support and extend the results of previous studies by demonstrating that the critical height in active regions is generally proportional to the separation of their magnetic polarities through time. When the separation of magnetic polarities in an active region increases, for example during the continuous emergence of a magnetic bipole, the critical height also tends to increase. Conversely, when the polarity separation decreases, for example due to the emergence of a new, compact bipole into an existing active region or quiet Sun environment, the critical height tends to decrease.

Solar magnetic activity can affect the Earth and the near-Earth environment, and we call these effects space weather. Large eruptions of plasma called coronal mass ejections (CMEs) can drive particularly severe space weather effects, and we could improve our efforts to forecast space weather by learning to predict CMEs. One proposed CME driver is the torus instability, which occurs when twisted magnetic structures reach a critical height in the solar atmosphere where the local magnetic field strength drops sharply with height. In this work, I calculate this critical instability height over time in a sample of 43 solar active regions. I identify trends and correlations between the evolution of the critical height and the changing magnetic flux through the solar surface. These trends could be used to identify regions on the Sun that are more likely to produce CMEs.

Nils Peter Janitzek [ESAC]; L. Berger, V. Heidrich-Meisner, S. Ramdani, R. Fournon, I. Merino-Martínez, A. Walsh, I. Zouganelis, P. Bochsler, B. Klecker, D. Pacheco, R. F. Wimmer-Schweingruber, G. Mason, G. C. Ho, R. Gómez-Herrero, J. Pacheco-Rodríguez, and the SOLO EPD Team

From the Solar Wind to Suprathermal and Energetic Particles: Utilizing Ion Composition Measurements to Understand Particle Acceleration at the Sun and in the Heliosphere

The emission of high-energy particles from stars and the existence of continuous stellar winds are ubiquitous phenomena throughout the universe. While for other stars our measurements are limited to remote-sensing observations, for the Sun we can directly measure the emitted material in the form of ions and electrons with in-situ particle instruments on various spacecraft. Despite these more complete observations we are still lacking a precise quantitative understanding for particle acceleration processes within the continuous solar wind stream and during spontaneous high energetic solar particle events.

Here we illustrate how the elemental and charge-state composition of solar ions can be utilized to infer and test different model-mechanisms for particle acceleration at the Sun and in the inner heliosphere. One key to understand e.g. the high variability in the intensity of solar particle events is to identify the source population of the observed energetic ions. In our studies we investigate this source population based on the latest measurements of suprathermal and energetic particles from the Solar Orbiter (SOLO) mission and newly derived thermal solar wind composition data from the SOlar and Heliospheric Observatory (SOHO). As a concrete example for an underlying acceleration mechanism we investigate the role of resonant wave-particle interaction for the acceleration of particles in the solar wind and in solar particle events.

As many other stars, the Sun emits particles in two forms: First, in the form of a continuous stream of low-energy particles - the so-called solar wind. Second, in the manner of spontaneous eruptions that can produce particles up to very high energies - the so-called solar energetic particle events.

The solar particles consist of ions and electrons and can be measured directly with particle detectors on various spacecraft as they fill out the heliosphere. The particle detectors can identify the type of the particle and its *energy. Regarding the ions we can further distinguish different elements and (for low energies) also the charge of the ions so that we obtain their elemental and charge-state composition.*

Despite ongoing measurement and modeling efforts we still do not have a fully satisfying physical model for the particle acceleration processes in the close vicinity of the Sun, that would allow us to predict the intensity of future events or to understand the solar wind acceleration up to the exact observed speeds. One key to understand the high variability in the intensity of solar particle events is to identify the so-called source population of these energetic particles. This means whether the particles are accelerated to high energies directly out of the solar wind or out of a different particle population with slightly higher initial energy and partially interstellar origin – the so-called suprathermal particles. In our studies we investigate this source population by comparing the latest measurements of suprathermal and energetic particles from the Solar Orbiter (SOLO) mission with newly derived solar wind composition data from the Solar and Heliospheric Observatory (SOHO). We also investigate whether the observations are in agreement with a proposed theoretical acceleration model which assumes that certain waves in the solar atmosphere and/or in the solar wind wind are the main responsible factor for the acceleration of the particles.

Detlef Koschny [ESTEC]; Richard Moissl, Joe Zender, Elliot Sefton-Nash, Håkan Svedhem

Lunar impact flashes - a faculty-funded project

Deci-meter sized meteoroids or small asteroids can be observed when the impact the Lunar surface, as they will emit an impact flash. The Greek 'NELIOTA' project is using a 1.2 m telescope and two high-end sCMOS cameras to record the unilluminated side of the Moon whenever possible. On average, an impact flash is observed once per hour. For smaller telescopes, e.g. 12' amateur instruments, we estimate an impact flash on average every 3 hours. However, observing the dark side of the Moon for that long is challenging to due geometrical and illumination constraints. We have started a 1-year project with the Greek team to develop and open-source tool to detect impact flashes. The idea is that this can be freely distributed to amateurs and professionals to increase their motivation to add to the data collection. Scientifically these observations are very relevant, as the flux density in this size range is not very well known. Also it is possible to find the newly formed craters in lunar orbiter images. This presentation will give a scientific overview, and show in detail where we stand with the project.

How many large meteoroids - or small asteroids - are there? We don't know very precisely. We can see them impacting the surface of the Moon. To increase the number of teams that do that, we develop an open source detection software.

Peter Kretschmar [ESAC]; I. El Mellah, S. Martinéz-Núñez, F. Fürst, V. Grinberg, A. A. C. Sander, J. van den Eijnden, N. Degenaar, J. Maíz Apellániz, F. Jiménez Esteban, M. Ramos-Lerate, E. Utrilla

Surprises from a well-known favourite - insights from writing a review on Vela X-1

More than seven years ago, the idea came up with some colleagues to summarise what we actually knew about the well-known X-ray binary Vela X-1, since we had found quite different assumptions about system parameters in the scientific literature. This 'easy to do' compilation took multiple years to complete, opened a number of questions we had not considered when we started and culminated in a 47-pages paper published in A&A, marked as highlighted paper and leading the A&A editors to consider a new category of papers. In this presentation we will not try to give a squeezed version of all the results published in the review, but instead reflect on what we learned in the process and what one might take as lessons in general.

Optimistically assuming that compiling the state of knowledge for a very well-known source should be straightforward, we embarked on what turned out to be a multi-year effort that brought us several surprises and taught us about hidden assumptions and uncertainties in our field of research, but probably applicable to many others. We reflect on these surprises and the insights we gained.

Nimisha Kumari [Baltimore]; R Amorin, E Perez-Montero, Jose Vilchez, R Maiolino

Using MaNGA to probe hardness of ionizing radiation fields in nearby star-forming galaxies and beyond

In this contribution, we use integral field spectroscopic data from the MaNGA survey to investigate radiation hardness within a representative sample of 67 nearby galaxies. The large wavelength range of MaNGA allows us to study the observational softness parameter (Vilchez & Pagel 1988) which is the ratio of the two emission line rations [OIII]/[OII] and [SIII]/[SII]. We analyze the relation between radiation hardness and various diagnostics sensitive to gas-phase metallicity, electron temperature and density, ionization parameter, effective temperature and age of ionizing populations. Low metallicity is found to be accompanied by hard radiation field though we do not find any direct evidence between radiation hardness and other nebular parameters. A comparison of MaNGA data with the photoionization models suggests that hard radiation fields from hot and old low-mass stars within or around star-forming regions might significantly contribute to the observed values of softness parameters in these star-forming galaxies. Such detailed studies and lesson learnt from them are useful in investigating the radiation hardness in high-redshift low-metallicity galaxies targeted by future ground and space-based telescopes such as James Webb Space Telescope and European Extremely Large Telescope.

The contribution will present an investigation of radiation hardness and its relation with physical and chemical properties of ionized gas and stellar populations. This is the first study of its kind performed on a large sample of star-forming galaxies by using the spatially-resolved observations from the MaNGA survey and including the photoionization models. Such detailed studies and lesson learnt from them are useful in investigating the radiation hardness in high-redshift galaxies targeted by future ground and space-based telescopes such as James Webb Space Telescope and European Extremely Large Telescope.

Andrew Lobban [ESAC]; Delphine Porquet, James Reeves, Valentina Braito, Nicholas Grosso, Francisco Pozo Nuñez

Exploring the Accretion Process Near to a Supermassive Black Hole in Mrk 110 with XMM-Newton, NuSTAR, and Swift

I will present the results of an observing campaign on the nearby, broad-line Seyfert 1 galaxy, Mrk 110, using XMM-Newton, NuSTAR, and Swift. Mrk 110 is an active galactic nucleus with a relatively high supermassive black hole mass of $\sim 10^8$ solar masses. Due to an absence of intervening ionised material in our line-of-sight, we are afforded an unimpeded, direct view of the 'bare' accretion disc as it feeds the central black hole. The high-resolution Reflection Grating Spectrometer on-board XMM-Newton reveals a broad component of the He-like oxygen (O VII) line, which can be modelled with a mildly-relativistic face-on accretion disc profile with the emission arising from very close to the black hole (20-100 gravitational radii). When compared with archival data spanning 16 years, the line also appears variable, and - for the first time - a significant correlation is measured between the O VII flux and the continuum flux from both the RGS and EPIC-pn data. Thus, the line responds to the continuum emission and is one of the clearest examples of such behaviour observed so close to a supermassive black hole to date. As such, this has implications for the accretion mechanism in the closest environs of a black hole. Through simultaneous NuSTAR data, we find that the broad-band X-ray spectrum is dominated by a combination of warm and hot Comptonisation, providing clues to the geometry of the X-ray-producing corona of relativistic electrons close to the black hole. Finally, through a contemporaneous, long-term multiwavelength monitoring campaign with Swift (covering a timeline of three years), we compute long-term rms spectra and use flux-variation-gradient methods to estimate the host-galaxy contribution in the optical and UV bands and independently estimate the bolometric luminosity and mass accretion rate. We also search for multiwavelength time delays, finding a series of lags, whereby longer-wavelength emission bands are systematically delayed with respect to shorter-wavelength bands. We compare these results to others reported in the literature, finding that the observed time delays are longer than predicted, suggesting a larger-than-expected disc. If these time delays arise from reprocessing of X-rays in the accretion disc, this poses challenges for standard accretion theory.

