Table of contents

Thermal effects on the bulk density of rocky planets: the Earth-like composition band

Artem Aguichine * [1], Francis Nimmo [1], Natalie Batalha [1], Jonathan Fortney [1]

[1] University of California [Santa Cruz] – United States

The diversity of masses and radii of terrestrial exoplanets is commonly attributed to a difference in bulk composition. In the mass-radius plane, terrestrial planets typically lie around the Earth-like iso-composition curve computed from theoretical planet interior structure models. This thought is reinforced by the fact that theoretical interior models predict a mere 1% change in radius when thermal expansion of the rocky material in the deep interior is included. However, the density of the material is not only affected by thermal contraction, but also phase transitions, in particular between the solid and molten states. It is well established that rocky planets are fully molten at their formation, but the rate at which they solidify is still under debate. Unlike thermal expansion, phase transition between the molten and solid state is accompanied by a greater change in density. We show that fully molten interiors can be up to 15% less dense than their condensed analogs, which challenges the current interpretation of the composition of rocky super-Earths. This result has important implications for the evolution of atmospheres and hydrospheres on terrestrial planets, and their habitability.

*Speaker

Structure and evolution of the envelopes of hot water worlds

Artem Aguichine * [1], Natalie Batalha [1], Jonathan Fortney [1], N. Nettelmann [1], James Owen [2], Eliza Miller Ricci Kempton [3], Olivier Mousis [4], M. Deleuil [4]

[1] University of California [Santa Cruz] – United States
[2] Department of Physics [Imperial College London] – United Kingdom
[3] University of Maryland [College Park] – United States
[4] Laboratoire d'Astrophysique de Marseille – Aix Marseille UniversitÃ©, Institut National des Sciences de l'Univers, Centre National d'Ã‰tudes Spatiales [Toulouse], Centre National de la Recherche Scientifique, Institut Origines – France

Sub-Neptunes represent compelling targets for being water worlds, exhibiting masses and radii that have been shown to match those of hypothetical water rich bodies. Recent work for irradiated water worlds predict that water in their envelope would be in the supercritical state, with steam atmospheres on top, which significantly alters the mass-radius relation. However, proper knowledge of the thermal state of the interior, which affects the predicted planetary radius, is elusive. This challenge is due to both lack of knowledge of laboratory data of material (equation of state and opacity), and difficulty to self-consistently model such interiors. Sub-Neptunes form with a huge energy reservoir, and cool down and contract over time, which has been incorporated into grids of H2-rich sub-Neptune models, but never for water worlds. Here, we present a new model that accounts for the thermal contraction of water rich envelopes. This model combines an interior structure model with a radiative-convective steam atmosphere model, that are coupled through the heat lost from the planet's interior. The interior structure model uses the most up-to-date thermodynamic data for pure water substance, and the steam atmosphere model uses a new treatment for the opacity of water. This model provides new mass-radius relationships for water-rich hot sub-Neptunes through time, which reassesses the water content in sub-Neptunes. This allows us to quantify the range of radii accessible to such hypothetical planets.

*Speaker

Current and future limits on the mass measurements of Earth-like planets due to stellar variability.

Suzanne Aigrain * [1], Nadège Meunier [2]

[1] University of Oxford – United Kingdom
[2] Institut de Planétologie et d'Astrophysique de Grenoble – Institut National des Sciences de l'Univers, Centre National d'études Spatiales [Toulouse], Centre National de la Recherche Scientifique, observatoire des sciences de l'univers de Grenoble, Université Grenoble Alpes – France

In a recent study, Meunier et al. (2023) used simulations to investigate the detectability of Earth-mass planets in the Habitable Zones of Sun-like stars. They considered both "blind" RV surveys, and a transit follow-up scenario, and tested several methods to model the activity signal and recover the planets. The results of that study showed that, with the methods considered, it is very challenging to detect such planets blindly, or to measure the masses of transiting planets at the 10% level (corresponding to PLATO's requirements), even with 1000 ESPRESSO-like measurements per target over 10 years. In this talk I will revisit these simulations with multi-dimensional Gaussian Process regression (multi-GP, Rajpaul et al. (2015; Barragan et al. 2022), to test whether a) joint (rather than sequential) modelling of the activity indicators and RVs can improve the results b) using simultaneous photometry as well as spectroscopic activity indicators improves the results and c) map out the parameter space accessible as a function of the duration of the RV observations campaign.

*Speaker

How to improve the characterisation of distant stars hosting transiting exoplanets?

Matthias Ammler-Von Eiff * [1], Daniel Sebastian [2], Jie Yu [3], Chen Jiang [1], Eike Guenther [4]

[1] Max-Planck-Institut fÃ¼r Sonnensystemforschung = Max Planck Institute for Solar System Research – Germany
[2] School of Physics and Astronomy [Birmingham] – United Kingdom
[3] School of Computing, Australian National University – Australia
[4] ThÃ¼ringer Landessternwarte Tautenburg (TLS) – Sternwarte 5 07778 Tautenburg, Germany

The accurate determination of the host star parameters is essential to characterise their orbiting planets. In the PLATO mission, the sample consists of stars as faint as V=13 mag, many of which may be too faint for the full characterisation via asteroseismology and ground-based spectroscopy, as planned for the brighter targets. Additionally, these stars tend to be distant, making interstellar extinction a more significant factor compared to other PLATO targets.
To assess the limitations of the stellar characterisation and to explore possible solutions in preparation for PLATO, we reviewed the stellar parameters of all 36 CoRoT planet hosts. These are typically faint (V=12-16 mag) and can be as distant as 1 kpc and more.

