ESA SCI Science Workshop #13
1–3 December 2020
Virtual Meeting

Abstracts

Organising Committee:
Guillaume Bélanger, Georgina Graham, Oliver Hall,
Michael Küppers, Erik Kuulkers, Olivier Witasse.

SSW#13 PROGRAMME (all times are in CET)

1 DEC 2020

PART 1

Moderator: Oliver Hall

14:30-14:40 - Welcome - Markus Kissler-Patig [10]
14:40-15:00 - Introduction of new RFs & YGTs (Pre-recorded) [20]
15:00-15:30 - Invited talk: Solar Orbiter - Daniel Mueller [20+10]
15:30-15:45 - A CME whodunit in preparation for Solar Orbiter - Alexander James et al. [10+5]
15:45-16:00 - Poster viewing/discussion in Gathertown [15]

16:00-16:30 - break

PART 2

Moderator: Georgina Graham

16:30-17:00 - Intro new H/DIV SCI-SC and presentation of SCI-ence budget - Gaitee Hussain [20+10]
17:00-17:15 - Searching for signs of life with the ExoMars Rover: why the mission is how it is - Jorge Vago & Elliot Sefton-Nash [10+5]
17:15-17:30 - Posters summary/advertisement talk - Solar System - Matt Taylor & Anik de Groof [15]
17:30-17:45 - Posters summary/advertisement talk - Astronomy/Fundamental Physics - Peter Kretschmar & Oliver Jennrich [15]
17:45-18:00 - Accreting black holes seen through XMM-Newton - Andrew Lobban et al. [10+5]

2 DEC 2020

PART 1

Moderator: Tereza Jerabkova

14:30-15:00 - Invited talk: BepiColombo: comprehensive exploration of Mercury - Johannes Benkhoff [20+10]
15:00-15:15 - ESA communications and PR, interactive session - Kai Noeske [15]
15:15-15:30 - Segmentation of coronal features to understand the Solar EIV and UV irradiance variability - Joe Zender [10+5]
15:30-15:45 - Spectrophotometry to study icy surfaces - Anezina Solomonidou et al. [10+5]
15:45-16:00 - Poster viewing/discussion in Gathertown [15]

16:00-16:30 - break

2 DEC 2020

PART 2

Moderator: Emily Rickman
16:30-16:45 - Life & Science during COVID-19 - Hans Huybrighs [15]
16:45-17:00 - Hubble Asteroid Hunter: exploring the ESA Hubble archives with citizen science - Sandor Kruk et al. [10+5]
17:00-17:15 - Expedition: Home - Alana Bartolini & Laylan Saaldin (Education Office) [15]
17:15-17:30 - The X-ray temporal and spectral analysis of incredibly variable blazars: the case of Mrk 421 - Luana Michela Modafferi [10+5]
17:30-18:00 - The ESTEC & ESAC Science Faculty 2.0 - Michael Küppers & Erik Kuulkers [30]

18:00-19:00 - Drinks & games in the Gathertown social area

24:00 Poster quiz deadline

3 DEC 2020

PART 1

12:00 Best poster vote deadline

Moderator: Francois Mernier
14:30-15:00 - Invited talk: ARIEL: Theresa Rank-Lüftinger [20+10]
15:00-15:15 - Towards a two-colour photometer at Dome C, Antartica - Nicolas Crouzet et al. [10+5]
15:15-15:30 - Poster quiz answers and final round - Matteo Guainazzi & Georgina Graham [15]
15:30-15:45 - Direct imaging and spectral characterisation of long-period exoplanets and brown dwarfs - Emily Rickman [10+5]

15:45-16:15 - break

PART 2

Moderator: Nuria Alvarez
16:15-16:30 - Posters & quiz: Prize - SOC
16:30-16:45 - From stars to galaxies with Gaia - Tereza Jerabkova et al. [10+5]
16:45-17:15 - Gaia EDR3 summary - Timo Prusti
17:15-17:30 - Closing remarks - Günther Hasinger

Oral Presentations

Listed alphabetically by 1st author last name

Alana Bartolini & Laylan Saaldin [ESTEC]

Expedition: home

The ESA Education office will present "Expedition: home", the website launched at the beginning of the COVID-19 pandemic, addressing kids and families in a home setting. The website features plenty of educational activities that use space as a learning context for the three age groups (3–6, 6–12, 12–18 years old). A demo of the new Paxi computer games for the juniors will close the session on an entertaining note.

Johannes Benkhoff [ESTEC]

BepiColombo: comprehensive exploration of Mercury

BepiColombo is a joint project between the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA). With its state of the art and very comprehensive payload, BepiColombo will perform measurements to increase our knowledge on the fundamental questions about Mercury's evolution, composition, interior, magnetosphere, and exosphere. The mission has been launched on 20 October 2018. In April 2020 BepiColombo has passed Earth and its second planetary was on 15th October 2020 at Venus. A status of the mission and a summary of first results from measurements taken during the first two flybys will be given.

Nicolas Crouzet, Exoplanet WG, Dennis Breeveld & Sander Blommaert [ESTEC]

Towards a two-colour photometer at Dome C, Antartica

We are upgrading a 40 cm telescope installed at Dome C, Antarctica to perform simultaneous two-colour photometry. The main goal is to observe exoplanet transits.

Hans Huybrighs [ESTEC]

Life & Science during COVID-19

Online conferences (EGU, EPSC...) in this corona era have been struggling to provide means for interaction between participants. How can we improve? I will show how we enhanced interaction between the participants using zoom breakout rooms during the '2020 moon-magnetosphere workshop' and report on other lessons learned.

Alexander James, Georgina Graham & Nils Janitzek [ESAC]

A CME whodunit in preparation for Solar Orbiter

We analyse remote-sensing images of the lower solar corona to decipher the pre-eruptive structures of two coronal mass ejections (CMEs). We then uncover the connection between these eruptions and a series of interplanetary measurements made between 0.4 and 1 AU at the MESSENGER, Venus Express, and STEREO-B spacecraft. These comparisons are aided by the application of a new flux rope modelling tool called AMUN-SA.

Tereza Jerabkova, O. Hall, D. Michalik, P.G. Garcia, J. de Bruijne, T. Prusti & G. de Marchi [ESTEC]

From stars to galaxies with Gaia

Stars and star clusters form in sub-pc dense filamentary regions of molecular clouds. The detailed small-scale physics of star formation, its initial conditions and how this couples to galaxy-wide scales via gravitational forces and stellar populations still remains to be fully understood. With this project we focus on tidal tails of star clusters and large-scale relics of star-formation in filaments. These are unique structures providing a physical link between the initial conditions of cluster formation and the Galactic potential, its tides, and shears. We take the advantage of the Gaia data that, for the first time, allow us to study such whole-sky extended regions. State-of-art detailed Nbody simulations in realistic (lumpy) Galactic potentials are performed to interpret the observations. To study co-evality of the large-scale stellar structures and tails, not properly constrained by photometric Gaia data, we use TESS-derived rotational period distributions as age probes.

We will present first results of the project and its future prospects.

Sandor Kruk, Bruno Merín & Pablo García Martín [ESAC]

Hubble Asteroid Hunter: exploring the ESA Hubble archives with citizen science

The Hubble Space Telescope (HST) archives can hide many unexpected treasures, such as trails of asteroids, showing a characteristic curvature due to the parallax induced by the orbital motion of the spacecraft during the exposures.

We present a new citizen science project exploring the ESA HST (eHST) archive for serendipitously observed asteroids. Hubble Asteroid Hunter (www.asteroidhunter.org) was set up as a collaboration between scientists and engineers at the ESAC Science Data Centre (ESDC) and Zooniverse and launched on the International Asteroid Day in June 2019. Since then, more than 10,000 volunteers provided 2 million classifications of 150,000 HST images and uncovered 1500 asteroid trails in them, many of the asteroids yet to be identified. Finding the asteroids in HST images allows us to refine the ephemerides of their orbits, as well as to study their orbital distribution. In addition to marking the positions of asteroids, the volunteers also tagged satellites in orbits higher than Hubble's and discovered new strong gravitational lenses and collisional ring galaxies. We argue that a combination of citizen science and artificial intelligence methods is an efficient way of exploring archival data and highlight some of the interesting results found by this project with the invaluable help of the Zooniverse volunteers.

Andrew Lobban, William Alston, Nuria Alvarez & Zsofi Igo [ESAC]

Accreting black holes seen through XMM-Newton

Accreting black holes are unique sources of some of the most extreme physics in the universe. They are a testbed for our understanding of general relativity and high-energy physics, and play a vital role in shaping the cosmos from its origins to how it appears today. In this talk, we will discuss some of our recent results using XMM-Newton to study both the accretion and ejection of matter as it approaches nearby super-massive black holes.

Luana Michela Modafferi [ESAC]; N. Álvarez Crespo, I. de la Calle

The X-ray temporal and spectral analysis of incredibly variable blazars: the case of Mrk 421

Active Galactic Nuclei (AGNs) are astrophysical sources located at the center of some galaxies, powered by accretion of matter into a supermassive black hole.

According to the Unification Model for radio-loud AGNs, blazars are AGNs in which a relativistic jet points towards our line of sight, so properties such as variability and luminosity are relativistically boosted-thus making blazars one of the most energetic objects in the Universe. Thanks to their special orientation, the observation of blazars allows us to study the physics of energy production in proximity of the centers of AGNs. There are two blazar classes according to their optical spectral properties: BL Lacs show weak or no emission lines (EW < 5 Å) and flat spectrum radio quasars (FSRQ) that show broad emission lines. This analysis focuses on the

former. The X-ray observatory XMM-Newton uses the nearby BL Lac Mrk 421 as calibration source for the Reflection Grating Array (RGS), as it is one of the brightest at X-ray energies.

Therefore most of the analysis focused mainly on RGS data. Six European Photon Imaging Camera (EPIC) observations were also added to the analysis, since the observations were in Science mode. A vast temporal and spectral analysis was performed on data of Mrk 421. Having over 100 available observations to be processed, the steps of data reduction, the building of the light curves and the fitting of the spectra were all automated by making a Python package. Also, the code was developed so that the analysis can be repeated for other XMM-Newton sources as well and therefore allows the comparison between results of different objects.

The individual light curves of each observation were extracted and used to build the historical X-ray light curve. This light curve allowed the determination of a threshold between low and high state of 20 cts/s, which was then used to analyse spectral properties in different states. Variability properties of the light curves were studied by means of mathematical tools such as the excess variance and the fractional variability. In particular, for the longest observations (duration $>$ 60 ks) the evolution of the average properties of the fractional variability was analysed more in detail in order to study the non-stationarity of the source.

In addition to the temporal analysis, the spectral analysis was carried out by extracting the spectrum of each observation. Each spectrum was also divided into pieces of 1ks each in order to collect more information and study more in detail the evolution of the parameters. Over 5000 spectra were analysed in an automated fashion. The results indicate that as the source flux increases, the spectral slope decreases, meaning that the spectra get flatter/harder. This trend is confirmed by studying the spectral parameters in different states of the source (low/high).

For observations presenting a rise and fall in their light curve, spectral loops were found. The chosen observations are characterized by both clockwise and anti-clockwise loops indicating the presence of both the processes of acceleration and cooling of the electrons. As for the EPIC analysis, the extracted light curves were separated into soft (0.6–2 keV) and hard (2–10 keV) bands so to compute the hardness ratio. The "harder when brighter" trend was found in the EPIC analysis as well.