A supermassive black hole is thought to reside at the centre of most - if not all - galaxies. Their masses can range from hundreds-of-thousands to billions times the mass of our Sun, and they are believed to play a key role in the formation and evolution of their host galaxies. A subset of these black holes are actively feeding on nearby material, which forms an 'accretion disc'. These discs can reach extreme temperatures, often outshining the entire population of stars in the galaxy, and offer an ideal way to study extreme gravity and the effects of general relativity. Such actively-feeding systems are known as 'active galactic nuclei' (AGN). I will present some recent *results from observations of one such AGN where we have a unique sight-line, affording us a direct, unimpeded view of the accretion disc. With XMM-Newton, we find evidence of ionised oxygen emission, originating from within the accretion disc itself. From over 16 years of observations, the oxygen emission is observed to respond to the overall X-ray brightness of the AGN. Additionally, the shape of the emission profile in the X-ray spectrum is seen to arise from a near-face-on viewing angle and is modified by general relativistic effects. As such, this oxygen signature arises from very close to the black hole, where strong gravity dominates. Then, through simultaneous NuSTAR observations, we are also able to model the X-ray behaviour over a broader energy range, allowing us to infer information about the geometry and structure of the extremely-hot population of electrons that gives rise to the X-rays in the first place. Finally, through three years of multiwavelength monitoring with Swift, we are also able to measure time delays between the X-ray, UV, and optical bands. Here, the X-rays lead, the UV follows, and then so does the optical band. It is thought that the emission in each band originates from further out from the black hole, respectively. However, our measured time delays are longer than expected, suggesting that the disc is larger than predicted. Therefore, this may have implications for our current understanding of how accretion discs form and feed supermassive black holes.*

Elena Manjavacas [Baltimore]; T. Karalidi, J. Vos, B. Biller and B. Lew

Revealing the Vertical Cloud Structure of a young low-mass Brown Dwarf analog to the beta-Pictoris b directly-imaged exoplanet

High precision time-resolved spectro-photometry provides us with information about the cloud structure at different pressure levels of the atmospheres of brown dwarfs, and directly imaged exoplanet analogs. The monitoring of the easier observable exoplanet analogs, provides an idea of how exoplanet analog atmosphere structures look like. We show the results of spectrophotometric monitoring in the J-band of the AB Pictoris b exoplanet analog, 2MASS J2208136+2921213, during ∼2.5h using the MOSFIRE at the Keck 1 telescope. We find a maximum variability amplitude of 3% in the J-band, that decreases with wavelength, and slightly enhanced variability in the Na I alkali line. The Na I alkali line traces deeper layers of the atmosphere of 2MASS J2208136+2921213, allowing us to provide an estimation of where the different cloud layers are settled in the atmosphere of the object using radiate transfer models.

Using the W. M. Keck Observatory in Hawaii we observed a nearby brown dwarf in infrared light. Unlike Jupiter, the young brown dwarf is still so hot it glows from the inside out. Because the brown dwarf has scattered clouds, light shining up from deep down in the dwarf's atmosphere fluctuates as the brown dwarf rotates, which we measured. We found that the dwarf's atmosphere has a layer-cake structure with clouds having different compositions at different altitudes.

Bruno Merin Martin [ESAC]; Sandor Kruk, Pablo García Martín, Marcel Popescu, Ross Thomson, Samet Karadag, Deborah Baines, Elena Racero, Fabrizio Giordano and Max Mahlke

Discovering new asteroids in the ESA HST Archive with Citizen Science and Deep Learning

Asteroids are leftovers from the formation of our Solar System about 4.6 billion years ago. Early on, the birth of Jupiter prevented any planetary bodies from forming in the gap between Mars and Jupiter, causing the small objects that were there to collide with each other and fragment into the asteroids seen today. Their statistical population study allows to constraint theories of the formation of the Solar System since orbital movements and migration of the giant planets in the different models would yield different populations of asteroids in different orbital configurations.

This talk will describe a long project carried out by ESA scientists to use existing data in the Hubble science data archive at ESAC, near Madrid, to constraint the population of asteroids serendipitously observed by HST over its 30 years of operations and with it the Solar System formation models that could explain it better.

This work involved a citizen science project called "Hubble Asteroid Hunter" (asteroidhunter.org) where over 11,000 volunteers classified 150,000 images from HST/WFC3 and HST/ACS instruments identifying several thousand candidate asteroid trails in the images. This sample of serendipitous observations were then cleaned and used as training sample in Google AutoML Vision API and used then to systematically search for such type of features in the whole HST archive in very short time and with high accuracy.

This resulted in a sample of 2,400 asteroid streaks, out of which 1,700 are likely associated with actual Solar System objects, most of which are new to the literature, have a magnitude distribution well extending beyond the 22 magnitude or most classified asteroids in the Minor Planet Centre and have an orbital distribution concentrated on the ecliptic plane but with an interesting population of out-of-plane candidate asteroids as well. We will discuss how this new global sample of asteroids puts constraints on the main models of Solar System formation and will illustrate how this new way of doing science involving citizen scientists and machine learning can enormously multiply the scientific potential of the data in our archives.

I will show lots of nice images form the ESA HST with asteroids streaks found by our deep learning algorithm as trained by the citizen scientists.

Francois Mernier [ESTEC]

The cycle of metals in the elliptical galaxy NGC1404

As the building blocks of complex life, metals are an essential component of our Universe. Quite spectacularly, these chemical elements essentially synthesised in (Type Ia and core-core-collapse) supernovae are found not only in/around stars, but also at megaparsec scales, in the hot, X-ray emitting atmospheres pervading galaxy clusters, groups, and massive galaxies. Studying the abundance of these metals and their spatial distribution using X-ray spectroscopy is essential to understand the chemical history of clusters and groups, from their formation till their age of maturity. Here, we focus on very deep XMM-Newton and Chandra observations of NGC1404, a giant elliptical galaxy plunging toward the center of the Fornax cluster. The intense ram-pressure stripping at play on the hot gas of this galaxy makes it an unique target to capture the entire journey of metals. We will discuss the unprecedented accurate abundance measurements (overall metallicity and alpha/Fe ratios) of NGC1404 we obtained, both globally and spatially resolved, and interpret them in the context of the chemical history of the galaxy and of its cluster host.

The science of this talk will discuss how heavy chemical elements (which we are all made of: O, Mg, Fe, etc.) are created by stars and supernovae, then propagate across galaxy hosts, before ending up at the largest scales of the Universe - in the hot gas permeating clusters of galaxies

Michela Muñoz Fernández [ESAC]; Pascal Rosenblatt, Håkan Svedhem, Leo Metcalfe

Mapping of the CO2 deposits on the Martian polar caps derived from neutron flux variations

Frozen CO2 sublimates at the Northern Martian polar cap in summer and condensates at the Southern Martian polar cap. The seasonal variations of atmospheric pressure have been accurately measured at lander sites, providing the CO2 seasonal cycle in the atmosphere. This cycle has been accounted for by a Global Circulation Model (GCM) providing in turn predictions of the seasonal cycle of CO2 deposits at polar caps. However, these deposits have not been monitored yet with high precision unlike the atmospheric pressure variations. In this study, we investigate how to improve the measurements of CO2 mass deposits at the polar caps over seasons.

We start by processing the Neutron flux data of the High Neutron Energy Detector (HEND) on board Mars Odyssey. High energy cosmic rays produce neutrons in the first meter of the subsurface of the soil. These neutrons interact with nuclei of subsurface material and are eventually reemitted out of the soil. The reemitted flux is partly absorbed by the CO2 deposits at the polar caps, hence the variations of the neutron flux measured by the HEND instrument reflect the variations of the CO2 deposits over the seasons. Based on specific calibration of the neutron flux, the surface density of the CO2 deposits at the polar caps can be derived. The integration of the surface density over the entire area of CO2 deposits allows us to monitor the polar caps mass at a given time in the season. The HEND dataset that covers almost 10 Martian years (since 2002) is currently under investigation. The end product will include maps of estimated CO2 polar caps with a spatial resolution of 5deg in latitude and longitude and 15deg in solar longitude. This study is supported by the science faculty research funding.

The objective is to derive the variations of the surface density of CO2 deposits at each Martian polar cap over several seasonal cycles. An overview of the research and current status of the work will be presented.

Sophie Musset [ESTEC]; M. Maksimovic, E. Kontar, V. Krupar, N. Chrysaphi, X. Bonnin, A. Vecchio, B. Cecconi, A. Zaslavsky, K. Issautier, S. D. Bale, M. Pulupa

Multi-spacecraft observations of solar radio emissions in the Solar Orbiter era

Combining observations the two new solar missions, Solar Orbiter and Parker Solar Probe, with measurements from existing spacecraft such as STEREO and Wind, allows for the first time to analyze solar radio emissions measured from four different points of view simultaneously. I will present the first analysis of this kind for five radio bursts observed during the commissioning phase of Solar Orbiter. By comparing the observed properties of these bursts with those predicted by models of radio-wave propagation in the heliospheric plasma, I will show how multi-spacecraft observations of solar radio emission can be used to characterize not only the radio source itself, but also the properties of the plasma in which radio-wave are propagating, in particular, the properties of the density fluctuations of the plasma responsible for radio-wave scattering.