We identified independent constraints that do not rely on details of stellar modelling, in particular stellar density based on transit light curves and distance from Gaia astrometry. We compared these to published estimates of extinction and effective temperature for CoRoT targets with planets. This way, we can determine how accurate stellar parameters are and reassess extinction. We found that published estimates of extinction and effective temperature do not match the constraints in several cases.
After constraining extinction and effective temperature, we can compute the radii of the host stars from stellar density and Gaia distance in a homogeneous way. To our knowledge, this is the first comprehensive characterisation of the full set of CoRoT host stars using precise distances from Gaia. These findings provide a framework for improving stellar characterisation in the PLATO mission, particularly for faint planet host stars.

*Speaker

False positive source distributions and validation potential for the PLATO dataset

David Armstrong * [1], Andreas Hadjigeorghiou , Kaiming Cui , Marina Lafarga-Magro

[1] Department of Physics [Warwick] – University of Warwick Gibbet Hill Road Coventry CV4 7AL, United Kingdom

Much experience has been gained from Kepler, K2, TESS and other surveys about the challenges of separating true planetary signals from false positives in lightcurve data. Even in Kepler data, the most precise long baseline dataset available, the problem of understanding whether a shallow, long period transit is real has not been fully understood and the reliability of such candidates can be difficult to measure. Probabilistic validation algorithms have grown in complexity and scope but as yet remain completely untested by ground truth in the long period shallow transit regime. I will use a new detailed simulation framework, implementing state-of-the-art knowledge of binaries, hierarchical triples, and other false positive source distributions, to explore what false positives may be expected for PLATO, and how we may be able to identify them. I will detail a new vetting and validation machine-learning based algorithm, RAVEN, developed for TESS but adaptable to PLATO, and capable of probabilistic validation on a large scale via an independent methodology to typical validation methods. RAVEN can reach accuracies over 99% depending on false positive scenario, and test planet scenarios against separate false positive sources, allowing a deeper understanding of which false positives are constrained in a given dataset for a given candidate. Implementing similar algorithms for PLATO data is a clear next step, with the biggest remaining unknown being a detailed understanding of the spacecraft noise properties.

*Speaker

Transit light curves in stellar convective noise: How accurate are hydrodynamical simulations for apprehending and counteracting this jitter?

Lionel Bigot * [1]

[1] Laboratoire LAGRANGE – Observatoire de la Cote d'Azur, Université Côte d'Azur, Centre National de la Recherche Scientifique – France

In the quest towards detecting small exoplanets in the habitable zone of late-type stars, the stochastic "noise" generated at stellar surfaces presents a significant obstacle for both detection and characterization of planets. Convective fluctuations generate a jitter comparable in magnitude to the detected signal, potentially affecting the accuracy of derived planetary parameters. Additionally, stellar limb-darkening effects impact the depth and shape of the transit and therefore planetary characterization.

Three-dimensional radiative compressible hydrodynamical simulations of stellar surface convection have demonstrated their realism and can help to quantify the impact of convection while informing strategies to mitigate its effects. In this talk, we present ongoing work that reconstructs the entire time-dependent stellar disk using exclusively results from 3D hydrodynamical simulations projected onto the sky plane, as will be observed by space missions like PLATO. This procedure is integrated with Keplerian code to account for various planetary orbital elements.

Our presentation focuses specifically on convection's impact across three stellar types: F-star, solar-like star, and M-dwarf. We will demonstrate synthetic transit light curves obtained through our approach and quantitatively assess how stellar noise affects the determination of planetary fundamental parameters and orbital elements. Finally, we will address recent controversies regarding the accuracy of 3D stellar limb-darkening models for exoplanet transit observations.

*Speaker

The ESPRESSO follow-up of small transiting exoplanets: perspectives for PLATO

Francois Bouchy * [1], Melissa Hobson [1], Christophe Lovis [1], Francesco Pepe [1], Xavier Dumusque [1], Baptiste Lavie [1], StÃ©phane Udry [1]

[1] Observatoire Astronomique de l'Université de Genève – Switzerland

The PLATO mission is expected to discover hundreds of small transiting exoplanet candidates, near or within the habitable zone of their host star. These candidates will require ground-based follow-up with extreme precision radial velocity instruments to confirm their planetary nature and precisely characterize their masses and bulk densities. The ESPRESSO spectrograph at the VLT is a key instrument for the RV characterization of small planets, thanks to its exquisite instrumental RV precision close to 10 cm/s and the large collection area of the VLT. Between 2018 and 2023, the ESPRESSO consortium monitored 50 stars hosting small transiting planet candidates from K2 and TESS, as part of the ESPRESSO Guaranteed Time Observations. A complementary PI program was dedicated to the follow-up of warm and temperate sub-Neptunes. In this contribution, we will focus on the lessons learned from these programs that should be kept in mind for the follow-up of the PLATO small and long-period planet candidates.