Future work consists in the implementation of the analysis of a second BL Lac which is fairly similar to Mrk 421 and also used for calibration by XMM-Newton. A comparison of the behavior of both sources is necessary to discern whether the conclusions are similar for both objects and therefore extrapolable to more blazars. Further analysis of the source is being carried out, such as the building of the SED and the PSD, the search of periodicities, the determination of a minimum variability time-scale and estimation of the black hole mass.

Daniel Müller [ESTEC]

Solar Orbiter

Solar Orbiter was launched on 10 February 2020 to explore the linkage between the Sun and the heliosphere. During its first months of operation, it has started to collect unique data at solar distances down to 0.51 AU and is now on en route to its first Venus fly-by on 27 December. By ultimately approaching as close as 0.28 AU, Solar Orbiter will view the Sun with very high spatial resolution and combine this with in-situ measurements of the surrounding heliosphere. Over the course of the mission, the highly elliptical orbit will get progressively more inclined to the ecliptic plane. Thanks to this new perspective, Solar Orbiter will deliver images and comprehensive data of the Sun's unexplored polar regions and the side of the Sun not visible from Earth. This talk will provide a mission overview and highlight first data from Solar Orbiter.

Kai Noeske [ESTEC]

ESA communications and PR

ESA communications and PR.

Timo Prusti [ESAC/ESTEC]

Gaia EDR3 summary

Gaia EDR3 is the first installation of the third Gaia data release that has been split into two parts. Gaia EDR3 contains an update of astrometry and integrated photometry. The remaining part, Gaia DR3, will bring updates and new elements in 2022. The presentation summarises the Gaia EDR3 contents and shows the advancement of science potential with the demonstration cases presented in the four performance verification articles accompanying Gaia EDR3.

Theresa Rank-Lüftinger [ESTEC]

ARIEL

ARIEL.

Emily Rickman [STScI]

Direct imaging and spectral characterisation of long-period exoplanets and brown dwarfs

Very little is known about giant planets and brown dwarfs at an orbital sep- aration greater than 5 AU. And yet, these are important puzzle pieces needed for constraining the uncertainties that exist in giant planet formation and evolu- tionary models. The complex molecular chemistry of their atmospheres leaves a relatively wide parameter space for models to span. Placing accurate mass and luminosity data to observationally populate the mass-luminosity relationship provides a major contribution to an understanding of brown dwarf and giant planet evolutionary models. I describe the progress towards the detection, char- acterisation and monitoring of widely-separated giant planets and brown dwarfs through both direct imaging and long-period radial-velocities. This includes the detection of several long-period radial-velocity giant planets and brown dwarfs, as well as the direct imaging of some of these companions with VLT/SPHERE and the discovery of a benchmark $\sim$50 M_{Jup} T-type brown dwarf.

Anezina Solomonidou & Ines Belgacem [ESAC]

Spectrophotometry to study icy surfaces

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

Jorge Vago & Elliot Sefton-Nash [ESTEC]

Searching for Signs of Life with the ExoMars Rover: Why the mission is how it is.

ExoMars 2022 was conceived, from the very beginning, to answer one question: Was there ever life on Mars? All project design decisions have focused and continue to center on the achievement of this one scientific objective. This is particularly the case for the Rosalind Franklin rover. Putting the science team in the best possible position to search for physical and chemical biosignatures has led to:

1. The need to have a 2-m depth drill;
2. The choice of payload instruments (including the trade-offs we had to make);
3. The science potential and age of landing site;
4. The surface exploration strategy: which targets, how much traveling, and way the instruments will be used.

We introduce some of the post-landing rover activities.

Joe Zender [ESTEC]; Rens van der Zwaart, Rangaiah Kariyappa, Luc Damé, and Gabriel Giono

Segmentation of coronal features to understand the solar EIV and UV irradiance variability

The study of solar irradiance variability is of great importance in heliophysics, the Earth's climate, and space weather applications. These studies require careful identifying, tracking and monitoring of features in the solar magnetosphere, chromosphere, and corona. We studied the variability of solar irradiance for a period of 10 years (May 2010-January 2020) using the Large Yield Radiometer (LYRA), the Sun Watcher using APS and image Processing (SWAP) on board PROBA2, the Atmospheric Imaging Assembly (AIA), and the Helioseismic and Magnetic Imager (HMI) of on board the Solar Dynamics Observatory (SDO), and applied a linear model between the identified features and the measured solar irradiance by LYRA.

We used the spatial possibilistic clustering algorithm (SPoCA) to identify coronal holes, and a morphological feature detection algorithm to identify active regions (AR), coronal bright points (BPS), and the quite sun (QS) and segment coronal features from the EUV observations of AIA. The AIA segmentation maps were then applied on SWAP images, images of all AIA wavelengths, HMI line-of-sight (LOS) magnetograms, and parameters such as the intensity, fractional area, and contribution of ARs/CHs/BPs/QS features were computed and compared with LYRA irradiance measurements as a proxy for ultraviolet irradiation incident to the Earth atmosphere.

We modelled the relation between the solar disk features (ARs, CHs, BPs, and QS) applied to magnetrogram and EUV images against the solar irradiance as measured by LYRA and the F10.7 radio flux. To avoid correlation between different the segmented features, a principal component analysis (PCM) was done. Using the independent component, a straightforward linear model was used and corresponding coefficients computed using the Bayesian framework. The model selected is stable and coefficients converge well.

The application of the model to data from 2010 to 2020 indicates that both at solar cycle timeframes as well as shorter timeframes, the active region influence the EUV irradiance as measured at Earth. Our model replicates the LYRA measured irradiance well.

Poster Presentations

Listed by Poster Number

[Poster #1] Alejandro Cardesin-Moinelo [ESAC]

Venus cloud opacity, particle size and cloud top temperature mapped in the nightside atmosphere by VIRTIS/Venus Express

In this work we have produced 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.

We have first obtained a global view of the nightside cloud opacity in the lower clouds mapping the integrated radiance in the infrared atmospheric windows around 1.74 μm and 2.3 μm. The radiance measured around these wavelengths originate below the cloud layer and both bands reflect the opacity of the lower cloud layer (44-48 km altitude), with common trends and high symmetry between the north and south hemispheres. Despite the common elements, the bands 1.74 and 2.3μm behave very differently with respect to the particle size, therefore the ratio between them provides an indirect estimation of the particle size distribution for these clouds, which is especially evident near the polar regions and also around the mid-latitude cloud belt. We have then produced maps of the brightness temperatures in the thermal region around 3.8 μm and 5.0 μm, which provide a direct indication of the temperatures at the top of the clouds (60–70 km altitude) and the cooling with local time visible in both hemispheres.

These maps provide a global view of the global atmospheric dynamics at various altitudes, showing the main regions of the planet and the main characteristics in line with the latest general circulation models of Venus. The equatorial region shows a uniform cloud opacity and particle size, with no significant local time variations throughout the night except for the gradual temperature cooling of the cloud tops from evening to morning. The midlatitude cloud belt extends uniformly over the night with the lowest opacity and lowest particle size distribution for both hemispheres, with an interesting asymmetry as the Northern hemisphere seems to have lower opacity and relative particle sizes. Towards the polar regions, the cold-collar appears with highest opacity and particle sizes, with a clear evening-to-morning cooling that had already been reported separately for the North and South hemispheres, and is now shown simultaneously providing a more global view of the atmospheric symmetry.

Reference publication: "Global maps of Venus nightside mean infrared thermal emissions obtained by VIRTIS on Venus Express". https://doi.org/10.1016/j.icarus.2020.113683

[Poster #2] Pedro Machado [Other]

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

We present here two different studies of the atmosphere of Mars performed in 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, 2020]. 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 spectrometer. For the analysis of the data we will also use the latest 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. This

new project is based on previous similar studies done on Venus. The methods include image navigation and processing techniques to characterise morphological properties of the detected waves (horizontal wavelength, packet length and width, orientation and relative optical thickness drop between crests and troughs) [Silva et al, 2020].

References: Machado, P., Valido, H., Cardesin-Moinelo, A., and Gilli, G.: Mars Atmospheric Wind Map Along the 2018 Global Dust Storm, Europlanet Science Congress 2020, online, 21 September-9 Oct 2020, EPSC2020-221, https://doi.org/10.5194/epsc2020-221
Silva, J., Machado, P., Peralta, J., and Brasil, F.: Characterising atmospheric gravity waves on the lower cloud of Venus - A systematic study, Europlanet Science Congress 2020, online, 21 September-9 Oct 2020, EPSC2020-281, https://doi.org/10.5194/epsc2020-281

[Poster #3] Detlef Koshny [ESTEC]

FRIPON - Luminous efficiencies of meteors

FRIPON - the 'Fireball Recovery and InterPlanetary Observation network' - is a network of all-sky cameras that continuously observe the night sky and detects bright meteors, called fireballs. Currently, more than 100 cameras are operational mainly in France and Italy. With support of faculty funding, we are expanding the network to the Netherlands. This gives us access to the complete FRIPON data.

In a collaboration with the University of Oldenburg, Germany, we are using the data to study the so-called luminous efficiency of meteors. This is the percentage of kinetic energy which is converted to light. It is an important parameter to estimate the mass of the underlying meteoroid from the brightness of the fireball.

We do this by using describing the light curve of the observed fireball using standard ablation equations (e.g. Gritsevich + Koschny 2011). The entry geometry can be directly measured; the initial mass, the so-called shape factor, and - the luminous efficiency, i.e. the percentage of kinetic energy which is converted to light. We have fitted >300 light curves of FRIPON fireballs with model data and derived the luminous efficiency from it. There is a trend visible that the luminous efficiency decreases with increasing entry mass. The same trend is visible in literature data for smaller-sized objects. Unfortunately, the trend does not match. This indicates an observational bias, which we are currently trying to understand. More information will be provided in the presentation/poster.

[Poster #4] Sebastien Besse [ESAC]

It's a MeSS - Summary of two years of exploitation

Summary of the MeSS after two years of exploitation:

- Three peer-reviewed publications with two rst-authored outside of ESA
- Four active international collaborations in Europe, and outside Europe
- Three manuscripts in preparation

The MESSENGER spacecraft has returned a wealth of data from Mercury that offers infinite research opportunities. The objective of our modest science team, the Mercury Surface Spectroscopy (MeSS) group, is to enable and maximise the science exploitation of the visible to near-infrared spectrometer (MASCS) onboard the MESSENGER mission to unravel Mercury's surface. The MeSS project is currently collecting research investigations of Mercury's surface through data mining, knowing that the output of this work is of paramount importance for the preparation of BepiColombo's exploration of Mercury. For instance our analysis of volcanic material on the surface of Mercury has highlighted the property of explosive volcanism, and in particular the underestimation of its volume. 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. In the future we are planning to investigate more scientic topics through the MeSS (space weathering, impact features, spectral properties of magnetic anomalies, etc.), and we aim at sharing our knowledge through a web service of our structured database.

[Poster #5] Sarah Joiret [ESTEC]

Weighting orbital elements of meteors

We are using data from CILBO, our double-station camera setup in the Canary Islands. Meteoroid orbits are computed using the Meteor Orbit and Trajectory Software (Koschny and Diaz, 2002). These data are relevant for assessing the impact risk to spacecraft, or linking the particles to their parent bodies. A big question is the accuracy of the determination of the orbital elements determined with this method. A Monte Carlo simulation is performed for each meteor assuming an astrometric inaccuracy of 1.36' (Schmidt 2019). Initially, the results displayed the orbital elements and velocities of each meteor as seen from the station in Tenerife, and from the station in La Palma. We investigate a way to rene the results by applying a weight on the respective stations based on the angle from which they observe each meteor, starting from the assumption that data have smaller errors for angles closer to 90 degrees. We obtain weighted orbital elements and a weighted orbital velocity for each meteor. In this poster, we will present some of our rst results. We conrm our assumption and show quantitative plots to demonstrate this.