Our Sun is an active star which produces accelerated particles during energetic events such as solar flares. Solar energetic particles fills our heliosphere and interact with the planets atmospheres and magnetospheres. To understand the origin of these particles, one has to address several questions, among which how particles get accelerated in the solar atmosphere, and how these particles can escape the Sun to fill the heliosphere. Luckily, energetic electrons propagating in the heliospheric plasma produce radio-waves that can be used to study the propagation of these particles as they propagate away from the Sun. Understanding how these radio-waves are emitted and how they propagate before they are measured by spacecraft and radiotelescopes is therefore key to answer the fundamental questions about the origin of solar energetic particles.

Quentin Nenon [ESTEC]; L. Miller, P. Kollmann, M. Pinto, O. Witasse

Anisotropy of energetic electron fluxes in the magnetosphere of Jupiter: from Galileo to JUICE

The magnetosphere of Jupiter is a powerful accelerator of charged particles. In particular, electrons with kinetic energies greater than tens of MeV are encountered around the giant planet! Where do these electrons come from and how do they reach such high energies? We will present the first analysis of the anisotropy of >1 MeV electrons observed by NASA's Galileo mission from 1995 to 2003. Starting in 2031, ESA's JUICE mission will observe these electrons with the engineering sensor named RADiation hard Electron Monitor (RADEM). We will discuss how the pointing of JUICE and RADEM can be optimized in targeted regions to adequately observe the anisotropy of high-energy electrons, in order to further our understanding of the Jovian magnetosphere and astrophysical particle accelerators in general.

A key tool to diagnose the origin and acceleration of energetic electrons around Jupiter lies in the anisotropy of their fluxes, as this anisotropy reveals whether the charged particles come from an equatorial reservoir or whether they are accelerated at high latitudes, where the spectacular Jovian aurora are powered.

We will present the first analysis of the anisotropy of >1 MeV electrons observed by NASA's Galileo mission from 1995 to 2003. Starting in 2031, ESA's JUICE mission will observe these electrons with the engineering sensor named RADiation hard Electron Monitor (RADEM). We will discuss how the pointing of JUICE and RADEM can be optimized in targeted regions to adequately observe the anisotropy of high-energy electrons, in order to further our understanding of the Jovian magnetosphere and astrophysical particle accelerators in general.

Space is not empty, it is full of small invisible particles. Around the giant planet Jupiter, these particles have velocities close to the speed of light. Where do they come from and how are they accelerated to such speeds? We will advance on this question by analyzing particle measurements gathered in-situ by NASA's Galileo mission fifteen years ago. This effort will not only advance our understanding of this invisible environment, but it will also help the planning of future observations by ESA's JUICE mission, which will arrive in orbit around Jupiter in 2031.

Jan-Uwe Ness [ESAC]; Kim Page, Julian Osborne, Andy Beardmore, Sumner Starrfield

Déja Vù? The 7th outburst of a famous Recurrent Nova in X-rays

In 2006, the 6th outburst of the recurrent nova RS Oph has triggered a lot of attention, motivating the Swift team for the first time to organise an extensive Swift fill-in X-ray+UV monitoring campaign of a nova with hour to day spacings between short snapshots for over 2 months. Deep XMM-Newton and Chandra observations were scheduled at strategic times in between, guided by the X-ray brightness evolution. The ejecta of the nova explosion ran with high velocity into the much slower stellar wind of the companion, producing bremsstrahlung emission (kinetic energy converted to radiation). This so-called shock episode was practically identical in 2006 and 2021. Once the ejecta become thinner, the hot plasma from nuclear burning on the surface of a white dwarf star became visible as super-soft (and super bright) X-ray emission (few hundred thousand degrees Kelvin). This episode has behaved completely differently.

Nova explosions occur in close binary systems where hydrogen-rich material is transferred from a normal star to a white dwarf that is a very compact object (size of Earth but mass of Sun). Once enough material is accumulated on the surface of the white dwarf, explosive thermonuclear fusion reactions start, the same processes that occur in the centre of our Sun and other stars. What we observe depends on the conditions of the absorbing ejected material that expands owing to the high radiation pressure produced by the nuclear chain reactions. Once the nuclear burning fuel is burned up, the white dwarf returns to quiescence, accretion starts again, and eventually another nova explosion occurs. A handful of novae recur on human time scales, RS Oph being one of the most famous ones and very popular among Amateur Astronomers.

Iris Nijman [ESTEC]; Iris Nijman

Storytelling for scientists

Humans have been telling stories for thousands of years, and it is still a very effective way of communicating, whether for the general public or science peers. Storytelling is not only useful when preparing an outreach talk or media interview, but also for writing grant proposals or giving a (poster) presentation at a conference. In this interactive talk, I will explain how storytelling makes science communication more effective and engaging, and what the difference is with the more 'traditional' ways of science communication. I will showcase how easy it is to get stuck in a 'bubble' of communication, and how to get out of it. I will also explore storytelling tools with participants that can help them to define the message that they want to convey about their research or mission in a way that will resonate with the listener.

How storytelling can help you communicate more effectively with the public and your peers.

Anna Francesca Pala [ESAC]

A multiwavelength perspective on accreting white dwarfs

In the last 20 years, the study of compact interacting stellar binaries has led to two major breakthroughs in astrophysics: the discovery of dark energy and the first direct detection of gravitational waves. Although stellar binaries are crucial to probe the properties of the Universe and to test fundamental physical theories, such as General Relativity, our understanding of their evolution is still far from complete. In this talk, I will discuss how the synergy between XMM-Newton, Gaia, the Hubble Space Telescope and the largest ground-based observatories allows us to obtain a full insight into the physical mechanisms driving the evolution of accreting white dwarfs. Such study is relevant for different astrophysical fields and is key to unveil the path towards Supernova Type Ia explosions (our yardstick for measuring distances on cosmological distance scales) and to constrain the evolution of the most compact stellar binaries (such as black hole and neutron star binaries), which are the sources of the gravitational waves only recently detected by the LIGO experiment.

A large fraction of stars in the Milky Way are bound in pairs by gravitational attraction. These systems are called stellar binaries and, among them, of particular importance are accreting white dwarfs. These are composed of a white dwarf, i.e. the final state of the life of stars like the Sun after they have exhausted their nuclear fuel, and a Sun-like companion star. Accreting white dwarfs owe their name to the fact that the companion star (often called donor) is losing mass, which is then transferred (i.e. accreted) onto the white dwarf. In this talk I will discuss why obtaining an understanding of the evolution of accreting white dwarfs is relevant for different astrophysical domains such as cosmology and the new and rapidly expanding field of multi-messenger astronomy, which combines the study of the incoming stellar light with that of gravitational waves.

Lucie Riu [ESAC]; John Carter, François Poulet

Global abundance distribution of phyllosilicates at Mars

Numerous locations at the surface of Mars have previously been identified to harbor hydrated minerals which offer unique insights on its past water activity. A radiative transfer model has been used to reproduce the near-infrared spectra – obtained with the OMEGA hyperspectral imager – of these specific locations. The lithology is summarized with 11 compositional maps of hydrated minerals at planetary scale at a sub-kilometer resolution. The hydrated mineralogy is dominated by an end-member of Fe-hydroxide, Fe- and Al-phyllosilicates and Fe/Mg micas which have on average an abundance >6vol% and are spread globally on the previously identified regions. Locally, spots with high abundance (>20vol%) of Al-smectite and Chlorite are also identified. The abundance of hydrated minerals is highest in Marwth Vallis, Nili Fossae and Meridiani Planum. However, the primary minerals almost always account for more than 50% of the composition. The modelling offers an opportunity to do local analysis of prospective landing sites and prepare for the upcoming landed missions. In the landing site for the ExoMars2022 and Mars2020 rovers, the obtained composition is in agreement with the expected detected mineralogy which demonstrates the robustness of the model and also offers a representation of the compositional variability.

In this talk, I wish to present new results about the hydrated mineralogy at Mars. Previous orbital and in situ studies of the red planet surface have shown that hydrated minerals (thus formed in the presence of water) are present in various locations across Mars. We performed a global (planetary scale) and quantitative analysis of these detections. This quantitative approach provides new insights to understand the processes and settings resulting into the formation of the previously detected hydrated minerals and it may contribute to understand the history of water at Mars.

Håkan Svedhem [ESTEC]; Colin Wilson

The ExoMars Trace Gas Orbiter - Nearly two Martian years of science results

TGO has now collected data during nearly two Martian years, and has made observations for well over a full Martian year after the Global dust storm in 2018. Seasonal effects can now be studied under normal conditions. Climatological studies, benefitting from the 400km, 74 degrees inclination non-solar synchronous orbit, have been initiated, even if the full potential will be visible only after several Martian years of operation. Dedicated searches of trace gasses, in particular biomarkers, like methane, ethane, ethylene and phosphine have resulted in new low upper limits. In the case of methane the upper limit has been established at about 20 pptv (2×10^{-11}). The FREND instrument has characterised the hydrogen in the shallow sub-surface on a global scale, at a spatial resolution much better than previous missions have been able to do. It has found areas at surprisingly low latitudes with significant amounts of sub-surface hydrogen, most likely in the form of water ice. The CaSSIS camera has made well above 20,000 of images over a large variety of targets, including the landing sites of the 2020 NASA and 2022 ESA rovers, Jezero Crater and Oxia Planum. Stereo imaging has enabled topographic information and precise 3-D landscape synthesis. Joint measurement campaigns with Mars Express have been made at several occasions and experimental mutual radio occultation measurements between Mars Express and TGO have been carried out at 16 opportunities. These campaigns will continue into the next year. This presentation will summarise the highlights and recent results and discuss planned activities for the near and medium term future.

The Trace Gas Orbiter, TGO, of the ExoMars program has now acquired a great data set covering almost two Martian years of operations. The result are used to characterise the present state of the atmosphere of Mars and to learn more about the seasonal and long term variations.