*Speaker

The Effect of Guide Star Variability on PLATO Pointing Stability

Samuel Bowling * [1,2], Juan Cabrera [3], Richard Lieu [2], Heike Rauer [1,4], Denis GrieÃŸbach [1], Carsten Paproth [1], René Heller [5], Chen Jiang [5]

[1] German Aerospace Center – Germany
[2] University of Alabama in Huntsville – United States
[3] German Aerospace Center – Germany
[4] Freie UniversitÃ¤t Berlin – Germany
[5] Max-Planck-Institut für Sonnensystemforschung = Max Planck Institute for Solar System Research – Germany

The main science goal of PLATO (PLAnetary Transits and Oscillations of stars) is to detect and characterize extrasolar planets, including terrestrial planets in the habitable zone (HZ) of their host stars. Detecting rocky planets in the HZ requires high photometric stability, which depends on the telescope's pointing performance. PLATO's pointing performance is managed by the Fine Guidance System (FGS), which utilizes a catalog of guide stars to determine the spacecraft's attitude. Previous missions have found that astrophysical variability in guide stars can introduce systematic errors in spacecraft pointing which produce artifacts in the output light curves. In this project, we study the impact of stellar variability in guide stars on PLATO's pointing stability.

*Speaker

What PLATO will tell you about exoplanets

David Brown * [1,2]

[1] University of Warwick – United Kingdom
[2] PSM Office – United Kingdom

The Exoplanet Analysis System (EAS) is PLATO's exoplanet data processing pipeline. Developed by the PLATO Mission Consortium, it has two major components: TransitPipe and PlanetPipe. TransitPipe is designed to detect possible transiting exoplanet signals in PLATO light curves, vet those signals to identify instrumental false alarms and astrophysical false positives, determine transit parameters for the remaining candidates, and grade them according to their likelihood of being real exoplanet signals. PlanetPipe is designed to perform full planetary system modelling to characterise the exoplanets found by the mission, both with and without the use of additional data from ground-based follow-up observations, such as radial velocity measurements.

Through these two major components, the EAS will produce not only a list of candidate exoplanets from PLATO, but also a catalogue of fully-characterised exoplanetary systems. All of the pipeline products will be regularly updated on a 3-monthly cycle (corresponding to the PLATO field rotation cadence) over the full lifetime of the PLATO mission through to the end of the post-operations phase. The EAS itself will also be updated throughout the mission, in response to specific scientific needs identified when using analysing real PLATO data during in-flight commissioning and science operations.

In this talk, we will present the EAS design and the philosophy behind it, give an overview of the major components (TransitPIpe and PlanetPipe), discuss the current status of the implementation and testing campaigns, and outline our plans for assessing the completeness and reliability of the EAS and estimating occurrence rates.

*Speaker

The calcium triplet as an infrared chromospheric indicator: a large-scale study, from Gaia DR4 to PLATO

Vincent Bruniquel * [1], Nadège Meunier [2], Lucile Mignon [3]

[1] Institut de Planétologie et d'Astrophysique de Grenoble – Université Grenoble Alpes – France
[2] Institut de Planétologie et d'Astrophysique de Grenoble – observatoire des sciences de l'univers de Grenoble, Université Grenoble Alpes – France
[3] Institut de Planétologie et d' Astrophysique de Grenoble – Centre National de la Recherche Scientifique – France

This work represents a first step towards a large-scale study of stellar activity using Gaia DR4 data (2026-2027). To accomplish this, I'm using the calcium infrared triplet (Ca II IRT) as an alternative indicator of stellar chromospheric activity, particularly suited to Gaia's spectral range, where the visible part is missing. In order to qualify the sensitivity of Ca II IRT and test the performance that can be achieved with Gaia DR4, I will present an analysis of a large sample of time series (FGK stars) of high-resolution spectra obtained with NARVAL and ESPaDOnS. Indeed, these 2 instruments give simultaneous access to Ca II IRT and standard chromospheric activity index log Râ€²HK. I thoroughly tested several indicators for analyzing chromospheric activity, one of the S-index type without photospheric correction and the other based on subtracting LTE models of inactive stars, thus correcting for the effect of the photosphere. Correlations with logR'HK, both on mean values and on individual time series, test the reliability and sensitivity of Ca II IRT. I have observed promising correlations, which also make it possible to characterize the amplitude of the variability observed in the 2 indicators. To ensure the feasibility of this analysis on Gaia DR4 data, I have studied the impact of all factors on the fiability of the CA II IRT indicators, and particularly the impact of the spectral resolution. Applying this method to Gaia DR3 and then DR4 will enable us to characterize the level of activity and variability of stars in the PLATO fields. This will be useful for radial velocity follow-up.