[Poster #6] Rowan Dayton-Oxland [Other]

Impact of using a collisional model on detecting Europa's plumes from a flyby.

H2O molecules from Europa's water plumes may be detected by a spacecraft flyby such as by JUICE in 2031. Previous work showing that JUICE's NIM instrument could detect these plumes has assumed a collisionless model of the plume particles (Huybrighs et al., 2017). More sophisticated DSMC models of the plumes including particle collisions have shown that a shock could develop in the plume interior as rising par- ticles collide with particles falling back to the moon's surface, limiting the plume's altitude. We report the extent to which the limited altitude of the shocked plumes reduces the ability of the JUICE spacecraft to detect plume H2O molecules, compared to a collisionless model, and show the detectable area is reduced by as much as 43putative plume sources (e.g. Roth et al. 2014, Jia et al. 2018, and Arnold 2019) is therefore reduced. We show that a 100km lower altitude flyby would improve the area on Europa's surface over which the spacecraft could detect plumes by around 30%.

[Poster #7] Pablo Garcia Martin [ESAC]

Science from ESAC's Archive products using Machine Learning

ESA's Hubble Space Telescope Archive contains 102 Tb of data. All these images were used in the past to conduct major breakthroughs in Astrophysics, but we still can find hidden treasures laying within them. We have used Machine Learning techniques to analyse 40k images from ACS/WFC and WFC3/UVIS instruments looking for serendipitous asteroid streaks passing between the telescope and its target. Starting from citizen science project Asteroid Hunter, we used data classified by volunteers to train Google's AutoML Object Detection model to identify asteroid streaks. As a byproduct, we also get satellite trails and gravitational lens arcs identified in these images. Around 1,200 asteroid streaks were found using this model (in addition to streaks already present in Asteroid Hunter data, used as training set). Our poster will feature a general view of model's performance, results and, of course, nice images from our model's discoveries.

[Poster #8] Elise Wright Knutsen [ESTEC]

Solar cycle induced galactic cosmic rays variations at Mars

The study of galactic cosmic rays (GCR) is an important part of heliophysics. GCR are known to have effects on the radiation environment, on the Earth's atmospheric chemistry, lightning, cloud formation, and even, potentially, on climate change. Numerous studies have shown the gradient of GCR with heliocentric distance, and the anticorrelation between solar activity and GCR impacting on Earth. The knowledge of GCR at Mars can be helpful in the preparation of the future human exploration, and in the study of the climate of the red planet.

We show here GCR variations at Mars in the period 2005–2020, utilising a Mars Express (MEX) engineering data set along with sunspot number time series. The MEX parameter used is called EDAC (Error Detection And Correction Code). An energetic particle hit on an on-board computer can cause memory errors due to the

charge deposited in the physical memory cells. Such errors are caught and corrected by the EDAC algorithm. Once a correction is done, the relevant EDAC counter is incremented by 1.

This data set can be used to identify solar events, such as the passage of Coronal Mass Ejections and Solar Flares, as well as to capture the variations of GCR over the course of solar cycles. We focus on the latter part here. Our analysis of GCR with the solar cycle yields an anticorrelation of -0.5 at a time lag of $\sim$5.5 months, which corresponds well with established literature. By combining MEX with Rosetta data, we calculate a $\sim$4% increase in EDAC count rates per astronomical unit.

The potential of engineering data for science purposes remains mostly unexplored. This study shows the usefulness of data mining and the utility of keeping missions alive for many years, providing complimentary data to nominal science instruments.

[Poster #9] Nils Peter Janitzek [ESAC]

An Improved Instrumental Response Model for Spaceborne Time-of-Flight Mass Spectrometers applied to Solar Wind Heavy Ion Measurements with SOHO/CELIAS/CTOF

Spaceborne time-of-flight mass spectrometers are state-of-the-art instruments to investigate in-situ the characteristic properties of ion populations throughout the solar system. In the solar wind context the sensors serve as indispensable experiments to determine the composition and kinetic properties of the thermal and suprathermal heavy ions (with atomic number Z>1) from a few hundred ev/e up to several tens of keV/e. In this study we present an improved response model for a common type of time-of-flight mass spectrometers that create the (start) time-of-flight signal by the passage of the ions through a thin carbon foil. The goodness of the model is tested with the heavy ion data recorded by the CELIAS/CTOF sensor on board the ESA/NASA Solar and Heliospheric Observatory (SOHO), but the model can be also transferred to similar instruments such as Ulysses/SWICS, ACE/SWICS and Solar Orbiter SWA/HIS. Finally, the influence of the response model on measured heavy ion abundances and speeds is investigated with the SOHO data.

[Poster #10] Martin Voelker [ESAC]

Melting Mountains on Mars? - Sheet Deposits in a Montane Environment

During an extensive grid-mapping campaign in the southern highlands of Mars, we detected sheet deposits (SD) flowing down a mountain range. Their surface is often characterised by faint lineations and their margins show distinctive flow fronts. The source of these deposits is often found at the base of layered outcrops. Their lengths may exceed 100 km, at their sources they often coincide with glacier-like flows and gullies. The region is also characterised by the highest internal heat flux on Mars (up to 12 $\mathrm{mW}\times\mathrm{m}^{-2}$) and strong remnant magnetic fields.

This work addresses the question if these SD are either of magmatic or volatile-based origin. We mapped their distribution, measured their thickness, and determined their age by crater counts.

Flowing downhill, the SD converge into small channels and diverge into small basins afterwards, indicating a certain viscosity of the material. The thickness of the SD varies from 5.6 to 31.7 m, while the glacier-like flows range from 39.6 to 89.1 m. The thickness of unambiguous volcanic flows found in two basins north of the mountain, has a depth of 85.3 to 103.8 m. The determined age of the volcanic flows is $\sim$1.2 Ga, and $\sim$100 – 190 Ma for the SD. The glacier-like flows formed $\sim$37 Ma ago.

Considering the lack of evident volcanic morphologies on top of the mountain, the uncommon geomorphology of the SD, and their relation to glacier-like flows and gullies, we suggest that the SD are either not of volcanic origin, or they are a yet unknown lava type. Alternatively, we suggest the following scenario:

The mountain evolved tectonically during the Noachian uplifting both volatile-poor and volatile-rich layers. Because of the deformation, these layers were outcropped at the broken crest of the mountain. During the Amazonian, SD began to form as the high heat flux triggered the melting of the outcropping volatile-rich layers. This mixture (ice and solids) began to move slowly downwards (allowing the formation of faint lineations on top of the flows). A screening on other mountains and volcanoes with much lower heat flux values did not reveal further findings of such deposits. Hence, the internal heat flux can be considered a potential scenario for unleashing the volatiles.

However, two questions remain. Why did the sheet flows commence during the Amazonian and not earlier? Is a heat flux of 12 $mW \cdot m^{-2}$ strong enough to melt subsurface volatiles, or was it once higher?

If the scenario of a warm subsurface and the presence of volatiles (water) is correct, the mountain could be an important location for the search of astrobiological habitats.

[Poster #11] Martin Voelker [ESAC]

Channels and Ponds on Mars - Indicators for Underground Ice?

During an extensive grid-mapping campaign, we detected narrow and comparatively short channels that seem to link enclosed depressions. These channels are characterised by lengths of up to a few kilometres, and narrow widths of up to a few decametres. The paths of the channels are usually single-threaded (no divergence/convergence with other channels).

The study area of this project is confined to an unnamed crater (∼80 km in diameter). The crater is located in a mid-latitudinal region (centred at 40degS 12degE) with most parts covered by a recent ice-rich mantling (similar to dirty snow). Considering its appearance, the crater is very likely of Amazonian origin, and hence, comparatively young on a geologic time scale. The ejecta of the crater has a very rugged topography, characterised by enclosed depressions and <100 m tall ridges (each with only a few kilometres in extent). The linking channels are often incised into the ridges that separate the enclosed depressions. The channels usually have a high sinuosity.

As the project is still at an early stage, we have defined the following questions we will attempt to address:

- Which process formed the channels? - Were they formed by molten rock (due to impact heat), fluvially, or ...?
- How could the channels flow over the 100 m tall ridges? - Maybe because the depressions once contained small overflowing lakes; similar to supraglacial lakes found on terrestrial ice shields.
- Could the high sinuosity of some channels and the apparent lack of sediments provide information about the process and geology? - As most of the linking channels are located on steep slopes, meandering is unexpected. Intense meandering of single-threaded channels usually occurs on low inclined slopes - except the subsurface is very loose or soluble (like ice). On Earth, such meanders are found on top of glaciers, formed by melting flows (such flows also lack deposits). If this interpretation correct, the study area is not just covered by a volatile-rich mantling, the underlying geology could also mainly consist of ice.
- If the channels are water-/ice-based, what triggered the melting? - High air temperatures or a high internal heat flux (caused by remnant impact heat of the young crater).
- Can we derive information from the distribution/geography of the channels around the crater? - Maybe they are aligned on top of faults caused by the impact, allowing internal heat flux to move upwards.
- How old are crater and channels?
- What do we already know? - Linking channels are no gullies (which are also young and faint channels that occur in the study area too). In contrast to the linking channels, gullies show both a clear source region and deposits. Moreover, gullies are assumed to be active today. The low visual contrast of the linking channels (compared to their surroundings) suggests that they are currently inactive. However, as the linking channels seem to be very young too (for Martian standards), they still might be of special interest to analyse the distribution of former liquid water and the accessibility of ice and on the Martian surface.

[Poster #12] Marc Costa Sitjà [ESAC]

Surveying potential cruise fly-by opportunities for an Ice Giant mission

We present a systematic approach to analyse rapidly fly-by opportunities for the cruise phase of a mission to an Ice Giant. Such flyby would provide a unique opportunities to characterise Jupiter Trojans, Centaurs, or Jupiter Family comets.

[Poster #13] Marie Liis Aru [ESTEC]

Search for Gaia spacecraft in-situ measurements of micro-meteoroid impacts

The European Space Agency Gaia spacecraft has been operating at the second Lagrangian point L2 since mid-2014. With its large sunshield and extreme sensitivity to (external) perturbations, the spacecraft is a unique platform for in-situ measurements of micro-meteoroid impacts. We present preliminary results of a search for such impacts using a custom data set of very precise spin rate data. These data have been reconstructed based on focal-plane transit timing measurements of billions of star transits collected over 34 months. In our data, micro-meteoroid impacts show up as deviations from the quiescent state with very specific time profiles. Combining the temporal and the amplitude distribution of the detected impacts provides a way to deduce their momentum transfer to the spacecraft, and ultimately to constrain the flux and size distribution of micro-meteoroids at L2.

[Poster #14] Laura Rodríguez-García [Other]

The Unusual Widespread Solar Energetic Particle Event on 2013 August 19 - Solar origin, CME-driven shock evolution and particles longitudinal distribution

Context. Late on 2013 August 19, STEREO-A, STEREO-B, MESSENGER, Mars Odyssey, and L1 spacecraft, spanning a longitudinal range of 222deg in the ecliptic plane, observed an energetic particle flux increase. The widespread solar energetic particle (SEP) event was associated with a coronal mass ejection (CME) that came from a region located near the central meridian on the far side from Earth view. The CME appeared to consist of multiple eruptions, and was accompanied by a ∼M3 flare as a post-eruption arcade and low-frequency (interplanetary) type II and shock-accelerated type III radio bursts.