Jack Wright [ESAC]; Alexander M. Barrett, Peter Fawdon, Elena A. Favaro, Matthew R. Balme, Mark J. Woods, Spyros Karachalios

NOAH-H: Deep Learning Terrain Classification of Jezero Crater, Mars

We applied a deep learning [1] terrain classification system, the "Novelty or Anomaly Hunter - HiRISE" (NOAH-H), originally developed for the ExoMars landing sites in Oxia Planum and Mawrth Vallis [2], to the Mars 2020 Perseverance rover landing site in Jezero crater. The NOAH-H model successfully classified the terrain in four 25 cm/pixel HiRISE images of Jezero, according to a suite of 14 ontological classes. We mosaicked the NOAH-H classified rasters and compared them with a human-made photogeological map of the landing site, and with Perseverance rover and Ingenuity helicopter images. Two raster products were produced, one showing all 14 "descriptive" classes, and the other the five "interpretive" groups set out in [2] We found that grouped NOAH-H classes correspond well with the human-made map and that individual classes are corroborated by the available ground-truth images. The comparison with ground truth can inform decisions as to which ontological classes would be hazardous for rover operations, and which would not. Despite being trained on examples from Arabia Terra, the model transferred well to the unfamiliar test site. In particular, it coped well with variations in orientation of aeolian bedforms compared to those seen in the training dataset. We conclude that our NOAH-H products can be refined to provide one component of more formal traversability analysis of the ExoMars Rosalind Franklin landing site at Oxia Planum. They can also be used to aid the photogeological mapping process.

[1] LeCun, Y.et al. (2015). Deep learning. Nature, 521(7553), 436-444. [2] Barrett, A. M. et al. (2021). NOAH-H, a deep-learning, terrain classification system for Mars: Results for the ExoMars Rover candidate landing sites. Icarus, 114701. [3] Stack, K. M. et al. (2020). Photogeologic map of the perseverance rover field site in Jezero Crater constructed by the Mars 2020 Science Team. Space Science Reviews, 216(8), 1-47.

NOAH-H is an AI that we have trained to read 25 cm/pixel HiRISE images of Mars to create maps of the terrain (bedrock, sand ripples, etc.) in the images. NOAH-H is being developed to support the ExoMars Rosalind Franklin rover mission to Oxia Planum, Mars. We have mosaicked four NOAH-H classifications of the Mars 2020 landing site, Jezero crater, where the Perseverance rover is currently active. There is good agreement between NOAH-H and a geological map of Jezero crater created by the Mars 2020 team based on HiRISE images. By comparing NOAH-H results with an active mission, we have been able to 'ground truth' NOAH-H before Rosalind Franklin has landed on Mars. We are working on a NOAH-H mosaic of Oxia Planum, which will contribute to ExoMars mission planning. NOAH-H mosaics might also help geologists make maps of Mars more easily.

Poster Presentations

Listed alphabetically by 1st author last name

Abstract: standard expert and *planetarium-audience*

[Poster #1] Sébastien Besse; Claudio Munoz, and Thomas Cornet

Revealing Mercury's surface properties through data mining of the MESSENGER datasets with MeSS

In preparation for the next Decadal Survey, the Mercury science community defined in 2019 a list of high priority science at Mercury. The Mercury Surface Spectroscopy (MeSS) group at ESAC is supporting many of those high priority questions, and in particular those related to surface analysis. Are geological processes (e.g. formation of hollows and scarps) actively taking place today? How and why has volcanism changed so dramatically through time? To what degree have secondary processes affected the surface composition and mineralogy of Mercury? With the use of the MeSS database, scientific users can explore those science questions with the MASCS observations.

The MeSS database is a PostgreSQL relational database. This MeSS database contains the entire set of observations acquired by MASCS (i.e. ∼4.700.000 footprints) with all the relevant metadata to evaluate the MASCS data. Additionally, the MeSS database provide access to a product that combine the UV-visible and near channels of the spectrometer. A python interface is available to provide query access to the database and explore the products of interest based on various criteria.

After few years of development, and despite a slow down due to the pandemic, the MeSS database has been used to explore Mercury's surface, and provide scientific results. Besse et al. (2020), Barraud et al. (2021), Rothery et al. (2021) made use of the MeSS database to explore the mineralogical and physical properties of volcanic landforms. Our results have in particular highlighted the size of explosive volcanism and the asymmetry of some specific deposits. Hollows are small depressions on the surface potentially created by degassing of the sub-surface, and our latest analysis using spectroscopic data favour scarp-retreat as one of the mechanisms explaining the growth of hollows [Barraud et al., 2020].

New parameters are and can be added to the MeSS database. In particular, the MeSS team is currently adding the spectral curvature calculated in [Barraud et al., 2020]. New datasets are always of interest to provide context to point spectrometers. The MeSS team is exploring the addition of MDIS and MLA data.

Access to the MeSS database could be requested to the team. Currently, the infrastructure is not ready for a full public access, but the content is open for collaborators that want to explore Mercury.

The MESSENGER spacecraft has returned a wealth of data from Mercury and the objective of the Mercury Surface Spectroscopy (MeSS) group is to enable and maximise the science exploitation of those data to unravel Mercury's surface.

During the last two years, our group has published 4 papers highlighting the particular properties of volcanic landforms and small active depressions. What they have in common is the lost of a volatile phase (e.g, CO2, CO, H2O, S) which in return provide valuable information on the amount and nature of those volatiles. The MeSS project is developing its research investigations of Mercury's surface through data mining, knowing that the output of this work is of paramount importance for the preparation of BepiColombo's exploration of Mercury.

[Poster #2] Sarah Boazman; David Heather, The HRE Lunar Lander Team

Landing Site Characterization and Hazard Mitigation for Luna 27

The Luna 27 lander is due to land in the south polar region of the Moon, where there is renewed interest because of the presence of volatiles, including water ice in the surface and sub-surface. One of the main goals of the Luna 27 mission is to explore and sample the lunar soil using the PROSPECT instrument. Characterization and mapping of the potential landing sites in the south polar region will be carried out to identify potential areas of interest, which could be sampled. Additionally, mapping of potential hazards such as boulders, craters, steep slopes, and the surface roughness of the south polar region will aid the PILOT instrument with a safe landing.

The Luna 27 lander is due to land near the south pole of the Moon, investigating and mapping out features present in the south polar region at potential landing sites will highlight hazards to the landing, and identify potential areas of interest to sample.

[Poster #3] Lisanne Braat; Mike Lamb, Elliot Sefton-Nash

Comparing sediment transport fluxes on Earth and Mars

It is important to understand the differences in fluvial sediment transport between Earth and Mars, especially when using Earth analogues in fluvial geomorphology to interpret the surface of Mars. Differences in transport can lead to differences in morphology and stratigraphy and should be considered when making interpretations of conditions based on geomorphologic evidence from orbital data. Therefore, the objective of this study is to isolate and examine the effects of gravity on sediment transport. A different effect of gravity on the two transport modes will affect sediment sorting and morphology. Since Mars has more suspended sediment and lower settling velocities, we predict a bigger chance for hyper-concentrated and density-driven flows. In addition, we expect that sediment will transport further away from the channel before it deposits. As a result, we expect foresets of river deltas to be less steep. Because of larger total fluxes on Mars, fluvial landforms (e.g. erosional valleys or deltas) can develop in less time than they would on Earth for the same discharge. Or, otherwise formulated, they become larger within the same time. Because gravity affects the transport modes differently, we argue that total load equations like Engelund and Hansen (1967) should not be used for calculations on Mars.

I aim to isolate and examine the effects of gravity on sediment transport fluxes in water. To study this, I use a 1D model with an Earth and Mars scenario, for which the only difference is gravity. My preliminary results show that the total sediment transport flux on Mars is higher for the same water discharge, especially for small grains up to the size of coarse sand. Additionally, a larger percentage of this flux is transported in the water column (instead of close to the river bed) compared to Earth. We observe a different effect of gravity on sediment transported in the water column compared to sediment transported along the bed. This impacts sediment sorting and therefore the shape and stratigraphy of fluvial landforms. For example, delta foresets are expected to be less steep on Mars and due to the larger transport, fluvial landforms develop quicker than on Earth.

[Poster #4] Alejandro Cardesín-Moinelo; Pedro Machado, Hermano Valido, Francisco Brasil, Jose Silva, Gabriella Gilli, Daniela Espadinha, Brigitte Gondet

Mars wind maps and gravity wave characterisation using Ground Telescopes and Mars Express and Trace Gas Orbiter observations

We present here a summary of various research projects on the atmosphere of Mars as part of a collaboration with the Institute of Astrophysics and Space Sciences in Lisbon.

The first study presents ground-based wind velocity measurements of Mars during the 2018 global dust storm using Doppler velocimetry techniques based on observations made with the Ultraviolet and Visual Echelle Spectrograph (UVES) at the European Southern Observatory's Very Large Telescope (VLT) facility in Chile [Machado et al, 2021]. This is the first time that a Doppler velocimetry method based on ground observations is employed to study the Martian atmosphere. The purpose of this research is to successfully apply and validate the method and obtain maps of Mars' middle atmosphere wind velocities. The ground observations performed in Summer 2018 were done in coordination with Mars Express observations by various instruments, in particular the OMEGA, SPICAM and PFS spectrometers. For the analysis of the data we also compare with the dust profiles obtained by the NOMAD and ACS instruments on-board Trace Gas Orbiter.

The second study mentioned here is the detection and characterisation of atmospheric gravity waves observed on the clouds of Mars using data from the OMEGA imaging spectrometer on-board Mars Express [Brasil et al, 2021]. The OMEGA images are composed of a hyperspectral cube with a spectral range of 0.38 to 5.1 m, taken with the visible and near-infrared (VNIR) and infrared (SWIR) spectrometers. We retrieved the OMEGA data and its IDL routines through the PSA archive from ESA, to produce OMEGA images which were later navigated and processed individually using ENVI software for optimal detection of wave features and accurate characterisation of wave properties, such as the horizontal wavelengths, packet width, packet length, location and orientation.