*Speaker

PLATO Mission Performance: search for Earth-like planets in the habitable zone

Juan Cabrera * [1], Sami-Matias Niemi , Reza Samadi , Claas Ziemke , Ulrike Witteck , Dave Walton , Peter Verhoeve , Bart Vandenbussche , Alan Smith , Gabriel Schwarzkopf , Francesco Santoli , Pierre Royer , Sara Regibo , Roberto Ragazzoni , Giampaolo Piotto , Martin Pertenais , Carsten Paproth , Gianalfredo Nicolini , Valerio Nascimbeni , Marco Montalto , Francesca Molendini , Paola Marrese , Silvia Marinoni , Demetrio Magrin , Alexander Koncz , Peter Klagyivik , Nicholas Jannsen , Sascha Grziwa , Valentina Granata , Goupil Mariejo , Nicolas Gorious , Denis Griessbach , Giacomo Dinuzzi , Joris De Ridder , Cilia Damiani , Yoshi Eschen , Anders Erikson , Philipp EigmÃ¼ller , SzilÃ¡rd Csizmadia , Francesco Borsa , Anko Boerner , Aaron Birch , Claudio Arena , Thierry Appourchaux , Jose Lorenzo Alvarez , James Windsor , Heike Rauer , Isabella Pagano , Miguel Mas Hesse

[1] German Aerospace Center – Germany

The science goal that drives the design and operations of the PLATO mission is the ability to detect terrestrial planets orbiting in the habitable zone of these stars. The payload is optimized to detect and characterize terrestrial planets around solar-type stars as well as at the study of their host star properties.
The payload consists on a complex multi-telescope configuration with 26 cameras of 12 cm pupil size covering a field of view of more than 2000 square degrees, spread over 104 CCDs of 20 million pixels each. The information of the cameras has to be combined in order to achieve the strict noise requirements at mission level. Recently, the PLATO Mission Consortium has delivered to ESA all the cameras, fully tested, with excellent performance. The cameras are being integrated in the spacecraft for further testing before launch scheduled end 2026.
In this talk we will review the drivers for PLATO Performance, we will present the most recent description of the status of noise budget and verification of main performance requirements, and we will summarize some key scientific results that can be achieved by the mission.

*Speaker

Impact of atmospheric composition on the position of the Habitable Zone

Guillaume Chaverot * [1], Lucile Mignon [2], Xavier Delfosse [3], Nadège Meunier [4]

[1] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – Université Grenoble Alpes – France
[2] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – Université Grenoble Alpes – France
[3] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – UniversitÃ© Grenoble Alpes – France
[4] Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) – Université Grenoble Alpes – France

The concept of the Habitable Zone (HZ; e.g., Kasting et al. 1993) remains a fundamental framework for evaluating the potential habitability of large samples of exoplanets, such as those expected from the PLATO mission (e.g., Dressing & Charbonneau 2015; Bryson et al. 2021; Bergsten et al. 2022; Hill et al. 2022; Chen et al. 2023). A widely used formulation of the HZ limits was proposed by Kopparapu et al. (2013, 2014), providing a computationally efficient method applicable across a range of stellar types and planetary masses. However, this classical formulation relies on the strong assumption of an Earth-like atmospheric composition, which does not account for the broad diversity of atmospheres observed - and expected - among exoplanets.
To address this limitation, we employed a one-dimensional radiative-convective climate model to investigate how variations in atmospheric composition affect the location of the inner edge of the HZ. Our preliminary results show large variations of the position of this inner edge and demonstrate that the assumption of a terrestrial-like atmosphere, as adopted in the key work of Kopparapu et al. (2013), may lead to non-conservative estimates of habitability boundaries and should therefore be revisited.
The long-term objective of this study is to contribute toward a revised definition of the HZ including all the relevant physics, and first integrating a broader range of atmospheric compositions. Such a refinement is essential for accurately evaluating the potential habitability of future PLATO targets and for guiding the selection of planets for further atmospheric characterization.

*Speaker

Will the RV follow-up of the PLATO mission be able to characterize the Earth-size habitable-zone transiting planets? Insights from the RV data challenge.

Michael Cretignier * [1]

[1] University of Oxford – United Kingdom

One of the objectives of the PLATO mission is to obtain a 10% accuracy on mass for a transiting Earth-like habitable zone exoplanet, via radial velocity follow-up. This translates to characterizing _˜10 - 30 cm/s RV planetary signals, which poses very important difficulties.
We organized an RV data challenge based on real HARPS, HARPS-N and ESPRESSO observations to assess the ability of the RV follow-up. The goal is to evaluate the accuracy of the mass retrieved by different data analysis methods. The first stage of the challenge focuses on the stellar activity corrections methods and used as playground a Sun-like active K1 dwarf observed by HARPS as well as 8 years of HARPS-N solar observations with three different time sampling. Opposite to previous data challenge (Dumusque et al. 2016, Zhao et al. 2021), the planets were injected at the spectrum level and homogeneously propagated downwards the sub-products (CCFs and time-series). While the transits information was always provided for at least one planet, we also included several non-transiting planets to mimic real-life scenarios and further test the capabilities of existing methods.
The six teams participating to the challenge span various methodologies, from time to wavelength-domain, including: GPs, CCFs data-driven approaches and spectra corrections. I propose to discuss in this presentation the main results obtained.