Aims. The main objectives of this study are two, disentangling the reasons of the different intensity-time profiles observed by MESSENGER and STEREO-A, longitudinally separated by only 15deg, and unravelling the single solar source related to the SEP event. Methods. The analysis of in situ data, i.e, particles fluxes, anisotropies and timing, plasma, and magnetic field data, is correlated to the remote-sensing observations. Models are used for CME-driven shock reconstruction and characterization of the heliosphere.

Results. The solar source associated with the widespread SEP event, is the shock driven by the multi-step CME, as the flare, observed as a posteruptive arcade, is late for the estimated particle onset. The different intensity-time profiles observed by STEREO-A, located at 0.97 au, and MESSENGER, at 0.33 au, can be explained in terms of enhanced particle scattering between the spacecraft locations. The longitudinal extent of the shock does not explain by itself the wide spread of particles in the heliosphere. The particle increase observed at L1 may be interpreted by cross-field diffusion transport, and this is also the case for STEREO-B, at least until the spacecraft is magnetically connected to the shock at ∼0.6 au. The CME-driven shock might be suffering distortion in its evolution in the heliosphere, such that the shock flank might be overtaking the shock nose at 1 au.

[Poster #15] Karol Fułat [Other]

Characterising Suprathermal Electrons at Interplanetary Shocks

Solar wind (stream of particles released from the Sun) propagates in the heliosphere where causes shock waves in plasma. These waves are collisionless - particles transform energy through electromagnetic interactions, not through binary collisions. Interplanetary shocks (IP) origin from co-rotating interaction regions (fast solar wind rams into slow solar wind) and huge releases of solar plasma called coronal mass ejections.

The aim of the project is characterisation and examination of suprathermal electrons (E $\sim$ 70 eV – 2 keV) associated with IP shocks. We use data from the Cluster mission. Four spacecrafts in tetrahedral configuration make in-situ measurements of angle-angle electron distribution (PEACE - "Plasma Electron And Current Experiment"), and magnetic field (FGM - "Fluxgate Magnetometer"). We examine different suprathermal populations, despite two major halo and strahl, also bidirectional beam, ninety-degree enhancement and loss-cone [1]. Description of populations is made during normal solar wind conditions, whistler waves and IP shocks. We analyze distributions using spectra of fitted spherical harmonics [2]. This method is quick and effective for distribution shape examination. We also provide qualitative statistical analysis of IP shock with different

parameters: Mach number, the angle between magnetic field vector and shock normal, magnetic field ratio, etc.

The spherical harmonic method with Python scripts will be used for Solar Orbiter data. We will be able to look at the evolution of angle-angle electron distributions while the propagation on an IP shock. Next step is also a qualitative analysis of shocks parameters using machine learning techniques.

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[Poster #16] Ines Belgacem [ESAC]

Regional study of Ganymede's photometry

Introduction
Jupiter's icy moons are at the center of future space exploration missions such as ESA's JUpiter ICy moons Explorer [1] and NASA's Europa Clipper [2]. Ganymede, in particular, will be the primary target of the JUICE mission. Knowledge of the surface is paramount to best plan the mission, help with navigation [3] and understand its geology.

1. Dataset
We used images from the Voyager's Imaging Science System (ISS) [5] and from the New Horizons' LOng Range Reconnaissance Orbiter (LORRI) [6] with a ground resolution between 10 km and 30 km at the subspacecraft point limited to the clear filter.

2. Method
2.1 Correction of meta-data
We need two elements to carry out this study: the reflectance and the geometry of observation. The first can be obtained after radiometric calibration of the images. The second necessitates accurate projections of each pixel. To that end, we developed an image processing pipeline and used SurRender [7] to correct metadata such as spacecraft pointing and position [8]. 2.2 Model and Bayesian Inversion
For this study we are considering the Hapke model detailed in Hapke, 1993 [4]. Six parameters are estimated: b, c, ω, θ, h and B0. We developed an inversion tool using a Bayesian approach based on previous work done on Mars [9, 10]. No a priori knowledge of the parameters were inferred except for their physical domain of variation. We also include in the model uncertainties on the absolute level reflectance (radiometric uncertainties) to correct for potential bias. This work is detailed in our previous study of Europa [11].

3. Results
We carried out a regional photometric study of 15 areas of Ganymede with a very limited dataset of 16 images for which we corrected the metadata and radiometric calibration discrepancies. We found that most of our areas are consistent with a global backscattering behavior of the surface with two notable exceptions - ROIs #2 and #4. They are situated in the polar latitudes, respectively in the north and in the south hemispheres. They are both very bright and rough and exhibit a strong and narrow forward scattering. This could be due to them being particularly favorable areas for ice redistribution at the poles or signs of possibly localized activity.

Conclusion
The preliminary results of this study are very encouraging and show areas of particular interest that could be targeted by future missions. Overall, the general trends of our results are consistent with past integrated photometric studies [13, 14]. We plan on extending this work with more photometric models and additional datasets.

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[Poster #17] Håkan Svedhem [ESTEC]

The MEX - TGO Mutual Radio Occultation Experiment

Conventional Radio Occultation measurements take place between a spacecraft in orbit around a planet (or during an occasional fly-by), and a ground station on the Earth. When the straight line between the sender and receiver crosses the ionosphere and the atmosphere of the planet the signal is affected by the electrons in the ionosphere and the molecules in the neutral atmosphere. This signal change is observed as a frequency shift in the received radio signal with respect to the transmitted signal. This shift is very small compared to the Doppler shift in the frequency due to the differential relative velocity of the spacecraft and the Earth, but can for a stable system be isolated, and profiles of electron density in the ionosphere and profiles of atmospheric density in the neutral atmosphere can be derived.

Here we are attempting to do occultation measurements between two spacecraft at Mars, Mars Express and ExoMars Trace Gas Orbiter, using the UHF link normally used for communicating between the orbiters and the landers on the surface of Mars, rather than using the X- or S-band transmitter used for the communication between a spacecraft and the Earth.

Such a Mutual Occultation technique has several significant advantages over the traditional spacecraft to Earth occultation measurements. In particular, it allows a much more even distribution of the samples over the surface of the planet and in time, and the observations are independent of Earth occultation seasons. The distance between the two spacecraft is much smaller than the distance to the Earth and therefore a much higher signal to noise ratio can be achieved, resulting in very low statistical errors. The Mutual Occultation s/c to s/c link also avoids that the signal passes through the Earth's ionosphere and atmosphere. The compensation for the Earth atmosphere and ionosphere is far from perfect and results in major contributions to the systematic errors. An additional positive effect is that the interplanetary plasma disturbance to the signal is a minimum due to the short distance between the two s/c and the large distance from the Sun.

The first experiment was carried out on the 2nd of November 2020 and demonstrated the feasibility of the technique and these data are presently being processed. Three more experiments will take place during November-December. Presently the Mars Express MelaCom system cannot send a pure carrier-only signal, but does send a modulated signal. This is disturbing the signal and makes the analysis more complex. A software update to the MelaCom system in being produced and once uploaded this is expected to significantly improve the performance and the quality of the measurements.

[Poster #18] Georgina Graham [ESAC]

The effect of heliospheric field path length on Solar wind electron beams

Strahl is a beam-like population of suprathermal electrons present in the solar wind. Strahl streams away from the Sun along the heliospheric magnetic field at a speed higher than that of the bulk flow of solar wind plasma. The characteristics of strahl mean that observations of these electrons can not only provide information on the topology and connectivity of the heliospheric magnetic field but also provide clues to solar wind acceleration. Strahl electrons are strongly tied to the magnetic field. In fact, recent observations with Parker Solar Probe in the inner heliosphere have shown that even for highly rapid 'switch backs' (local inversions in the magnetic field direction), strahl will tightly follow the path determined by the field direction. We present work from investigations of the strahl electrons that demonstrate the effect of the path length of the heliospheric magnetic field on strahl propagation within the Heliosphere. We examine observations from spacecraft at multiple locations in the Heliosphere as well as modelled results.

[Poster #19] Elena Racero [ESAC]

The ESASky Solar System Object Search Service (SSOSS) and the case of Psyche

Solar System Objects (SSOs) are often difficult, or even impossible, to query for in astronomy archives if they were not the target of the observation, owing to their ever-changing coordinates. We aim to provide the scientific community with a service to search for all the potential detections of any SSOs (asteroids, Kuiperbelt objects and comets) within the ESA astronomy archival imaging data, called the Solar System Object Search Service (SSOSS). This service performs a geometrical cross-match of the orbital path of each SSO, as seen by the satellite reference frame, with respect to the public high-level imaging footprints stored in the ESA archives. About 800,000 asteroids and 2,000 comets are included in this work. This service is available through the ESASky application and it provides both targeted and serendipitous observations. For this first integration, three representative missions covering a wide range of frequencies, from X-Rays (XMM-Newton) to far infrared (Herschel) including the UV-Near Infrared band from the Hubble Space Telescope (HST), were chosen as a proof of concept.

A catalogue with the complete list of potential detections of Solar System Objects in the Herschel, XMM-Newton and HST archival imaging data has been produced, including over 116,000 both targeted and serendipitous observations and over 230,000 objects. The service functionalities have also been applied to the specific case of asteroid (16) Psyche, for which no information in the far infrared (70–500 microns) was previously reported, to derive its thermal properties in preparation for the upcoming NASA Psyche mission to visit the asteroid. This poster presents the main results of the work, which are soon to be submitted to A&A (E. Racero et al., 2021, A&A, in preparation).

[Poster #20] Elliot Sefton-Nash [ESTEC]

Mapping the Oxia Planum landing site for the ExoMars 2022 Mission

Introduction: Oxia Planum is the selected landing site for the ESA-Roscosmos ExoMars Programme's 2022 mission. Rosalind Franklin (delivered to Oxia Planum by the descent module and 'Kazachock' surface platform) has goals of searching for signs of past and present life on Mars and investigating the geochemical environment in the shallow subsurface. Oxia Planum is located at the transition between the ancient terrain of Arabia Terra and the low lying basin of Chryse Planitia. It forms a shallow basin, open to the north, characterized by clay-bearing bedrock, and contains geologic units formed in the mid-Noachian (> 3.7Ga), when Mars fostered more habitable conditions.

Team mapping campaign: Gaining a thorough understanding of the landing is essential to developing testable hypotheses to facilitate science traceability into operations planning. In pursuit of this, the Rover Science Operations Working Group (RSOWG), performed a detailed group mapping exercise of Oxia Planum. A leadership and coordination team began in Q4 2019 planning the mapping project, generating data layers, configuring the web-mapping platform, and prepared a training and familiarisation programme. 88 volunteers from the ExoMars science community participated in the mapping of $\sim$150 1x1km quads covering the 1-sigma landing ellipse envelope. Mapping was complete in September 2020 and the subsequent phase, to reconcile the raw mapped data and interpretations, is underway (see figure). The exercise achieves a number of crucial outcomes for ExoMars 2022 science readiness:

- Team experience working and communicating together on a large, complex project with a common goal - a precursor for daily rover activity planning and science operations from 2023.
- Building team knowledge about the Oxia Planum landing site, and its main scientific interpretations.
- RSOWG-curated remote-sensing datasets and software for science and operations team use.
- A configurable web-Geographic Information System (GIS) to support mission science.
- High-resolution geologic map data for development of the mission strategic plan.

[Poster #21] Daniel Müller [ESTEC]

3D Visualisation of Solar Data with JHelioviewer

The Solar Orbiter and Parker Solar Probe missions focus on exploring the linkage between the Sun and the heliosphere. These new missions are collecting unique data that allow us to study the cause and effect of physical processes taking place on the Sun and their manifestations in the heliosphere.