References:
Machado, P., Valido, H., Cardesin-Moinelo, A., Gilli, G., Brasil, F., and Silva, J. E.: Final Results of Doppler Velocimetry Winds on Mars' Atmosphere, Europlanet Science Congress 2021, online, 13-24 Sep 2021, EPSC2021-295, https://doi.org/10.5194/epsc2021-295
Brasil, F., Machado, P., Gilli, G., Cardesín-Moinelo, A., E. Silva, J., Espadinha, D., and Gondet, B.: Characterising Atmospheric Gravity Waves on Mars using Mars Express OMEGA images - a preliminary study, Europlanet Science Congress 2021, online, 13-24 Sep 2021, EPSC2021-188, https://doi.org/10.5194/epsc2021-188

Summary of various research projects on Mars atmosphere: measuring winds from the Earth during global dust storm and monitoring waves on the clouds.

[Poster #5] Alejandro Cardesin-Moinelo; Giuseppe Piccioni, Alessandra Migliorini, Davide Grassi, Valeria Cottini, Dmitri Titov, Romolo Politi, Fabrizio Nuccilli, Pierre Drossart

Maps of Venus cloud opacity, particle size and cloud top temperature seen Venus Express/VIRTIS

Global maps of Venus nightside atmosphere using the complete infrared dataset of VIRTIS mapping channel onboard Venus Express between 2006 and 2008. Despite the local variability and high dynamics of the clouds, the accumulation of data over several years allowed us to obtain a global mean state of the atmosphere, where we can observe the average structure of the clouds from equator to the polar regions with a high symmetry north/south even for the local time dependencies.

Reference publication: 'Global maps of Venus nightside mean infrared thermal emissions obtained by VIRTIS on Venus Express'. Cover Page of ICARUS, Volume 343, June 2020, https://doi.org/10.1016/j.icarus.2020.113683

Global view of Venus atmosphere using Venus Express infrared data, unveiling nightside cloud opacity and temperatures.

[Poster #6] Patricia Cruz; Enrique Solano, Miriam Cortés-Contreras, Roberto Saito, Dante Minniti

Identifying M dwarfs in VVV tile b294 using Gaia

M-dwarf stars account for more than 70% of the stars in our galaxy and have an important role in several astrophysical contexts, for instance, as prime targets in the search for life outside our Solar System. In this work we aim to identify and characterise M dwarfs in the b294 tile from Vista Variables in the Via Lactea (VVV) survey, a deep near-infrared survey towards Galactic southern plane. We used parallax measurements and proper motions from Gaia Early Data Release 3, in addition to different colour cuts based on VISTA filters, to select a list of 7896 M dwarfs within tile b294. We performed a SED fitting to obtain the effective temperature for all objects using broad-band photometry available at Virtual Observatory archives. The objects in our sample have temperatures varying from 2800 to 3900 K. In the near future, we will search for transit-like events in the VVV light curves with around 300 observed epochs.

M-dwarf stars, small stars with less half of the mass of the Sun, are the great majority of stars in the Milky Way. They are the most interesting targets to search for exoplanets. We have identified a list of M dwarfs in the Vista Variables in the Via Lactea (VVV) survey. We will show how we selected and characterised these interesting objects using data from the Gaia Early Data Release 3.

[Poster #7] Bernhard Geiger; Rafael Andrés

Radiometric Calibration of the Rosetta Navigation Camera

The Navigation Camera on board the Rosetta spacecraft was essential for optical navigation in the vicinity of the comet 67P/Churyumov-Gerasimenko. Images acquired throughout the mission are also of high scientific interest. In order to extend the range of potential applications, we generated datasets of radiometrically calibrated images. For this purpose, methods based on stellar observations as well as cross-calibration with images of the extended comet nucleus were investigated. In this poster, we illustrate some of the techniques applied for determining appropriate calibration factors as well as for correcting detector effects and artefacts. The calibrated images were archived in the Planetary Science Archive.

Many images of the comet Churyumov-Gerasimenko were taken with the Navigation Camera on board the Rosetta spacecraft. We converted the raw data into quantitative information with physical units so that the images can be used for more types of scientific studies.

[Poster #8] Beatriz M. González García; Marina Cano, Sergio Manthey

Conducting scientific research in class with the CESAR Team: The hidden Universe

The CESAR Team is offering to primary and secondary schools and Universities worldwide Space Science Experiences, where students, guided by their teachers and the CESAR Team, can conduct scientific research in Space/Astronomy topics. We present a brand new Scientific Challenge for students in the last years of secondary school and first years of University, called 'The hidden Universe'. Students are guided with a student's guide, supported by their teachers (who have access to the teacher's guide) as well as the access to the CESAR Team as part of their Space Science Experience.

Acknowledges: Pedro Gómez, 2021 ESA/SCI-S internships.

In this Scientific Challenge, we encourage students to follow the scientific method and recreate, in a simpler way, some research projects, such as the estimation of the mass of a gravitational lens causing an Einstein's ring detected by HST, the analysis of a real case study of a gravitationally lensed quasar with quadrupole images [1] and the estimation of the contribution of dark matter in two spiral galaxies by comparing their predicted and measured rotational curves [2]. Before doing that, the CESAR Team provides students with an introduction to Newton's and Einstein's theories on gravity, gravitational lensing and their various patterns resulting from different lenses as well as rotation curves of galaxies, among other related topics. Students are instructed about how to inspect real scientific data through ESASky, as astronomers do in their daily life.

[1] Inada, N., Oguri, M., Pindor, B. et al. A gravitationally lensed quasar with quadruple images separated by 14.62 arcseconds. Nature 426, 810-812 (2003). https://doi.org/10.1038/nature02153 [2] Yoshiaki Sofue, Dark halos of M31 and the Milky Way, Publications of the Astronomical Society of Japan, Volume 67, Issue 4, August 2015, 75, https://doi.org/10.1093/pasj/psv042

[Poster #9] Beatriz M. González García; Marina Cano

Conducting scientific research in class with the CESAR Team: In search of our origins

The CESAR Team is offering to primary and secondary schools and Universities worldwide Space Science Experiences, where students, guided by their teachers and the CESAR Team, can conduct scientific research in Space/Astronomy topics. We present a brand new Scientific Challenge generated by the CESAR Team for students in the last years of secondary school and first years of University, called 'In search of our origins'. In this Scientific Challenge, we encourage students to follow the scientific method and recreate, in a simpler way, a master's thesis conducted by Marina Cano in 2021 with the Ludwig-Maximilian University (LMU) under the title "Identifying accreting candidates in the Carina Nebula with VPHAS+ data". Students are guided with a student's guide, supported by their teachers (who have access to the teacher's guide) as well as the access to the CESAR Team as part of their Space Science Experience.

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In this Scientific Challenge, we encourage students to follow the scientific method and recreate, in a simpler way, a master's thesis conducted by Marina Cano in 2021 with the Ludwig-Maximilian University (LMU) under the title "Identifying accreting candidates in the Carina Nebula with VPHAS+ data". Before doing that the CESAR Team provides students with an introduction about measurements in astronomy (distances, sizes, magnitudes, colours), how stars form and how to detect classical T Tauri stars (CTTS) in the Carina Nebula Complex among other topics. To identify CTTS candidates three criteria must be matched at the time: A relevant Halpha equivalent width (in the ugriHalpha photometric catalogue from VST (vphas+)), infrared excess emission (in the 2MASS catalogue) and a strong X-ray contribution (in the 4XMM-DR10 X-ray catalogue). The final sample of CTTS candidates should be matched with the GAIA catalogue to check for any foreground star contamination. Students are instructed about how to inspect and download scientific data (images and catalogues) from ESASky *and how to analyze them using spreadsheets and astronomical software like SAOImage DS9 and TopCat, as astronomers do in their daily life.*

[Poster #10] Björn Grieger; Arthur Dent

A new take on the CBL test of the Copernican principle and implications for the Hubble tension

A test of the Copernican Principle (later called CBL test) which is completely independent of the cosmological model was proposed by Clarkson, Bassett, and Lu (2008). It is based on the combination of Observational Hubble Data (OHD) from passively evolving galaxies and distance measurements of Supernovae Type Ia (SnIa) to compute cosmological curvature in dependence on redshift. This test was actually conducted by Sapone, Majerotto, and Nesseris (2014). The outcome was inconclusive, which was attributed to the insufficient data available at that time. Sapone et al. also investigated the prospects of the CBL test employing Euclid data.

By now, more OHD observations are available, so we perform a new take on the CBL test. The test requires interpolation of the OHD and SnIA data and estimation of the derivative of the latter. While Sapone et al. have used simple binning and numerical derivation, respectively, we employ Bayesian approaches, namely an extended version of Kriging for the interpolation of OHD and Tikhonov regularization for the inverse estimation of the derivative of SnIa distance measurements.

Our results are still inconclusive and do not provide any evidence of a deviation of the cosmological curvature from zero at any redshift. However, turning the argument around and assuming zero cosmological curvature, the Tikhonov regularization of the SnIa distance measurements provides an estimation of Today's Hubble parameter H0.

The final results of the Planck Collaboration (2018) using an "early universe" technique based on the cosmic microwave background gave a value of H0=(67.66±0.42) km/s/Mpc. Note that while data from the early universe is used, this is still an estimation of Today's H0. As a recent example of a "late universe" technique based on distance ladders, Riess et al. (2021) put forward a value of H0=(73.2±1.3) km/s/Mpc. The discrepancy between these techniques is called the Hubble tension. Curiously, the result we obtain with the Tikhonov regularization of SnIa distance measurements (which are also a "late universe" technique) is H0=(70.43±0.35) km/s/Mpc, just in between the Planck and the Riess et al. values.