*Speaker

High time-resolution analysis of X-ray data from Proxima Centauri

Andrea Damonte * [1], Ignazio Pillitteri [2], Antonio Maggio [2], Antonio García Muñoz [3], Giusi Micela [4]

[1] CEA Saclay - INAF Palermo – CEA, CNRS, UniversitÃ© Paris-Saclay, CEA Saclay 91191 Gif sur Yvette France – France
[2] INAF - Osservatorio Astronomico di Palermo – Italy
[3] CEA Saclay – CEA Saclay, 91191 Gif-sur-Yvette Cedex, France – France
[4] INAF - Osservatorio Astronomico di Palermo – Italy

X-ray and extreme ultraviolet (together, XUV) radiation from stars play a major role in shaping exoplanetary atmospheres and strongly affect their habitability. Stellar flares are extreme events, during which XUV emissions can increase by several orders of magnitude. M dwarf stars exhibit long-term flaring activity, and the habitable zone (HZ) for these stars is located much closer to the star than in other systems, further enhancing XUV flux and making them particularly interesting targets for study. Proxima Centauri represents one of the best candidates for in-depth studies of XUV radiation from flares. It is the closest star to us and is highly active. Standard analysis products usually consist of long-time average spectra with no reported uncertainties. For our analysis we use nearly 6 days of XMM-Newton observations of Proxima Centauri spread over 19 years. We present a methodology to obtain high time-resolution (up to 90 s for this target) flux density measurements while also estimating their uncertainties. We present a novel correction for the pile-up effect, a detector artifact in which multiple photons are registered as one. This effect is often present in X-ray observations of nearby stars and affects around 22% of the observational time of Prox Cen. We find that it can cause up to a 30% loss in total flux, which is greater than the derived instrumental uncertainties. Corrected synthetic spectra time series in the 1-100 Å range are presented with uncertainties less than 10% and average time-resolution of 5 minutes. These data will be useful to investigate the long-term stability of Proxima Centauri b's atmosphere and the effects of flares on the surface habitability of the planet.

*Speaker

Earth-like Planet Predictor: a machine-learning approach

Jeanne Davoult * , Yann Alibert [1], Romain Eltschinger [2]

[1] Center for Space and Habitability – Switzerland
[2] Space Research and Planetary Sciences [Bern) – Switzerland

Searching for planets analogous to Earth in terms of mass and equilibrium temperature is currently the first step in the quest for habitable conditions outside our Solar System and, ultimately, the search for life in the universe. Future missions such as PLATO, LIFE, or HWO will begin to detect and characterise these small, cold planets, dedicating significant observation time to them. The aim of this work is to predict which stars are most likely to host an Earth-like planet (ELP) to avoid blind searches, minimises detection times, and thus maximises the number of detections. Thanks to synthetic populations of planetary systems from the Bern model, we studied the correlations between an ELP and the observable properties of its system (such as the observable architecture, and the mass, radius, and period of the innermost detectable planet of this system). We then developed a Random Forest model able to learn the difference between the systems hosting ELPs and the systems that do not, based on those correlations. We present here our model and the 44 systems, as now, identified as likely to host an ELP.

*Speaker

Residual Stellar Biases in Transmission Spectroscopy: A Caution for Atmospheric Characterization of Planets in the Habitable Zone

William Dethier * [1], Benjamin Tessore [2], Nuno Santos [3,4], Eduardo Cristo

[1] Centro de AstrofÃsica da Universidade do Porto – Portugal
[2] Institut de PlanÃ©tologie et dÃstrophysique de Grenoble – Centre National de la Recherche Scientifique : UMR5274, Institut national des sciences de lÚnivers, UniversitÃ© Joseph Fourier - Grenoble 1, Institut national des sciences de lÚnivers : UMS832, Centre National de la Recherche Scientifique, UniversitÃ© Grenoble Alpes, Institut national des sciences de lÚnivers, Institut national des sciences de lÚnivers : UMS832, Institut national des sciences de lÚnivers, Institut national des sciences de lÚnivers : UMS832, Institut national des sciences de lÚnivers, Institut national des sciences de lÚnivers : UMS832, Institut national des sciences de lÚnivers, Institut national des sciences de lÚnivers : UMS832 – France
[3] Instituto de AstrofÃsica e CiÃªncias do EspaÃ§o (IA/U. Porto) – CAUP, Rua das Estrelas, 4150-762 Porto, Portugal
[4] Departamento de FÃsica e Astronomia, FCUP, Portugal (DFA-FCUP) – Departamento de FÃsica e Astronomia, Faculdade de CiÃªncias, Universidade do Porto, Rua do Campo Alegre, 4169-007 Porto, Portugal, Portugal

As we prepare for the PLATO mission and its promise to uncover terrestrial planets within the habitable zones (HZs) of solar-like stars, robust atmospheric characterization of these worlds will become a critical next step. Transit spectroscopy is one of our most powerful tools for probing exoplanet atmospheres, yet its interpretation is vulnerable to biases from stellar contamination.
A common technique used in recent years attempts to mitigate stellar effects by dividing observed transit absorption spectra by synthetic absorption spectra generated for an atmosphereless planet. This process aims to isolate the atmospheric signature by correcting for distortions caused by stellar rotation and center-to-limb variations.

In this study, we demonstrate that while this method reduces stellar contamination, it does not fully remove it. Using both analytical simplifications and synthetic transit simulations, we show that the corrected spectra still carry residual biases due to spatial inhomogeneities in the stellar spectrum. These biases can subtly distort the retrieved atmospheric signals, potentially leading to incorrect inferences about the composition and properties of exoplanet atmospheres. Our findings underscore the importance of understanding and mitigating these effects as we enter the PLATO era and for follow-up studies aiming at characterising the discovered planets. The precise atmospheric characterization of HZ planets will hinge on our ability to disentangle planetary signals from stellar noise - a challenge that must be met if we are to reliably assess planetary habitability.