Overall, the scientific community has now access to large volumes of complex remote-sensing and in-situ observations from different, and time-dependent, vantage points, complemented by petabytes of simulation data. Answering overarching science questions like "How do solar transients drive heliospheric variability and space weather?" will only be possible if the science community has the necessary tools at hand to visualise these data and assimilate them into sophisticated models.

A key piece needed to bridge the gap between observables, derived quantities like magnetic field extrapolations and model output is a tool to routinely and intuitively visualise large heterogeneous, multidimensional, time-dependent data sets. The open-source JHelioviewer software, which is part of the ESA/NASA Helioviewer Project, is addressing this need. This contribution highlights recent extensions of JHelioviewer that support the scientific planning process and data analysis for Solar Orbiter.

[Poster #22] Charlotte Goetz [ESTEC]

Singing comet waves - where are they generated?

At low gas production rates the cometary plasma environment is dominated by highly compressional, large amplitude magnetic field waves in the $10 - 100$ mHz range. Currently, the waves are proposed to be caused by an ion-Weibel instability due to a cross-field current. The cometary pick-up ions are accelerated along the solar wind convective electric field leading to a highly non-gyrotropic distribution of cometary ions.

Since the injection region of the ions is much smaller than the ion gyro radius, this constitutes a current that subsequently becomes unstable. To find the wave power, frequency and bandwidth, we develop a new method that can also distinguish between intervals with wave activity and without.

The waves may be found everywhere in the coma, regardless of convective electric field direction. A correlation analysis of the wave frequency and measured plasma density shows no co-dependence. These results do not agree with previous publications of data analysis and simulations. However a dependence of the frequency on the position of the spacecraft in a comet fixed frame is in agreement with the model prediction from the ion-Weibel instability. From these results, we deduce that the wave generation region must be much larger than the distances covered by the Rosetta spacecraft at comet 67P/Churyumov-Gerasimenko.

[Poster #23] Bernard Foing [ESTEC]

Astrobiology research with EuroMoonMars Field campaigns

We shall describe the programme and results (with emphasis on astrobiology) from our EuroMoonMars campaign activities, and will describe opportunities for future astrobiology research. EuroMoonMars is an ILEWG programme following up ICEUM declarations as a collaboration between ILEWG, space agencies, academia, universities and research institutions and industries. The ILEWG EuroMoonMars programme includes research activities for data analysis, instruments tests and development, field tests in MoonMars analogue, pilot projects , training and hands-on workshops , and outreach activities. EuroMoonMars includes a programme of grants for Young Professional Researchers. Prof Bernard Foing (ILEWG Executive director, ESA ESTEC senior scientist, Prof VU Amsterdam) is EuroMoonMars programme manager. EuroMoonMars field campaigns have been organised in specific locations of technical, scientific and exploration interest. Field tests have been conducted in ESTEC, EAC, at Utah MDRS station , Eifel, Rio Tinto, Iceland, La Reunion, LunAres base at Pila Poland , and HiSEas base in Hawaii. These were organised by ILEWG in partnership with ESTEC, VU Amsterdam, NASA Ames, GWU in Utah MDRS (EuroGeoMars 2009, and then yearly for EuroMoonMars 2010-2013). Other EuroMoonMars analogue field campaigns using selected instruments from ExoGeoLab suite were conducted in other MoonMars extreme analogues such as Eifel volcano, Rio Tinto, Iceland, La Reunion, Hawaii. Latest campaigns have been conducted jointly between EuroMoonMars -International MoonBase Alliance -HiSeas (EMMIHS).

EuroMoonMars field campaigns started with EuroGeoMars2009 (Utah MDRS, 24 Jan-1 Mar 2009) with ILEWG, ESA ESTEC , NASA Ames, VU Amsterdam , GWU and continued with yearly EuroMoonMars Field campaigns in Utah (2010-2014), and in other Moon-Mars terrestrial analogues (Eifel volcanic area, Rio Tinto, Iceland, La Reunion, LunAres base in Poland , and HiSEAS base in Hawaii). EuroMoonMars 2018-19 supported field campaigns at IMA HISEAS base on Mauna Loa volcano in Hawaii. The Hawaii - Space Exploration Analog and Simulation (HI-SEAS) Hawaii habitat on Mauna Loa, on the Big Island of Hawai'I is owned and operated by the International Moonbase Alliance (IMA). Latest EMMIHS campaigns include:
2018 EMMIHS0 EMM-IMA-HISEAS scouting campaign May 2018 (Crew: Rogers H&A, Foing, Wilhite, Machida; support@ BluePlanet: Ponthieux, Cox et al)
2019 EMMIHS1 February (crew: Musilova, Sirikan, Mulder, Weert, Burstein, Pothier; support@ BluePlanet: Foing, Ponthieux, Cox, Rogers)
2019 EMMIHS2 8–22 December in Moonbase, (crew: Musilova, Kerber, Castro, Wanske, Pouwels, d'Angelo; support@ BluePlanet: Cox et al, support@ESTEC/VUA: Ageli, Foing, Heemskerk, Beniest, Sitnikova, Preusterink)
2020 EMMIHS3 18 Jan– 1 Feb in Moonbase, (crew: Heemskerk M&H, Rajkakati, Musilova, Brasileiro, Edison; support: BluePlanet & ESTEC/VUA)
2020 EMMIHS4 1–15 Feb in MoonbaseEMMIHS0, (crew: Boross, Dehler, Musilova, Neidlinger, Pantazidis, Sheini; support: BluePlanet & ESTEC/VUA)

[Poster #24] Alexander James [ESAC]

A new trigger mechanism for coronal mass ejections

Many previous studies have shown that the magnetic precursor of a coronal mass ejection (CME) takes the form of a magnetic flux rope, and a subset observed at plasma temperatures of $\sim 10^7$ K have become known as 'hot flux ropes'. We seek to identify the processes by which these hot flux ropes form, with a view of developing our understanding of CMEs and thereby improving space weather forecasts. Extreme-ultraviolet observations were used to identify five pre-eruptive hot flux ropes in the solar corona, and the evolution of the photospheric magnetic field was studied over several days before they erupted to investigate how they formed. Evidenced by confined solar flares in the hours and days before the CMEs, we conclude the hot flux ropes formed via magnetic reconnection in the corona, contrasting many previously-studied flux ropes that formed lower down in the solar atmosphere via magnetic cancellations. This coronal reconnection is driven by observed 'orbiting' motions of photospheric magnetic flux fragments around each other, which bring magnetic flux tubes together in the corona. This represents a novel trigger mechanism for solar eruptions, and should be considered when predicting solar magnetic activity.

[Poster #25] Marcos López-Caniego [ESAC]

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

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

[Poster #26] Helen Middleton [ESAC]

WHISPER Noise Floor

WHISPER is an instrument on Cluster that observes natural plasma emissions (waves) between 2 and 80 kHz, using one of two EFW antenna pairs. In order to understand the signals observed by the WHISPER experiment, one needs to know the noise floor, where any observations are not from actual emissions. What this noise floor is for each of the 4 spacecraft that make up Cluster, and whether/how they change around the EFW probe failures that have occurred over the 20-year mission, is the purpose of this study.

[Poster #27] Björn Grieger [ESAC]

Brute force image decompression

Lossy compression of images — like a digital cosine transformation (DCT) with quantization or elimination of coefficients — implies loss of information. As a consequence, the original image cannot be reconstructed unambigu- ously. In fact, many possible images are compatible with the compressed data.

Common decompression algorithms (like an inverse DCT) give us only one image, and this one is in general not even compatible with the compressed data. If the recovered image is re-compressed, it produces deviating data, so it could not have been the true image. This is related to the well-known fact that repeated JPEG compression does successively reduce image quality.

To accept an image not compatible with the compressed data means that we do not make use of all the information we have. Moreover, for aggressive compression factors, the decompressed image exhibits considerable compression artifacts, which were of cours absent in the true image (which is just one of the many images compatible with the data).

So, why do we get an image with added spurious structures that is not compatible with the compressed data?

The reason that we get what we get is just that it can be computed by the inverse DCT easily and very efficiently. Even decades ago your image viewer could decompress a JPEG image within the wink of an eye.

Could we do better if computation time was no issue?

I investigated this question using up many nights of computation time with the laptop humming lonely in my home office. The basic idea was to create an image that is ideally the mean of all images compatible with the compressed data, or at least of a significant subset of all such images. Results for a real image of Titan's surface taken by the Descent Imager Spectral Radiometer (DISR) aboard the Huygens probe and for a terrestrial landscape image (where "ground truth" is known) are presented.

[Poster #28] Arnoud Masson [ESAC]

DOI related to ESA science archives datasets: Google dataset search and Machine learning

Reproducibility is at the core of Science. For this reason, it has become a common practice for authors to provide links to the data used in their manuscripts upon submission to peer-reviewed journals, both for results based on measurements and on simulations. In space physics and astronomy in general, reference to archives' websites of major data providers like space agencies are for the moment still accepted by most journals. However, these websites cannot serve as persistent links and will eventually not be accepted once journals require full compliance with the FAIR (findable, accessible, interoperable, and reusable) data principles. On the contrary, Digital Object Identifiers (DOIs) associated to specific datasets or group of datasets can provide persistent links. DOIs have been widely adopted by the publishing industry and the research world in particular. For instance, all published peer-reviewed articles are nowadays associated to a DOI. Furthermore, DOIs would not only link refereed publications to their data, but could also offer the capability for data producers and data publishers to eventually trace the use of their data, by requesting or even enforcing the use of the corresponding DOIs in publications. For data producers, proper attribution is important in the context of securing research grants or extension of projects, including also space missions. Additionally, structured metadata included in the DOI landing pages offer the possibility for datasets to be discoverable by the new Google Dataset Search engine, available since January 2020. This presentation is meant to describe the on-going activities at the European Space Agency (ESA) to mint DOIs for datasets served across the space science archives, and how a subset of

these DOIs are already discoverable by Google. Machine learning techniques have been identified and will be applied to fine tune the keywords of each DOI landing page (especially in the field on astrophysics) to improve their findability.

[Poster #29] Peter Zeidler [STScI]

A young star cluster in motion - The complex velocity structure of Westerlund 2

Westerlund 2 is one of the most massive young star clusters in the Milky Way. The combination of Hubble Space Telescope and Gaia photometry with ground-based VLT/MUSE integral field spectroscopy opened new ways to study and analyze the stellar and gas kinematics. The latter reveals that the HII region that surrounds the cluster is expanding, which is driven by the stellar winds of the many O and B-stars in the cluster center. Not only does the stellar velocity dispersion increase with decreasing stellar mass, as it is expected in a highly mass-segregated cluster, but the low-mass pre-main-sequence stars are also clustered in five distinct velocity groups. Four out of five velocity groups coincide with the two clumps, Wd2 is built from, while the stars from the remaining group appear as halo-like structure. Given the young age, we conclude that we see the imprint of the initial cloud collapse that formed Wd2. Comparing the dynamical mass with the photometric mass shows that the cluster is super-virial and the system is likely to dissolve in the near future.

[Poster #30] Victoria Foing [Other]

Characterising exoplanets and stellar activity using Machine Learning Gaussian MonteCarlo Markov Chain method: combining Kepler, TESS and ground based data

We compare the information obtained from TESS, and Kepler lightcurves, and integrating information obtained from ground based observatories. We apply Machine learning methods for modelling stellar and instrumental systematics in lightcurves because they can quickly identify patterns in data without prior knowledge of the functional form. We want to address the following questions:

RQ1: How accurately can we model the stellar and instrumental systematics in TESS and Kepler lightcurves with machine learning?

RQ2: To what extent can we use these models to interpret the rotation periods and activity cycles of the stars?