The Copernican principle states that we are not living at a special place in the universe. In 2008, a test of the Copernican principle was proposed that involves, among other data, observations of the Hubble parameter, the varying expansion rate of the universe. The test was actually conducted in 2014, but the results were inconclusive because of insufficient data.

We redo that test using additional data and applying more elaborate statistical methods, but the results are still inconclusive. However, turning the argument around and assuming that the the curvature of the universe is zero everywhere (which encompasses the Copernican principle), we can estimate the value of the Hubble parameter Today, which describes the current expansion rate of the universe. The result is just in between two values contradicting each other which have been put forward.

[Poster #11] Ana M. Heras; Chistoph Hönes, Bernard Foing, Benjamin K. Miller

Identifying Transit Shape Anomalies in TESS Data with Deep Learning

In recent years Deep Learning methods have gained great popularity in astronomy. In the field of exoplanetary science, they are successful in the automated detection of exoplanet transit signals in light curve data, even for low signal to noise ratios and small planets. Also, for exoplanet candidate classification which separates true exoplanetary transits from false positives, deep learning models obtain state of the art results proving that they can extract useful information.

Supervised learning methods, however, require a large number of labelled examples which often involves a lot of human effort. Therefore, in this work we use deep learning methods using unsupervised learning, with the objective to identify deviations of exoplanet transit shapes from their theoretical transit model. This allows us to automatically find transit events with peculiar shapes for follow-up study in a large set of transits. Peculiar transit shapes may be associated with e.g. stellar activity, gravitational darkening, evaporating planets, or instrumental effects. We apply our method to the TESS Objects of Interest (TOI) catalogue. For benchmarking our method, we additionally create an artificial transit dataset with ground truth anomaly labels.

We extract features from transit light curve data using two 1D convolutional Variational Autoencoders (VAE). The first architecture, the TransitVAE, is trained to predict a theoretical transit model from noisy input data. This part is trained on artificial training data where ground truth transit models are available. The second architecture, the ResidualVAE, is trained to encode potential patterns in the residuals of the input transit and the transit model predicted by the TransitVAE. The features extracted by the ResidualVAE are used as input for traditional unsupervised anomaly detection methods like the Local Outlier Factor (LOF), the One-Class Support Vector Machine (OCSVM), the Isolation Forrest (IF) or the Mahalanobis distance. With an ensemble of these methods, we create an anomaly ranking of transits. The performance of our method is evaluated in terms of Precision-Recall curves and average precision on the artificial datasets with ground truth labels. We can show that our method vastly improves the performance of the traditional unsupervised anomaly detection methods and also outperforms standard VAE features. On real data we perform a classifier two-sample test to show that top-ranked anomalous transit shapes are significantly different from the majority of transits.

We present an Artificial Intelligence method for application to large datasets that allows us to detect exoplanet transits that show differences in shape with respect to their expected transit profile. These anomalies may be associated with e.g. stellar activity, gravitational darkening, evaporating planets, or instrumental effects. We apply our method to the TESS Objects of Interest (TOI) catalogue.

[Poster #12] Hans Huybrighs; Thomas Winterhalder, Rowan Dayton-Oxland, Arnaud Mahieux, David Goldstein

JUICE can detect Europa's water plumes with its particle detector instruments

Jupiter's moon Europa harbours a potentially habitable subsurface ocean. However, the icy crust prevents us from directly assessing the ocean's habitability. Recently discovered water plumes might allow us to directly take samples of the ocean with particle detector instruments, during a spacecraft flyby.

In this work we employ a particle tracing code to demonstrate that the neutral (NIM) and ion mass spectrometers (JDC) part of the Particle Environment Package (PEP) on JUICE can detect H2O and H2O+ molecules from the plumes. We show that the possibility to distinguish the H2O from the atmospheric component strongly depends on the mass flux of the plumes. The trajectory of the second flyby represents the best opportunity to detect the putative sources of plumes, down to the lowest mass fluxes. The plume described by Roth et al., 2014 is the most likely to be detected (during the first flyby). If the opportunity arises to lower one of the two JUICE flybys, lowering the first flyby would help increase the chance to detect a plume. We also demonstrate that shocks occurring due to neutral collisions in plumes at high mass fluxes decrease the size of the plume and shrink the area from which they can be detected by 50%.

Jupiter's moon Europa harbours a potentially habitable subsurface ocean. However, the icy crust prevents us from directly assessing the ocean's habitability. Recently discovered water plumes might allow us to directly take samples of the ocean by flying through such a plume.

[Poster #13] Nils Peter Janitzek; R. F. Wimmer-Schweingruber, D. Pacheco, A. Walsh, and the SOLO EPD Team

The First Year of Energetic Particle Measurements with Solar Orbiter's Energetic Particle Detector

Solar Orbiter (SOLO) is the most recent ESA/NASA science mission to study the Sun and the inner heliosphere. The spacecraft has been launched successfully in February 2020. On its first two orbits the spacecraft has approached the Sun as close as 0.5 astronomical units, which allows unprecedented measurements with a comprehensive suite of in-situ and remote-sensing instruments.

As part of the SOLO in-situ instrument suite, the Energetic Particle Detector (EPD) has now been operating and providing excellent data for more than a year after its comissioning in spring 2020. EPD measures suprathermal and energetic particles in the energy range from a few keV/nuc up to (near-) relativistic energies. We present an overview of initial results including two impulsive solar particle events in July and December 2020 which illustrate the measurement capabilities of the instrument.

Solar Orbiter (SOLO) observes the Sun from a unique elliptical orbit that allows unprecedented measurements from relatively close distances to the Sun. One major phenomenon of interest are eruptions on the Sun that *emit high-energy particles. These particles are measured by the Energetic Particle Detector (EPD) on Solar Orbiter. We present here an overview of EPD observations for the first year of SOLO operation between March 2020 and March 2021.*

[Poster #14] Oliver Jennrich; N. Lützgendorf, I. Thorpe, J. Slutsky, C. Cutler

Will the solar wind disturb LISA's measurements?

LISA will measure gravitational waves by observing the phase-shift of laser light travelling between the spacecraft. Electron density variations in the beam path will create a changing 'refractive index' and thus contribute to the observed phase shift as a noise. We estimated the size of the effect based on available measurements of electron densities in an Earth-like orbit and simple propagation models of the plasma density variations.

[Poster #15] Tereza Jerabkova

Tidal tails of open star clusters with Gaia

All star clusters have tidal tails. This poster presents recent advances in search for tidal tails of open star clusters using N-body simulations and Gaia data. These are particularly challenging because they are hidden in the Galactic disk in a process of becoming part of the field stars.

This posters shows how we can look at the night sky and find out that star clusters are much bigger than they seem to be. All star clusters are part of structures called tidal tails. Older the star cluster is the large tidal tails it has.

[Poster #16] Nimisha Kumari; R Maiolino, J Trussler, F Mannucci, G Cresci, M Curti, A Marconi, F Belfiore

Evidence for both gas infall and starvation by extending the fundamental metallicity relation beyond the BPT star-forming sequence

The fundamental metallicity relation (FMR) is a well-known relation between the star-formation rate, metallicity and stellar mass, and has been studied so far for the star-forming galaxies. In this contribution, we extend the FMR to galaxies beyond the star-forming (SF) sequence on the classical emission line diagnostic BPT diagrams. The extension to the BPT-non-SF galaxies has been made possible because of a recent work by Kumari+2019 which derived the first-ever metallicity calibrations for the BPT-non-SF galaxies. We use metallicity calibrations for both BPT-SF and BPT-non-SF galaxies from the Sloan Digital Sky Survey to study the FMR. The study shows evidence of starvation and gas infall, along with rejuvenation, chemical enrichment and outflows dominating at different evolutionary stages of galaxies.

[Poster #17] Belén López Martí; Dieter Engels (Hamburger Sternwarte), Francisco Jiménez Esteban (CAB, INTA-CSIC), Enrique Moya (CAB, INTA-CSIC), Pedro García Lario (ESA/ESAC)

Building the Gaia Catalogue of Galactic AGB Stars

Evolved low- and intermediate-mass stars experience significant mass loss during the AGB phase, which leads to the formation of circumstellar envelopes of gas and dust, dimming the central stars in the visual and near-infrared wavelength range. These sources become strong mid-infrared emitters, and in the case of oxygen-rich chemistry, often also maser emitters, in particular of OH at 1612 MHz. We cross-correlated the Gaia EDR3 release with a sample of more than 2000 OH maser sources to extract parallaxes and to derive distances to these stars. Gaia counterparts were found for about 50% of the sample, and reliable parallaxes were provided for about one third of the detected sources. With the aid of the Virtual Observatory, we constructed the spectral energy distribution of the whole sample to separate the AGB from post-AGB stars and other interlopers. We fitted the spectral energy distributions with theoretical models and estimated luminosities for those with reliable distances. In this contribution, we will discuss the results of our study of oxygen-rich AGB stars with OH maser emission and present the first results of a complementary study of nearly 4000 carbon-rich AGB stars. Both studies are building blocks for the construction of the Gaia Catalogue of Galactic AGB Stars, which will provide distances and luminosities for a significant number of these stars, thus becoming a benchmark for future studies in this field.

Asymptotic Giant Branch (AGB) stars are stars born with masses up to eight times larger than the Sun that are reaching the end of their lives. They will eventually lose their outer layers and form glowing clouds of gas, called planetary nebulae, that will get dispersed in space, leaving only the naked star cores: those dim, small, hot objects known as white dwarfs. We are building a catalogue of AGB stars that have been detected by Gaia and included in the last version of its catalogue, Gaia EDR3. Our goal is to obtain a representative list of these stars with accurate distance and luminosity estimations, which will be used to test evolutionary theories and to learn more about the history and fate of these interesting objects.