*Speaker

Magnetic cycles of cool stars in the PLATO fields

Manon Diez * [1], Julien Morin [1], Pascal Petit [2]

[1] Laboratoire Univers et Particules de Montpellier – Université de Montpellier, CNRS, LUPM/UMR 5299, 34095, Montpellier, France – France

[2] Institut de recherche en astrophysique et planétologie – Université de Toulouse, CNRS, IRAP/UMR 5277, 14 Avenue Edouard Belin, 31400,Toulouse, France – France

The ESA PLATO mission aims to detect and characterize exoplanets, particularly Earth-like planets orbiting Sun-like stars. It will also deliver long-term photometric and seismic monitoring of stellar activity. In this context, identifying and studying target stars in advance is essential to optimize the use of future PLATO data, especially for investigating stellar magnetic cycles.
To address this goal, we engaged in a spectropolarimetric campaign focused on a selection of cool stars from the PLATO South Field, chosen based on their spectral type, variability, and relevance for magnetic activity studies. These observations are carried out using ESPaDOnS and SPIRou at the Canada-France-Hawaii Telescope (CFHT), and Neo-Narval at the Télescope Bernard Lyot (TBL). ESPaDOnS and Neo-Narval provide observations in the visible range, while SPIRou enables access to magnetic signatures in the infrared, offering valuable complementary insights for characterizing stellar magnetic fields of low-mass objects.

The acquired data allow us to extract information on the intensity and topology of surface magnetic fields. We use the Zeeman-Doppler Imaging (ZDI) technique to reconstruct magnetic maps of the observed stars and analyze the dependence of their magnetic geometry as a function of stellar parameters (rotation, effective temperature). The goal is to better understand the diversity of magnetic field configurations and their temporal evolution, which is crucial for assessing the impact of stellar activity on exoplanetary environments.
We will present the first results of this campaign, including the detection and analysis of magnetic f ields, as well as the reconstruction of ZDI maps for key targets.

*Speaker

Unveiling PLATO's sensitivity to Earth-like planets

Yoshi Eschen * [1]

[1] University of Warwick – United Kingdom

The ESA PLATO mission will be launched by the end of 2026 with the goal to detect terrestrial planets in habitable zones of bright, Solar-like stars. Our study assesses PLATO's capability to discover transiting planets by computing its detection sensitivities. We analyse how these PLATO detection sensitivities vary across F, G, and K-type stars and evaluate the effectiveness of different observing strategies. Specifically, we compare the impact of longer observations in the Southern hemisphere versus transitioning to the Northern field to determine which approach maximizes PLATO's sensitivity to detect a true Sun-Earth analogue.

In addition to estimating PLATO's sensitivities, we compute these values for other photometric missions, mainly TESS. Comparing the sensitivities between the two missions allows us to highlight the discovery space that was not covered by TESS but will be by PLATO.

As photometric data for the Northern and Southern PLATO field exists from other missions, we make use of this existing photometry which enhances our sensitivity estimates. In the Southern hemisphere we leverage TESS observations, while in the North we integrate data from both TESS and Kepler. Although PLATO has a higher precision than TESS, when including this archival data, especially from the continuous viewing zone where more than 3 years of TESS data are available, PLATO's detection sensitivities are enhanced.

Our results provide insights into PLATO's planet discovery potential and the observing strategy that will have the highest sensitivity to Earth-like planets in the habitable zone of their Sun-like stars.

*Speaker

Characterisation of the Earth-sized, temperate planet Gliese 12 b

Yoshi Eschen * [1], Daisy Turner [2], Annelies Mortier [2]

[1] University of Warwick – United Kingdom
[2] University of Birmingham – United Kingdom

Gliese 12 is a nearby (12 pc) metal-poor M dwarf that is orbited by the transiting planet Gliese 12 b. This planet is orbiting its star at a period of _˜12.76 days placing it just outside its stars habitable zone and giving it an equilibrium temperature of 315 K. Excitingly, using TESS and CHEOPS data it was found that Gliese 12 b has an Earth-size radius (with 6% precision). To characterise this target further, we obtained radial velocity (RV) observations, including 35 ESPRESSO, 87 HARPS-N and 93 CARMENES data points. Analysing these RVs with a multitude of techniques, including a multi-dimensional GP using several activity indicators, we derived a precise mass detection of _˜1 Earth mass. This establishes Gliese 12 b in a unique position of being the only temperate planet of Earth-size and -mass around a nearby star of which we have an accurate RV mass measurement. Our results pave the way for future atmospheric follow-up observations to probe the habitability of our Earth-like neighbour.