RQ3: To what extent can we use these models to detrend the lightcurves and improve transit exoplanet characterization?

We use the information from LombScargle analysis, autocorrelation and Markov Chain Monte Carlo algorithms . We illustrate the comparison and the astrophysical results in the case of WASP62 and Kepler 76 targets.

[Poster #31] Bernard Foing [ESTEC]

Fullerenes, graphenes, PAHs in space and the Diffuse Interstellar Bands

C60 was discovered in 1985 from a mass spectrometer peak by Kroto, Curl, Smalley & al,, for which they got the Nobel Prize in Chemistry in 1996. It was then produced in macroscopic quantities by Kratschmer et al in 1990, that allowed to confirm the structure of soccer ball geometry, and started a revolution in research and application, to the delight of chemists, physicists, astronomers, architects and UEFA-FIFA fans. In 1994 Foing & Ehrenfreund reported the discovery of two near IR diffuse bands coincident with C60+ bands, with abundance of about 0.5 % of cosmic carbon .The interstellar bands detected at OHP observatory at 9577 & 9632 A were consistent with C60+ spectra in frozen matrix lab measured in 1992 by D'Hendecourt, Fostiropoulos & Léger & other groups. The DIBs assignment as C60+, largest (and most beautiful) interstellar molecule was celebrated by H. Kroto, and confirmed in subsequent observations (ESO, CFHT, etc.. and recently by latest near gas phase laboratory experiments (Campbell et al 2015). The quest for fullerenes, PAHs and large organics in space and Diffuse Interstellar Bands (DIBs) research has advanced since 20 years. DIB observational surveys, DIB families, correlations and environment dependences, resolved substructures indicative of rotational contours by large molecules. DIBs carriers have been linked with large organic molecules observed in the interstellar medium such as IR bands (assigned to PAHs, with some new bands detected by Spitzer assigned to fullerenes, Cami et al 2010), Extended Red Emission or recently detected Anomalous Microwave Emission (AME). Fullerenes

and PAHs have been proposed to explain some DIBs and specific molecules were searched. These could be present in various dehydrogenation and ionisation conditions, for example fully dehydrogenated (Vuong, Foing 2000), in a form similar to graphenes (Nobel prize Physics 2010). Experiments in the laboratory and in space (on FOTON BIOPAN, ISS EXPOSE, OREO Cubes) allow to measure the survival and by-products of these molecules. New observations from VLT EDIBLES programme (Cox et al 2017, Lallement et al 2018) and from HST STIS (Cordiner et al 2917, 2019) give new information on fullerenes and DIBs carriers (see also EAS talk abstract by Cox et al) .

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[Poster #32] Tereza Jerabkova [ESTEC]

Building bridges between stars and galaxies

We use empirical constraints on star-formation on sub-pc scales to build- up stellar populations in galaxies. This approach presents a link allowing to interpret galaxy-wide stellar populations in terms of individual star-forming regions. It has also the potential to constrain the physics of star-formation in distant galaxies where individual stars cannot be resolved. We developed the freely accessible code, GalIMF, that can compute and evolve stellar populations in galaxies on a star-by-star basis and self-consistently accounts for chemical enrichment. We used GalIMF to compute stellar populations in star-clusters, to understand the eect of star-formation and metallicity on the galaxy-wide stellar initial mass function in early type and ultra-faint galaxies and recently applied these results to compute the cosmic star-formation rate density as based on the empirically driven variable stellar initial mass function on the embedded-cluster scale. The production of E-MILES spectra with the computed galaxy-wide stellar initial mass function is in progress, will open new means of comparison with data and thus constrain the physics of star-formation and build-up of stellar populations in galaxies across cosmic time.

[Poster #33] Reiner Frickmann [ESAC]

Detecting galaxy clusters in simulation data - in preparation for the Euclid mission

Powerful upcoming missions like Euclid, LSST, JWST offer outstanding potential for both galaxy cluster cosmology and galaxy evolution. With these wide-field surveys, we are moving into an era where samples of hundreds of thousands of galaxy clusters will be available out to high redshift. However, detecting the galaxy clusters from a field distribution of galaxies is a non-trivial task. Thus, to detect these galaxy clusters in future survey data, several cluster-finding techniques have been developed in the Euclid Consortium, and tested extensively on Euclid mock data. The work of the Euclid Consortium identified two highly competitive algorithms, but also call for investigation into systematic effects including deducing cluster membership, and the need to independently test the Euclid-selected cluster finding algorithms on different datasets. This work tests the Adaptive Matched Identifier of Clustered Objects (AMICO) on two well-characterised mock catalogues used in the Galaxy Cluster Mass Reconstruction Project. This is done by creating an ideal optimal filter and applying AMICO on the mock catalogues. The mock catalogues have different properties, than the observational data that Euclid will produce, namely by being of low redshift. Returned cluster candidates are matched to the true clusters of the catalogues, and the performance of the algorithm is compared to other cluster-finding techniques applied to the same catalogues. Amongst other preliminary results, it is found that AMICO returns a tighter scatter in the mass-richness scaling relation with respect to other methods, which is useful for maximising the detection of galaxy clusters, aiding more accurate measurements of the cluster mass function.

[Poster #34] Rachana Bhatawdekar [ESTEC]

Studying the high redshift universe combining HST, JWST and the power of gravitational lensing

Exploring the very first galaxies is one of the major contemporary problems in astronomy. We do not know when the first galaxies formed, nor how their formation occurred. The James Webb Space Telescope (JWST) will be launched in 2021 and will search for the First Light objects in the redshift range of z=10–15. Reaching these galaxies will be routine with JWST, however, until then, our best chance to study these systems is through deep observations of lensing clusters with the Hubble Space Telescope (HST) by using them as 'Cosmic Telescopes'. Therefore, to extend its reach even farther beyond its technical capabilities before JWST is launched, the HST observed six massive clusters of galaxies as gravitational lenses to find the faintest and earliest galaxies in the Universe, ∼10–100 times fainter than any previously studied, as a part of the Hubble Frontier Fields (HFF) program. In this poster, I will present how we detect and examine the objects behind HFFs lensing clusters. We have developed a novel method to subtract the massive foreground galaxies from these clusters, allowing for a deeper and cleaner detection of the faintest systems. With photometry from HST, Spitzer and K-band imaging, I will present new measurements of the evolution of the galaxy stellar mass functions, UV luminosity functions, stellar mass density, UV luminosity density, and UV spectral slopes (beta) for galaxies from z = 6 – 9 in the Hubble Frontier Fields. I will further discuss how these results reveal new information on the faint-end of the mass function from the faintest galaxies at high-z, as well as their UV spectral slopes, suggesting the lack of evidence for Pop III stellar populations, unveiling the potential science that can be done with JWST.

[Poster #35] Patricio Yael Reller García [ESAC]

Automatic Identification of Astronomical Objects using Deep Learning

So far, most of the searches of the ESA science data archives and all other astronomical archives are based on metadata from the observations (date of observation, instrument, filter, proposer, target, etc.), while there is an immense amount of information content in the images that has not yet been fully exploited systematically. We present an inference-first approach for identifying and classifying astronomical objects in complete datasets of FITS images, with the objective of simplifying the task of processing large datasets with different classification models. This work will enable users to do data-driven searches (e.g. show me all the optically resolved galaxies with an X-ray point source counterpart of hardness ratio X and with a Far-infrared Herschel observation available or show me all the co-moving Gaia sources in the star-forming region Y with clean near-IR background and no PSF blending issues) in a relatively near future via the ESASky portal.

As an initial Proof of Concept, we are applying a current state-of-the-art neural network model (Morpheus https://arxiv.org/abs/1906.11248) to the 2MASS and Skymapper optical image datasets, to generate a Machine Learning catalogue, using ESAC's GPU grids, Docker and Kubernetes. The poster will discuss the steps of the inference process and will present preliminary scientific results.

[Poster #36] Oliver Hall [ESTEC]

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

When stars of solar-like masses evolve along the red giant branch, their degenerate cores will eventually ignite Helium fusion. The event these stars undergo is called the Helium flash, after which they will settle onto a region of the HR diagram called the Red Clump. Because these stars ignite Helium at near-identical core masses, they also have similar magnitudes. This allows us to use Red Clump stars a standard candles, and the better we understand the physics of the Clump, the better this standard candle becomes.

Recent studies (Hall et al. 2019, Chan & Bovy 2020) have used Gaia DR2 to look at the magnitude and spread of the Red Clump, and how these change with properties such as colour, metallicity, and abundance of alpha-elements. With a view on Gaia EDR3, this poster shows how we use a new Hierarchical Bayesian Model to describe the Red Clump using the covariances between these parameters. Finally, we show how to use our results to improve standard candle precision for distant Red Clump stars.

[Poster #37] Oliver Hall [ESTEC]

New asteroseismic rotation rates of Kepler dwarf stars confirm a change in their rotational evolution in the second half of their lifetime

Studies using asteroseismic ages and rotation rates from star-spot rotation have indicated that standard age-rotation relations may break down roughly half-way through the main sequence lifetime, a phenomenon referred to as weakened magnetic braking. While rotation rates from spots can be difficult to determine for older, less active stars, rotational splitting of asteroseismic oscillation frequencies can provide rotation rates for both active and quiescent stars, and so can confirm whether this effect really takes place on the main sequence.

In this work, we measured new asteroseismic rotation rates for 91 stars observed by the Kepler mission. Using a hierarchical Bayesian mixture model, we determined that this ensemble more closely agreed with a rotational evolution scenario that included weakened magnetic braking than one without. This confirmation using independent rotation rates is an important next step in the direction of understanding this strange event in main sequence evolution.

[Poster #38] Nick Indriolo [STScI]

The cosmic-ray flux in sub-millimeter bright galaxies at z > 2

Interstellar chemistry is driven by fast ion-molecule reactions, and in molecular clouds the chemical reaction network is initiated primarily by the ionization of H and H2 by cosmic rays. Particles are accelerated in shocks associated with supernova remnants and stellar wind bubbles, so it is expected that the cosmic-ray ionization rate in a galaxy scales with its star formation rate. Molecules such as OH+ and H2O+, with abundances highly dependent on the ionization rate, have been used extensively in the Milky Way to infer interstellar cosmic-ray ionization rates. We have used ALMA to observe OH+ and H2O+ absorption in a sample of 12 galaxies with a range of star formation rate surface densities from 10 to 1000 solar masses per year per square kiloparsec at $2 < z < 6$. In concert with chemical models, these observations are used to infer average cosmic-ray ionization rates in the target galaxies. Here, I will present our preliminary findings on cosmic-ray ionization rates in sub-millimeter bright galaxies and the relation with star formation rate.

[Poster #39] Nicolas Crouzet [ESTEC]

Towards a two-colour photometer at Dome C, Antartica

Dome C in Antarctica offers unique conditions on Earth for astronomical observations. The 3-month continuous night during the Antarctic winter enables uninterrupted observations and the atmospheric conditions are excellent in particular during the winter. The ASTEP project (Antarctic Search for Transiting ExoPlanets) aims at searching and characterising transiting exoplanets by high precision photometry from this site. A 40 cm optical telescope has been installed in 2010 and provides lightcurves with a precision at the millimagnitude level. It is undergoing a major upgrade with two new cameras and a new camera box that will enable simultaneous observations in two colours with a much better throughput. ESA is contributing to this upgrade via a Faculty project. In the last months, we have collaborated with the SCI-FIV team at ESTEC to manufacture mechanical parts for the new camera box. This collaboration was fruitful and all the parts have now been delivered. In the meantime, the telescope has been operating with its original setup and has observed during the whole Antarctic winter 2020, mainly to investigate the nature of exoplanet candidates delivered by the NASA TESS mission. These observations contribute to finding the most interesting exoplanets to observe with CHEOPS, JWST, and later with Ariel, and help refine and maintain accurate transit ephemerides, which is crucial for future space-based observations. In this poster, we will present the advancement of the project, the collaboration with the SCI-FIV team, and the observations made during the 2020 campaign.