[Poster #18] Marcos Lopez-Caniego; D. Herranz

Detection of compact sources in maps of the microwave and sub-millimeter sky with convolutional neural networks

The detection of compact sources in maps of the microwave and sub-millimeter sky as seen by Planck and Herschel is a complex problem that over the years has been approached in different ways. The most common techniques used to detect compact sources are based on linear filters, and are typically applied in combination with simple statistics like signal-to-noise thresholding or Bayesian techniques that define more complex regions of acceptance. More recently, convolutional neural networks (CNNs) have been applied to detect compact sources in other areas of astronomy where the backgrounds are not so complex with great success. The application of CNNs to the detection of compact sources in Planck and Herschel could lead to more complete and less contaminated catalogues of sources. In the particular case of Planck this can have an impact on the uncertainties of the cosmological parameters derived from CMB maps where undetected compact sources can introduce unaccounted contamination, both in intensity and polarization. In this work we want to present an on-going work comparing the performance of different techniques used to detect compact sources under well controlled simulations.

In this work I am comparing different methods to detect compact objects in simulated maps of the microwave and sub-mm sky, in particular linear filters and convolutional neural networks, to assess the performance of both approaches.

[Poster #19] Oriel Marshall; (SCI-SC YGT, now at University of Antwerp), Catia Cardoso (ESA Education), Sandor Kruk (ESTC Research Fellow, now at Max Planck Institut für Extraterrestriche Physik), Kate Isaak (SCI-SCS), Juli Schmidt (formerYGT in ESA Education), Allysse Marshall (YGT in ESA Education).

Exoplanets in the Classroom: a CHEOPS case study.

The topic of exoplanets is one that captures the imagination of scientists and laypeople alike. Linked to the very simple yet profound question of whether we are alone in the Universe, exoplanet science is easy to relate to. As such, it provides an excellent means through which to teach basic science, technology, engineering and maths (STEM) skills and to introduce to, and engage young people in, some of the thrills of science. In this poster we give a pictorial overview of CHEOPS-based class room activities and resources that are under development by a small team focused around the work of a YGT based in Science and working within the Education unit. The emphasis of the activities has been on transit photometry and more specifically CHEOPS, with a key objective to use in-flight CHEOPS observations to engage young audiences. We are also developing problem-solving class room activities based on recent exoplanet discoveries made using CHEOPS. These will be integrated into a suite of topic-based exoplanet activities being developed by ESA Education and the ESEROs (ESA Space Education Resource OFfices (ESEROs) in members states, which can be used in the context of other missions with an exoplanet focus.

The topic of exoplanets is one that provides excellent means through which to engage young people in some of the thrills of science, whilst at the same time engaging teach basic science, technology, engineering and maths (STEM) skills to young people, whilst at the same time engaging them in some of the thrills of science. In this poster we give a pictorial overview of CHEOPS-based class room resources and problem-solving activities that are under development by a small team focused around the work of a YGT based in Science and working within *the Education unit. These will be integrated into a suite of topic-based exoplanet activities being developed by ESA Education and educators from members states for use in the context of other missions with an exoplanet focus.*

[Poster #20] Arnaud Masson; J. Morena Ventas, Peter Kretschmar, Elena Jimenez Bailon

Improving the indexing of ESA science datasets DOIs

Digital Object Identifiers (DOIs) associated to specific datasets or group of datasets can provide persistent links to be cited in refereed publications. Since early 2021, more than 25,000 DOIs have been minted by the European Space Agency to describe datasets measured by its scientific spacecraft. Additionally, structured metadata was included in all the DOI landing pages to make these datasets discoverable by the new Google Dataset Search engine (Masson et al., 2021; https://doi.org/10.1016/j.asr.2021.01.035). A manual process was followed to populate the keywords, contained inside the structured metadata, for a handful of these DOI landing pages, including those related to: experiments onboard heliophysics' missions and the Gaia astrometric/photometric catalogues. However, for planetary or other astrophysics' missions, most of the DOIs' keywords describing their datasets are static per mission. To improve the indexing of these DOIs, a novel approach has been taken for the 3000 XMM-Newton DOIs. It is based on the classic Term Frequency Inverse Document Frequency (TF-IDF) weighting but also on the MIT Rapid Automatic Keyword Extraction (RAKE) python library. A training set was analysed by XMM-Newton scientists to tailor these algorithms which were then used to derive the keywords automatically. This presentation will explain in more details how it was done.

Since early 2021, more than 25,000 DOIs have been minted by the European Space Agency to describe datasets measured by its scientific spacecraft. To improve the indexing of these DOIs, a novel approach has been taken for the 3000 XMM-Newton DOIs.

[Poster #21] Simone Migliari; J. López-Miralles (U. Valencia), Manel Perucho, José María Martí, Simone Migliari, Valentí Bosch-Ramón

3D RMHD simulations of jet-wind interactions in High Mass X-ray Binaries

During the last years, there have been several attempts to describe the propagation of jets in X-ray Binaries (XRBs) from a numerical perspective, especially on understanding the effect of the ambient medium in the flow dynamical evolution. For example, Perucho et al., 2010 probed with 3D hydrodynamical simulations that low-luminosity jets may be disrupted by the lateral impact of the stellar wind, conditioning the radio-band detection of this population of XRBs. However, previous numerical simulations ignore the effect of one fundamental ingredient of relativistic jets of all scales: the existence of magnetic fields within the plasma. In this contribution, we present the first 3D Relativistic Magnetohydrodynamics (RMHD) numerical simulations of microquasar jets performed with our new computational tool for Relativistic Astrophysics; the code LÓSTREGO v1.0. We explore the interaction of the jet with the moderate-to-strong wind of the companion star using typical values for High-Mass XRBs, focusing on how the presence of magnetic fields with different intensity affect the jet propagation, collimation and long-term stability.

The ejection of collimated beams of plasma is the most powerful consequence of accretion onto compact objects (i.e, Neutron Stars and Black Holes). These outflows, called relativistic jets, are ubiquitous in the Universe, and can travel to long distances near the speed of light. In the case of Black Holes, jets are observed to be ejected from supermassive Black Holes at the center of active galaxies, but also from stellar-mass Black Holes within our own galaxy. In the latter scenario, called X-ray Binaries or microquasars, jets are formed when a stellar-mass Black Hole orbits a companion star and accretes the outer layers in the form of an accretion disk. In this contribution, we use a powerful supercomputer (Tirant, University of Valencia) to simulate how these jets interact with the stellar winds of the companion, and what is the effect of magnetic fields in the jet propagation. The results of these simulations are useful to interpret observations of these systems at different wavelengths performed with space observatories like Chandra, Swift, XMM-Newton or the Rossi X-ray Timing Explorer, among others.

[Poster #22] Daniel Müller; B. Nicula, F. Verstringe, B. Bourgoignie, B. Fleck, A. De Groof, A. Walsh, D. Williams, C. Watson, Y. Zouganelis, L. Sanchez

JHelioviewer: 3D Visualisation of Solar Data & Solar Orbiter Science Planning

The Solar Orbiter mission focuses on exploring the linkage between the Sun and the heliosphere. Already during its cruise phase, the mission has been collecting unique data, largely from the four in situ instruments (https://www.aanda.org/component/toc/?task=topic&id=1340). In preparation for the start of Solar Orbiter's nominal mission phase, and its first close solar encounter in March 2022, simultaneous observations of the six remote-sensing and the four in-situ instruments are being scheduled to test the operational approach to observe, e.g., the expected source regions of the solar wind that the spacecraft will subsequently fly through. Choosing the targets of such observing campaigns is under the responsibility of the scientific coordinator of the respective Solar Orbiter Operations Plan (SOOP), typically external to ESA, and requires assimilating recent image data from several space missions orbiting the Sun, as well as models of the Sun's large-scale magnetic field to forecast which areas on the Sun's surface are most likely magnetically connected to the spacecraft (http://connect-tool.irap.omp.eu/). In this contribution, I will present how the ESA JHelioviewer software (https://doi.org/10.1051/0004-6361/201730893, developed with SCI-S research funds), has been augmented to achieve this.

The Solar Orbiter mission focuses on exploring the linkage between the Sun and its surrounding plasma bubble, the heliosphere. Already during its cruise phase, the mission has been collecting unique data, largely from the four in situ instruments. In preparation for the start of Solar Orbiter's first close solar encounter in March 2022, simultaneous observations of the six remote-sensing and the four in-situ instruments are being scheduled to test the approach to observe, e.g., the expected source regions of the solar wind that the spacecraft will subsequently fly through. Choosing the targets of such observing campaigns requires combining recent images from several space missions orbiting the Sun, as well as models of the Sun's large-scale magnetic field to forecast which areas on the Sun's surface are most likely magnetically connected to the spacecraft. In this contribution, I will present how the ESA JHelioviewer software has been augmented to achieve this.

[Poster #23] Karen O'Flaherty; Kate Isaak, Mark McCaughrean

Demonstrating the feasibility of an ArtScience Programme in the Science Directorate

Space has long fascinated artists and is a recurring topic of creative dialogue in society. In recent years, there have been several formal and informal initiatives at ESA to facilitate ArtScience collaborations. Each has been a unique, distinct and highly successful endeavour, targeting a particular mission or opportunity. Such collaborations benefit both the artists and the scientific and technical experts working on a project. The artists are exposed to ideas that inspire and influence their practice; the experts experience directly the cultural and artistic aspects of their work and its impact on society. We have initiated a project to demonstrate the feasibility of running an ArtScience programme in the Science Directorate. This builds on the interest in the work of the Science Directorate that has been expressed by artists from many countries in recent years, and on experience gained within the Directorate with the art&science@esa residency. The COVID landscape has introduced challenges to implementing and sustaining what are by definition interactive collaborations. With this in mind our first activity, restricted to artists based in the Netherlands, is an initiative in partnership with Science Gallery Rotterdam to engage under-served communities in the Rotterdam area in Space Science. In this poster we give a graphical overview of the pilot project.