*Speaker

Detection of exoplanets in transit light curves with Conditional Flow Matching and XGBoost

Stefano Fiscale * [1,2], Alessio Ferone [3], Angelo Ciaramella [3], Laura Inno [3,2], Massimiliano Giordano Orsini [1], Giovanni Covone [2,4,5], Alessandra Rotundi [1,3]

[1] UNESCO Chair ”Environment, Resources and Sustainable Development”, Department of Science and Technology, Parthenope University of Naples – Italy
[2] INAF - Osservatorio Astronomico di Capodimonte – Italy
[3] University of Naples â€œParthenopeâ€, CDN, IC4, I-80143 Naples, Italy – Italy
[4] Dipartimento di Fisica ”Ettore Pancini” – Italy
[5] Istituto Nazionale di Fisica Nucleare, Sezione di Napoli – Italy

NASA's space-based telescopes Kepler and the Transiting Exoplanet Survey Satellite (TESS) have detected vast amounts of transiting signals, typically classified using Convolutional Neural Networks (CNNs). In this talk, we present a hybrid approach to distinguish planetary transits from astrophysical false positives and instrumental artifacts, with a model trained to classify the features extracted from the transiting signals in a two-dimensional space, where they can be easily separated according to their class. Specifically, our model integrates three main components: (i) feature extraction performed with the CNN VGG19, (ii) dimensionality reduction using t-Distributed Stochastic Neighbor Embedding, and (iii) classification through a zero-shot classifier diffusion model based on Conditional Flow Matching with XGBoost.

During model assessment, we evaluated its performance on both Kepler and TESS datasets, with a particular focus on the Kepler Q1–Q17 Data Release 25 for the classification of long-period planetary signals. Our results demonstrate the robust capabilities of the model in correctly classifying long-period planets, achieving average F1-scores of 99%.

These promising results indicate that our model is well-suited for application to the long-period transit signals expected from ESA's PLATO mission. Moreover, since the model processes phase-folded and binned light curves as input, it can be easily adapted to PLATO data without requiring any architectural modifications, which are highly time-consuming and often associated with a loss in predictive performance. Architectural details and experimental results will be discussed in detail during the presentation.

*Speaker

Lessons learned from the HIP 41378's system: Preparing for Long-Period Planet Characterisation with PLATO

Salomé Grouffal * [1], Alexandre Santerne [2], Stéphane Udry [3]

[1] Laboratoire d'Astrophysique de Marseille – Aix Marseille Université, Institut National des Sciences de l'Univers, Centre National d'études Spatiales [Toulouse], Centre National de la Recherche Scientifique – France

[2] Laboratoire d'Astrophysique de Marseille (LAM) – INSU, CNRS : UMR7326, Aix Marseille Université – PÃ´le de l'étoile Site de Chateau-Gombert 38, rue Frédéric Joliot-Curie 13388 Marseille cedex 13, France

[3] Observatoire de Genève, Université de Genève, Chemin Pegasi 51, 1290 Versoix, Switzerland

The discovery and characterisation of long-period exoplanets will be one of the major breakthroughs of the PLATO mission. For planets with orbital periods of several hundred days, PLATO will detect multiple transits, enabling precise measurements of radii and periods. However, follow-up of such planets presents challenges, whether through radial velocity (RV) measurements to determine mass or more detailed analyses such as stellar spin-orbit alignment and ground-based atmospheric characterisation.

Drawing on a decade of observations of the bright F-type star HIP 41378, a system hosting five transiting planets with periods up to 1.5 years, I will share insights directly relevant to upcoming PLATO discoveries. I will first present the latest results on HIP 41378, including the outcome of a seven-year RV campaign with HIRES, HARPS, HARPS-N, and ESPRESSO. This monitoring has allowed us to determine the masses of the five transiting planets and uncover two additional ones with periods of 61 and 1200 days. I will also present the Rossiter–McLaughlin measurement of HIP 41378 f (P = 542 days), the longest-period planet for which an obliquity has been measured, thanks to a global effort involving nine high-precision RV instruments observing in a single night.

Finally, I will look ahead to 2028–2029, when PLATO begins delivering detections of long-period (> 100 days) planets. Building on our experience with HIP 41378, I will discuss strategies for their follow-up, particularly the challenge of RV confirmation for _˜1yr-period planets, where Earth's motion complicates observations. We will explore how a star's sky position enables or limits global campaigns. We will also examine added complexity from transit timing variations in multi-planet systems, which will be crucial for future atmospheric characterisation from both space- and ground-based observatories.

*Speaker

SINGLETRANS – A Dedicated Pipeline for the Detection of Single Transits in Stellar Light Curves

Sascha Grziwa * [1], Hendrik Schmerling [1], Martin Pätzold [1]

[1] Rheinisches Institut für Umweltforschung, Abteilung Planetenforschung, an der Universität zu KÃ¶ln (RIU-PF) – Germany

Most known exoplanets have been discovered in high-precision light curves from space missions such as CoRoT, Kepler, K2, and TESS using automated detection pipelines. These rely heavily on the periodicity of transit events, employing algorithms like Box Least Squares (BLS) or frequency-based methods (e.g., Fourier analysis). Typically, at least three transits are needed for detection, meaning light curves must cover more than twice the orbital period. Consequently, single transits (mono-transits) often remain undetected by standard pipelines.

While large or deep single transits-such as those from Hot-Jupiters may be found visually or within multi-planet systems, shallower events from smaller planets (e.g., Neptune- or Super-Earth-sized) are likely still hidden in archival data. In particular, the shorter observing baselines of K2 and TESS make them rich in undetected single transit(nos with orbital periods up to _˜100 days.