[Poster #40] Nuria Alvarez Crespo [ESAC]

Environment of a sample of AzTEC submillimetre galaxies in the COSMOS field

Submillimetre galaxies (SMGs) are bright sources at sub-mm wavelengths. Made up mostly of high-z galaxies ($z > 1$), they are amongst the most luminous dusty galaxies in the Universe. SMGs are thought to be the progenitors of the massive elliptical galaxies in the local Universe and to reside in massive halos at early epochs.

Studying their environments and clustering strength is thus important to put these galaxies in a cosmological context.

Here we present an environmental study of a sample of 116 SMGs in 96 ALMA observation fields, originally discovered in the James Clerk Maxwell Telescope (JCMT)/AzTEC 1.1 mm continuum survey within the COSMOS survey field, having either spectroscopic or unambiguous photometric redshift. We analyse their environments making use of the latest release of the COSMOS photometric catalog, COSMOS2015, a catalog that contains precise photometric redshifts for more than half a million objects over the 2deg2 of the COSMOS field. We search for dense galaxy environments computing the so called overdensity parameter as a function of distance within a radius of 5' from the SMG. We validate this approach spectroscopically for those SMGs for which spectroscopic redshift is available. As an additional test, we search for extended X-ray emission as a proxy for the presence of hot intracluster medium, performing an X-ray stacking analysis in the 0.5 - 2 keV band with a 32" aperture and our SMG position using all available XMM-Newton and Chandra Xray observations of the COSMOS field.

We find that 27 % (31 out of 116) of the SMGs in our sample are located in a galactic dense environment, a fraction that is similar to previous studies. Out of these 31 sources, for 15 of them the spectroscopic redshift is known so this photometric approach was tested using spectroscopy, and we are able to confirm that 7/15 SMGs lie in high-density peaks. However, the search for associated extended X-ray emission via an X-ray stacking analysis leads to a not statistically significant detection.

[Poster #41] Mireia Leon-Dasi [ESAC]

Projecting a duck: geological mapping of comet 67P

The data from the Rosetta mission have permitted to reconstruct the shape of comet 67P/Churyumov-Gerasimenko and to identify the terrains and features forming the surface. The peculiar form of the comet has made it challenging to project these features on an unambiguous frame. As a result, the geological maps published to date are created on top of comet images, making the product dependent on the viewing angle and image resolution. To overcome this limitation we present an integrated geological map of the comet displayed on an unambiguous projection. The map combines the features published in previous studies in a single framework and is completed with newly identied features. The Small Body Mapping Tool (SBMT) software is used, which allows outlining the features on OSIRIS images projected on top of a 3D shape model of the comet. For each region, the geological maps are displayed in the Quincuncial adaptive closed Kohonen (QuACK) projection. The QuACK layout solves the spatial ambiguity issues and reduces the shape and area distortions of the classical projections, which especially aect the polar regions.

[Poster #42] Lyndsay Old [ESAC]

The GOGREEN Survey: probing the unknown properties of galaxies in extreme environments over 8 billion years ago

Galaxy clusters are among the most massive structures in the Universe, with up to 1000 trillion times the mass of the Sun contained in stars, gas and dark matter. In addition to being excellent cosmological tools, galaxy clusters are extraordinarily valuable as astrophysical laboratories: hosting the most massive galaxies and some of the first luminous objects to form in the Universe. As such, they play a central role in studies of mechanisms which may govern how galaxies evolve through cosmic time. Thanks to extensive studies in the local Universe, we typically see that galaxies in higher-density environments like galaxy clusters have ceased forming stars compared to those in lower-density environments. Above redshift z$\sim$1 ($>$ 8 billion years ago), however, the typical properties of galaxies in galaxy clusters are almost completely unknown. To understand the dominant mechanisms at play in the quenching of star formation in galaxies from high redshift to the present day, we need to characterise the properties of cluster galaxies at this fairly unconstrained epoch. In this poster, I will present the rst science results from the Gemini Observations of Galaxies in Rich Early Environments (GOGREEN) survey. The GOGREEN survey is a multi-object spectroscopic campaign of 21 groups and clusters at high redshift ($1 < z < 1.5$), targeting the evolutionary counterparts of local groups and clusters, and is aimed at providing a rst look at environmental eects on galaxy evolution at a time when galaxies were growing in a fundamentally dierent way from the present day. In addition to early science results, I will describe the first GOGREEN survey public data release (August 2020) which includes fully reduced images and spectra, with

catalogues of advanced data products including redshifts, line strengths, star formation rates, stellar masses and rest-frame colours.

[Poster #43] Luana M. Modafferi [Other]

The X-ray temporal and spectral analysis of incredibly variable blazars: the case of Mrk 421

Active Galactic Nuclei (AGNs) are astrophysical sources located at the center of some galaxies, powered by accretion of matter into a supermassive black hole.

According to the Unification Model for radio-loud AGNs, blazars are AGNs in which a relativistic jet points towards our line of sight, so properties such as variability and luminosity are relativistically boosted-thus making blazars one of the most energetic objects in the Universe. Thanks to their special orientation, the observation of blazars allows us to study the physics of energy production in proximity of the centers of AGNs. There are two blazar classes according to their optical spectral properties: BL Lacs show weak or no emission lines (EW < 5 A) and flat spectrum radio quasars (FSRQ) that show broad emission lines. This analysis focuses on the former. The X-ray observatory XMM-Newton uses the nearby BL Lac Mrk 421 as calibration source for the Reflection Grating Array (RGS), as it is one of the brightest at X-ray energies.

Therefore most of the analysis focused mainly on RGS data. Six European Photon Imaging Camera (EPIC) observations were also added to the analysis, since the observations were in Science mode. A vast temporal and spectral analysis was performed on data of Mrk 421. Having over 100 available observations to be processed, the steps of data reduction, the building of the light curves and the fitting of the spectra were all automated by making a Python package. Also, the code was developed so that the analysis can be repeated for other XMM-Newton sources as well and therefore allows the comparison between results of different objects.

The individual light curves of each observation were extracted and used to build the historical X-ray light curve. This light curve allowed the determination of a threshold between low and high state of 20 cts/s, which was then used to analyse spectral properties in different states.

Variability properties of the light curves were studied by means of mathematical tools such as the excess variance and the fractional variability. In particular, for the longest observations (duration > 60 ks) the evolution of the average properties of the fractional variability was analysed more in detail in order to study the non-stationarity of the source.

In addition to the temporal analysis, the spectral analysis was carried out by extracting the spectrum of each observation. Each spectrum was also divided into pieces of 1ks each in order to collect more information and study more in detail the evolution of the parameters. Over 5000 spectra were analysed in an automated fashion. The results indicate that as the source flux increases, the spectral slope decreases, meaning that the spectra get flatter/harder. This trend is confirmed by studying the spectral parameters in different states of the source (low/high).

For observations presenting a rise and fall in their light curve, spectral loops were found. The chosen observations are characterized by both clockwise and anti-clockwise loops indicating the presence of both the processes of acceleration and cooling of the electrons. As for the EPIC analysis, the extracted light curves were separated into soft (0.6–2 keV) and hard (2–10 keV) bands so to compute the hardness ratio. The "harder when brighter" trend was found in the EPIC analysis as well.

Future work consists in the implementation of the analysis of a second BL Lac which is fairly similar to Mrk 421 and also used for calibration by XMM-Newton. A comparison of the behavior of both sources is necessary to discern whether the conclusions are similar for both objects and therefore extrapolable to more blazars. Further analysis of the source is being carried out, such as the building of the SED and the PSD, the search of periodicities, the determination of a minimum variability time-scale and estimation of the black hole mass.

[Poster #44] Nimisha Kumari [STScI]

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 firstever 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 #45] Nimisha Kumari [STScI]

Effect of diffuse background on Schmidt relation in nearby star-forming galaxies

The Kennicutt-Schmidt relation relating the surface densities of the star-formation rate (SFR) and gas (atomic and molecular) is a widely-accepted star-formation relation. However, it is a disk-averaged law smoothing over local variations, and hence may not provide an explanation for the local relationship between SFR and gas density at the sub-galactic scale. To further probe this, various groups have carried out spatially-resolved studies of star-formation in nearby spiral galaxies using different methods. However, most of these studies do not take into account the effect of the spatially varying diffuse background which is potentially present in all star-forming galaxies and affects all the usual SFR tracers (optical, far-ultraviolet and midinfrared). In this contribution, I present the results from an analysis (Kumari et al. 2020) of nearby spiral galaxies using aperture photometry where the effect of the diffuse background is taken into account. Making use of a novel split of the overall light distribution as a function of spatial scale allows us to subtract the diffuse background in the SFR tracers and determine the current localised SFR density. This is then combined with the gas density estimates (molecular gas from CO(2-1) and atomic gas from HI) to study the relation between SFR and gas density. An analysis is also done for the effect of diffuse background in the atomic gas, should it be present. This work indicates that removal of a diffuse background in SFR and atomic gas tracers results in a slope $\sim 1.4 \pm 0.1$, which agrees with dynamical models of star formation accounting for flaring effects in the outer regions of galaxies.

[Poster #46] Johannes Sahlmann [ESAC]

Astrometric orbits and masses of compact substellar binaries

The population of known brown-dwarf binaries is biased against small separation systems because of the relative faintness of substellar objects and the associated observational limitations. High-precision astrometric monitoring is a powerful technique to discover the orbits of such systems and measure the individual component masses. Here, we present first results of a multiyear astrometry campaign using optical imaging with the Gemini-South and Gemini-North telescopes. We measure the complete astrometric orbits for two systems (2M0805+48 and 2M1059−21) and find that their T-dwarf companions are surprisingly massive compared with their predictions from evolutionary models. The companion of 2M0805+48 is among the latest-type brown dwarfs with well-constrained masses. We show that astrometry represents an underutilised avenue for characterising compact substellar binaries and discuss its prospects in light of the upcoming Gaia data releases.

[Poster #47] Guido De Marchi [ESTEC]

They call it anomalous extinction? Trust me, it's the norm...

With my colleagues I studied the extinction curve in and around the Tarantula Nebula in the Large Magellanic Cloud (LMC), making use of thousands of red giants as standard candles. We discovered a flattening of the curve at optical wavelengths, corresponding to a ratio of total-to-selective extinction Rv=Av/E(B−V) exceeding 4.5 and implying a larger fraction of big grains than in the diffuse ISM. Our further investigation of the ultraviolet extinction properties revealed that big grains are not formed at the expense of small grains, since a steepening of the curve at wavelengths shorter than 2000 Åclearly shows that small grains are even more abundant than in the diffuse ISM.

I now show that this is not just the case of the massive Tarantula nebula. We find that a value of Rv$\sim$4.5 is characteristic of all the young and intermediate-age clusters observed with Hubble in the LMC that contain enough dust to reveal an elongated red giant clump. Even better, a Herschel survey of the dust emission over the entire LMC shows that there is a one-to-one correspondence between the amount of dust in the regions and the length of the extended red clump, but the shape of the extinction curve is always the same and requires

an excess of big grains. By dating ongoing and previous star-formation episodes through isochrone fitting, we show that the elevated Rv value is present in these regions for at least 60 Myr and possibly 200 Myr after the most recent star formation event. In these regions, where formation of massive stars has been ongoing for over 20 Myr, a process able to naturally account for the injection of new grains is the explosion of massive stars as core-collapse supernovae. It is now clear that in these environments an anomalous extinction law is the norm rather than the exception. As a result, if a canonical extinction law is adopted, the values of total extinction derived from optical colours in regions of recent intense star formation (and therefore of all high-redshift star forming regions) will be systematically underestimated.