Space has long fascinated artists and is a recurring topic of creative dialogue in society. Such dialogue is of benefit to both artists and scientists and engineers working on space projects: the artists are exposed to ideas that inspire and influence their practice; the experts experience directly the cultural and artistic aspects of their work and its impact on society. In this poster we give a graphical overview of a pilot project that is running to demonstrate the feasibility of running an Art Science Programme in the Science Directorate.

[Poster #24] Saida Ramdani; Nils Janitzek, Andrew Walsh

First Measurements of Solar Wind Heavy Ions with Solar Orbiter

In-situ particle measurements in the solar wind are crucial to investigate several of the most outstanding questions in solar (and stellar) physics such as the heating of the solar corona and the acceleration of the solar wind. Furthermore, elemental composition measurements of the solar wind can help us to find the source population of high-energy particles that are accelerated in large gradual solar events related to coronal mass ejections. This analysis presents first data and an early calibration of the Heavy Ion Sensor (HIS) as part of the Solar Wind Analyzer (SWA) instrument onboard the ESA/NASA Solar Orbiter (SOLO) spacecraft. The sensor measures precisely the velocity distribution functions of a wide range of solar wind heavy ions (with atomic number Z>1), from which one can derive the ions' kinetic properties but also the elemental and charge-state composition of the solar wind plasma at the spacecraft site. SOLO was launched in February 2020 and the presented data is recorded in the end of June 2020 when the spacecraft approached the Sun as close as 0.5 astronomical units - allowing for unprecedented measurements of solar wind heavy ions in the very inner heliosphere.

The joint ESA/NASA Solar Orbiter (SOLO) mission is designed to study the Sun in great detail by approaching our host star as close as one third of the distance between Earth and Sun. As one of ten instruments onboard SOLO, the Solar Wind Analyzer (SWA) instrument measures low-energy particles that are emitted continuously by the Sun, the so-called solar wind. The solar wind consists of electrons, protons and heavy ions from elements that are heavier than hydrogen. By measuring the speed and elemental abundances of the ions, one can investigate several outstanding questions related to the physics of the Sun (and similar stars), such as the high temperatures in the outermost layer of the solar atmosphere, the acceleration of the solar wind, but also eruptions on the Sun that create high-energy particles. SOLO was launched in February 2020 and here we present first solar wind ion data that was recorded with the SWA Heavy Ion Sensor (HIS) in the end of June 2020 when the spacecraft approached the Sun as close as half the distance between Sun and Earth. Only a few other spacecraft have come that close to the Sun and none of them carried the instrumentation to measure the ion component of the solar wind in such detail as Solar Orbiter, so that exciting new results can be expected from these measurements through the course of the ongoing mission.

[Poster #25] Johannes Sahlmann

Astrometric orbits of stars with exoplanets

Exoplanet host stars exhibit positional changes caused by the orbiting companion that can in principle be detected with the help of astrometric measurements in an absolute reference frame. This orbital motion is superimposed to parallax and proper motion but usually is much smaller in amplitude. We will describe the basic principles of the astrometry technique for exoplanet characterisation, discuss the typical amplitudes of exoplanet host stars in the context of available instrumentation, and highlight recent results. We will then show how the Gaia mission is about to add astrometry to the mainstream of exoplanet characterisation techniques.

This is an overview of results obtained with a specific exoplanet discovery technique (astrometry) and an outlook on how Gaia is changing the game.

[Poster #26] Richard Saxton; Margherita Giustini

Is a diet of black holes bad for stellar digestion?

The science of stars which are disrupted and accreted by super-massive black holes, giving off flares of UV and X-ray radiation, has now entered the mainstream of observational astronomy and is becoming well known. But, what about the reverse? What would happen if a small, planet-mass, black-hole was accreted by a star? Would the combined object explode? If so, how long would it take? Would the system show spectral or temporal evidence that would allow us to detect it observationally? In this poster we take a high-level look and discuss the chances of such systems forming and the progress made so far in the subject.

[Poster #27] Dima Titov

Mars ionospheric composition from ASPERA-MARSIS/ Mars Express sounding

The Mars Express payload enables an innovative technique to study low energy plasma environment around the spacecraft. Operating the active radar MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding) results in acceleration of the local thermal ions to energies up to 800 eV that are detected by the

Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3). About 50,000 events of the Sounder Accelerated Ions (SAI) were documented in 2007 though 2018. The measurements supported by modelling allow retrieval of the ion density of the main (O+, O2+ and CO2+) and even minor (O2++, C+, CO+) plasma components with accuracy of 30-50%. This novel active sounding technique opens new possibilities to study the Martian ionosphere and can also be used on other missions with a similar combination of instruments.

[Poster #28] Claire Vallat; Rosario Lorente, Detlev Koschny, Nicolas Altobelli, Juergen Schmidt, Xiadong Liu, Katherina Fiege, Mario Trieloff, Anna Mocker, Ralf Srama

Icy moons' surface weathering characterization in preparation for the JUICE mission: Simulations and laboratory experiments results

We report on the latest status of complementary activities performed at ESAC in collaboration with partner universities, supported in part by the science faculty, to characterize the Jupiter's icy moons surface weathering.

The ESA JUICE mission is planned to arrive in early 2030s in the Jupiter system, with one of its main science objectives being to characterize the Jupiter icy moons as potential habitat.

40 years earlier, Galileo imaging and reflectance spectroscopy data had revealed different alterations in the Galilean moons' surfaces between leading and trailing hemispheres in terms of albedo, structural properties and composition as the consequence of exogenic bombardment of the surfaces of the tidally locked moons by energetic ions and electrons as well as by micrometeoroids.

Since those exogenic agents alter the surface on time scales shorter than the surface evolution, disentangling the exogenic and endogenic contribution of to the moons' surface characteristics is needed, in particular because material from the moons' interior may be reaching the surface, carrying information on the putative oceans, before being altered by the exogenic weathering.

Micrometeoroid impacts contribute, among other processes (radiolysis, thermal desorption, plasma sputtering) to the exogenic energy deposit that alter the surface of the Jovian moons, leading to both surface weathering and possibly to exosphere formation by secondary ejectas and surface vaporization. Simulations of the dust environment around the Jovian icy moons are necessary to quantify those phenomena and can be used to constrain laboratory experiments designed to understand the weathering of icy surfaces by dust impactors. Primary interplanetary dust (IDP) impacts fluxes are inferred from the ESA Interplanetary Micrometeoroid Environment Model (IMEM) at Jupiter's Hill radius, and corrected for gravitation focusing to infer the fluxes and the moons' orbits distances. IDP impacts on the moons generate secondary ejectas that evolve dynamically in the Jovian system before re-impacting another moon's surface, resulting in compositional mixing. The impact flux of those secondary ejectas is computed at each moon using the ESA Jovian Micrometeoroid Environment Model (JMEM), maintained at the Free University of Berlin.

In addition, laboratory measurements led by the University of Heidelberg has provided an evaluation of the effects of irradiation of ices mixtures mimicking the expected composition and temperature of the icy moons. The next step, led by the University of Stuttgart, is now to set up the experimental environment to produce ice targets with proper compositions and temperature before performing ices samples bombardment by silicates using a 2MV dust accelerator.

We report on the latest status of complementary activities performed at ESAC in collaboration with partner universities, supported in part by the science faculty, to characterize the Jupiter's icy moons surface weathering.

[Poster #29] Antonia Vojtekova; Bruno Merin, Ivan Valtchanov, Mattias Wangblad, Henrik Norman, Marcos López Caniego and Nuria Álvarez

Where in the sky are the ESASky users looking?

ESASky is a science-driven discovery portal providing full access to the entire sky as observed with Space astronomy missions. ESASky portal offers multiple features for scientists and the general public to explore over one million astronomical observations. The preliminary results show how our users use the essential ESASky tools, how they interact with new features implemented at the latest release and which parts of the sky do they explore more statistically. In further work, we hope to create a simple recommender system for users based on their different profiles.

[Poster #30] Peter Zeidler; Antonella Nota, Elena Sabbi

The fate of Westerlund 2 - the complex dynamical state of a young massive Milky Way star cluster

We present the radial velocity analysis of the young massive Milky Way star cluster Westerlund 2, using VLT/MUSE integral field spectroscopy and Gaia proper motions. We demonstrate that the cluster member stars kept the kinematic imprint of the initial Giant Molecular Cloud collapse that formed Westerlund 2. This conclusion was drawn from the detection of five distinct low-mass star velocity groups, which are spatially correlated with the cluster's two stellar sub-clusters. Furthermore, the gas motion agrees with the assumption that the onset of star formation in this region is the result of a cloud - cloud collision.

A thorough analysis of the dynamical cluster mass together with the result of an increasing velocity dispersion with decreasing stellar mass puts Westerlund 2 in a super-viral state, hence leading to the conclusion that it is doomed to dissolve in the future. Additionally, we also identified 22 runaway candidate stars with peculiar velocities up to 546 km/s.

The detailed study of the kinematics in young star clusters are vital to understand their long-term evolution and survivability - in other words, is a star cluster massive enough to overcome the so-called infant mortality hence surviving internal and external processes, i.e. supernova explosions or the interaction and collision with giant molecular clouds in their host galaxy, which all eventually lead to their dissolution and destruction. We used VLT/MUSE, an integral field spectrograph and proper motions from the Gaia satellite to show that Westerlund 2, one of the most massive young star clusters in the Milky Way, is not massive enough to be long lived. Furthermore, we demonstrated that even after a few million years the cluster stars still trace the motion of their parental gas and dust cloud their formed from and that star formation in this region was initiated by the collision of at least two Giant Molecular Clouds.