[Poster #48] Elena Manjavacas [STScI]

MOSFIRE Spectro-photometric variability of the planetary-mass L3 brown dwarf 2M2208+2921

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, provide an idea on how exoplanet analog atmosphere structures look like. We show the results of spectrophotometric monitoring in the Jband of the L3 exoplanet analog, 2M2208136+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 alkali lines.

[Poster #49] Emilia Järvelä [ESAC]

Jet-galaxy interactions in narrow-line Seyfert 1s revealed!

Narrow-line Seyfert 1 galaxies (NLS1) are the young rebels of the active galactic nuclei family. They mostly reside in spiral galaxies, and harbour low-mass, effectively accreting black holes, all the while being able to launch and maintain powerful relativistic jets - in contradiction with the traditional jet paradigm. NLS1s often show compact radio morphologies, but a fraction of them exhibit kpc-scale radio emission, and even diffuse emission resembling radio relics has been found, possibly indicating intermittent nuclear activity. These structures can be examined in detail using, for example, optimal tapering of the data to reveal low-intensity radio emission, and radio spectral index maps that can be used to derive physical properties of the emission, such as its age, energetics, and possible interaction with the surrounding medium. Here we present the highlights of a study of a sample of NLS1s with extended radio emission found in our earlier JVLA survey, and analysed using the aforementioned methods.

[Poster #50] Emilia Järvelä [ESAC]

J2118−0732: first of its kind

J2118−0732 is a gamma-ray emitting active galactic nucleus (AGN) at z=0.26, originally classied as a narrow-line Seyfert 1. Here we present the detailed analysis of new, high-quality spectroscopic data obtained with the 6.5 m Clay Telescope, and reclassify J2118−0732 as an intermediate-type Seyfert galaxy. Furthermore, we present the results of modelling the Ks-band image of its host galaxy obtained with the 6.5m Baade telescope, indicating that it is hosted by a late-type galaxy in an interacting system. These new data prove that J2118−0732 is the rst non-local, interacting, late-type intermediate Seyfert galaxy with relativistic jets. One of a kind — for now.

[Poster #51] Enrica Bellocchi [ESAC]

Large scale (parsec) mechanical heating in NGC 4945. The multi-phase ISM in the nearby composite AGN-SB galaxy NGC 4945

We carry out a comprehensive study of the nearby composite AGN-SB galaxy, NGC 4945, using spectroscopic and photometric data from the Herschel satellite. In particular, we characterize the thermal structure in this galaxy by a multitransitions analysis of the spatial distribution of the 12CO emission at different spatial scales. We also establish the dominant heating mechanism at work in the inner region of this object at smaller spatial scales (200 pc). Indeed, the thermal structure derived from the 12CO multi-transition analysis suggests that

mechanical heating, like shocks or turbulence, dominates the heating of the ISM in the nucleus of NGC 4945 located beyond 100 pc (>5") from the center of the galaxy. Shocks and/or turbulence are likely produced by the barred potential and the outflow, observed in X-rays. This result is confirmed by the mechanical heating models, which suggest the existence of PDRs but mainly dominated by mechanical heating (i.e., feedback from SNe) in the inner regions of NGC 4945 (Bellocchi et al. 2020).

[Poster #52] Enrica Bellocchi [ESAC]

First results at sub-kpc scale in local LIRGs with ALMA

In this work we present the preliminary results obtained for the dust and molecular gas derived for NGC3110, ESO264-G036 and ESO267-G030 which belong to a representative sample of 23 local LIRGs observed with ALMA at ∼80 pc spatial resolution. We aim at combining the emission from the spatially resolved cold molecular gas CO(2-1), the dust (at 230 GHz or 1.3 mm), and the SF regions (HST Pa-alpha imaging) to estimate the range of gas-to-dust ratios and dust temperatures compatible with the observations. The comparison between the radial extension obtained for the dust and the molecular emissions with those derived for the stellar and ionized gas (Hα) emissions as a function of the LIR, activity and morphology will be analyzed. We also plan to test how reliable are previous dust-to-molecular gas mass conversion methods (e.g., Scoville+14) when using one single continuum observation in the millimeter band.

[Poster #53] Belén López Martí [ESAC]

Gaia catalogue of galactic OH/IR stars

OH/IR stars make up a subsample of the so-called Asymptotic Giant Branch (AGB) stars. They are low and intermediate-mass post-Main Sequence stars that are experiencing mass loss, which leads to the formation of circumstellar envelopes of gas and dust around them, which are sources of strong OH maser and infrared emission. Evolutionary models predict that OH/IR stars, which are in a final stage on the AGB, come predominantly from the most massive AGB stars ($M \geq 3M_{\odot}$). This picture is challenged by studies in the Galactic Bulge, where OH/IR stars with luminosities consistent also with lower progenitor masses were found.

We are currently creating a catalogue of OH/IR stars with reliable parallax measurements as provided by ESA's Gaia mission. Using multiwavelength photometry from different public catalogues, publicly available through the Virtual Observatory, we can construct the spectral energy distributions of the stars with unprecedented coverage. Combined with accurate distance estimations and evolutionary models of AGB stars fundamental physical parameters, as luminosities, mass-loss rates, and progenitor main-sequence masses can be derived. The sample will provide a means to test the progenitor masses of a larger sample of OH/IR stars. In this contribution, we will explain the process of construction of the catalogue and its current status. This catalogue will become a benchmark for further studies in the field.

[Poster #54] Antonia Vojtekova [ESAC]

Learning to Denoise Astronomical Images with U-nets

Astronomical images are essential for exploring and understanding the universe. Optical telescopes capable of deep observations, such as the Hubble Space Telescope, are heavily oversubscribed in the Astronomical Community. Images also often contain additive noise, which makes de-noising a mandatory step in post-processing the data before further data analysis. In order to maximise the efficiency and information gain in the post-processing of astronomical imaging, we turn to machine learning. We propose Astro U-net, a convolutional neural network for image de-noising and enhancement. For a proof-of-concept, we use Hubble space telescope images from WFC3 instrument UVIS with F555W and F606W filters. Our network is able to produce images with noise characteristics as if they are obtained with twice the exposure time, and with minimum bias or information loss. From these images, we are able to recover 95.9% of stars with an average flux error of 2.26%. Furthermore the images have, on average, 1.63 times higher signal-to-noise ratio than the input noisy images, equivalent to the stacking of at least 3 input images, which means a significant reduction in the telescope time needed for future astronomical imaging campaigns.

[Poster #55] Andrew Lobban [ESAC]

X-Ray Variability Analysis of a Large Series of XMM-Newton and NuSTAR Observations of NGC 3227

I will present a wealth of spectral-timing results from a long XMM-Newton + NuSTAR campaign on the bright, variable active galactic nucleus (AGN) NGC 3227, consisting of >800 ks of X-ray data. I will present an analysis of the lightcurves, showing that the source exhibits a curious, transient period of spectral hardening. The spectral hardening event is accompanied by a change in the depth of an unresolved transition array (UTA), whose timedependent behaviour is resolved using the high-resolution RGS data. This UTA fingerprint allows us to identify this as a transit event, where a clump of mildly ionised gas, having a column density of $\sim 5 \times 10^{22}$ atoms cm^{-2}, occults $\sim$60% of the continuum photons over the course of approximately a day. This occulting gas is likely associated with clouds in the inner broadline region. An additional zone of gas with lower column and higher ionisation, matches the outflow velocity of the variable zone, and may represent transmission through the cloud limb.

By spectrally decomposing the data, I will also show that the bulk of the variability is continuum-driven and, through rms variability analysis, strongly enhanced in the soft band. I will show that the source largely conforms to linear rms-flux behaviour and that the behaviour of the frequency-dependent X-ray power spectrum is largely consistent with existing scaling relations. Additionally, we compute X-ray Fourier time lags using both the XMM-Newton and - through recently-developed maximum-likelihood methods - NuSTAR data, revealing a strong lowfrequency hard lag and evidence for a soft lag at higher frequencies at both low and high X-ray energies. The discovery of a negative lag between the 3–5 and 15–50 keV bands may have implications for existing reverberation models.

[Poster #56] René Laureijs [ESTEC]

Nancy Roman Space Telescope - an ESA Mission of Opportunity

The Nancy Grace Roman Space Telescope (former name: WFIRST) is NASA's next astronomical flagship mission after JWST. The mission is optimised to carry out large area imaging and spectroscopic surveys, and, in addition, includes a stellar coronagraph as a technology demonstrator. It has recently been endorsed by the SPC as an ESA mission of opportunity. An overview will be given of the mission and its scientific capabilities, with the latest instrument developments. I shall pay some attention to the contributions by ESA, and give possible avenues how ESA could support the scientific return of the Roman Space Telescope in Europe. A summary of the development status and the project schedule will be presented.

[Poster #57] Jos de Bruijne [ESTEC]

Benford's Law in the Gaia Universe

Benford's Law states that for scale- and base-invariant data sets covering a wide dynamic range, the distribution of the first significant digit is biased towards low values. This has been shown to be true for wildly different datasets, including financial, geographical, and atomic data. In astronomy, earlier work has shown that Benford's Law also holds for distances estimated as the inverse of parallaxes from the ESA Hipparcos mission. We investigate whether Benford's Law still holds for the $\sim$1.3 billion parallaxes contained in the second data release of Gaia (Gaia DR2). We also investigate the use of Benford's Law as a validation tool for the zero-point of the Gaia parallaxes.

[Poster #58] Catarina Alves de Oliveira [ESAC]

The final countdown

The SSW#13 should be the last departmental workshop before JWST launches in 2021. As we patiently await the real data, I will showcase how I plan to use ESA's contributed NIRSpec instrument in the quest to further understand star formation in our Galaxy.

[Poster #59] Romain Mottier [Other]

Modelling of the near surface of Mercury. Application to Ice stability at the poles and other surface features and global temperature maps

The main objective of the BepiColombo space mission is to explore and better understand Mercury. Due to its very close proximity to the Sun, it is the least explored terrestrial planet in the solar system. This mission will provide valuable information on the formation and evolution of solar systems and in particular the planets that make it up.

The results presented are obtained in the frame of an internship and this work is part of a larger project aimed at explaining the stability and origin of volatile structures like ice inside polar craters and hollows. Hollows are geological phenomena unique to Mercury, they are rimless depressions with flat floors and surrounded by haloes of bright material. The work carried out during this 3 month period, the modeling of the surface temperatures of Mercury as a function of its position in the orbit around the Sun and on temperatures below at near surface layers of Mercury and its applications on the ice stability in near surface layers and at the poles, will be presented.

By implementing the equations from a numerical model to describe the physical and chemical evolution of near surface layer of planetary bodies global temperature maps of Mercury could be created as well as the evolution of the internal temperature at different latitudes were studied. The results obtained proofed our concept and the physical correctness of the use algorithms. We were able to estimate properties of the surface like thermal heat conductivity and stability of volatile elements. For water ice we found that it is very unlikely to exist in near surface layers of Mercury for longer time scales. Also to explain Hollows by outgasing of volatile elements from near surface layers seems to be very unlikely taking the obtained results into account. Even at high latitudes temperatures at some meters below the surface are to warm, allowing volatile material to exist overlong time scales.