We have developed SINGLETRANS, a wavelet-based detection pipeline designed specifically to identify such mono-transit events. Developed within the framework of the DFG financed SPP1992 program, SINGLETRANS can now be applied to archival data from CoRoT, Kepler, K2, and TESS. It focuses on discovering single transits of small-radius planets that would otherwise be missed.

SINGLETRANS extends the exoplanet candidate population toward longer-period planets and supports their confirmation via follow-up (e.g., ground based radial velocity or using dedicated space telescopes like CHEOPS). Early detection of single transits in future missions such as PLATO can help prioritize targets and forecast subsequent transits. The algorithm also demonstrates sensitivity to periodic and quasi-periodic transits, including systems with strong transit timing variations or circumbinary planets.

*Speaker

The importance of moist convection inhibition for planets in the habitable zone

Tristan Guillot * [1], Steve Markham [2]

[1] Laboratoire Lagrange – Université de Nice-Sophia Antipolis, Observatoire de la Cote d'Azur (OCA) – France
[2] New Mexico State University – United States

Planets in the habitable zone are difficult to find, especially when looking for transiting planets orbiting Sun-like stars. They may also be difficult to characterize and to model, owing to the condensation of water in their atmosphere. From everyday's experience we know that in the Earth atmosphere water condensation leads to the formation of clouds and sometimes storms, caused by the release of latent heat that accompanies it. For an exoplanet, this implies a time-variability that will complicate the interpretation of observations. But in an exoplanet with an a-priori unknown atmospheric composition, this also means that the interior may be hotter than expected. Indeed, if the atmospheric mean molecular weight is below that of water, moist convection may become inhibited: When that occurs, the release of latent heat inhibits rather than favors convection, implying a potentially much warmer interior than otherwise envisioned. We will review moist convection inhibition and its importance for the interpretation of PLATO results.

*Speaker

The WEAVE-TwiLight Survey: Unravelling Bright Exoplanet Hosts with a Novel Observing Mode

Thomas Hajnik * [1]

[1] University of Cambridge [UK] – United Kingdom

Stars and planets originate from the same material, linking their compositions. Elements produced by the α-process shape planetary cores and atmospheres, with studies showing that key elemental ratios (e.g. Fe/Si, Mg/Si) in planets reflect those of their host stars. While correlations between stellar abundances and planet occurrence, mass, and orbital properties have been suggested, definitive confirmation remains challenging due to the subtlety of these trends. Large, homogeneous, high-precision spectral datasets are essential to uncover potential relationships.

Bright stars ($V < 11$ mag), such as PLATO's priority-one targets, provide an ideal sample for high-quality stellar and chemical abundance measurements and are expected to yield thousands of new planetary discoveries in the coming years. However, modern fibre-fed multi-object spectroscopic (MOS) surveys often exclude these stars due to their low on-sky number density, leading to inefficiencies in traditional observing strategies.

The WEAVE-TwiLight Survey (WTLS) solves this problem by employing a groundbreaking observing mode that combines multiple fields into a single fibre configuration, allowing pointing offsets without reconfiguring the field. This is achieved by superimposing individual fields with respect to a central guide star. This allows up to three fields to be observed with the same fibre configuration. The technical implementation of the new mode has now been completed, and first tests have been successfully performed.

With an input catalogue derived primarily from the northern PLATO long-duration-phase field, WTLS will act as a pilot for the new mode, resulting in a highly homogeneous spectral dataset characterizing approximately 6,000 future PLATO targets, including 68 confirmed planet hosts. In addition, the new mode shows great potential for efficiently observing low number density configurations, allowing quick false positive detection by identifying spectroscopic binaries in the northern PLATO field.

*Speaker

Reaching mass measurements of Earth-like planets

Nathan Hara * [1], Michael Cretignier *

2

[1] Laboratoire d'astrophysique de Marseille – Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France – France
[2] University of Oxford – United Kingdom

One of the key objectives of the PLATO mission is to measure the mass of transiting Earth-like planets with a precision of 10%. This necessitates extremely precise radial velocity measurements. The most stable spectrographs have a photon noise low enough, that the required precision could be reached. However, instrument systematics and stellar variability create additional, complex noises, which severely affects the accuracy of mass measurements. To overcome this difficulty, a data challenge was organised, where participants were asked to recover the mass of transiting and non-transiting planets injected in real datasets. In this talk, we present the results of the challenge, and outline a roadmap to reach the required radial velocity precision.

*Speaker

The SOPHIE search for northern extrasolar planets-XIX. A system including a cold sub-Neptune potentially transiting a V = 6.5 star HD88986

Neda Heidari * [1], Isabelle Boisse , Et Al.

[1] Institut d'Astrophysique de Paris (IAP) – Institut National des Sciences de l'Univers, Sorbonne Universitè, Centre National de la Recherche Scientifique – France

Transiting exoplanets with orbital periods longer than 40 days are rare among the 5,000+ planets discovered to date. This scarcity limits our understanding of the demographics, formation, and long-term evolution of such systems. In this talk, we report the detection and characterization of HD 88986b, a potentially transiting sub-Neptune that stands out as one of the longest-period transiting small planets (radius < 4 R$_⊕$)*withaprecisemassmeasurement*(*fractionaluncertainty*< 2
*transiteventsobservedinTESSsectors*21*and*48, *bothconsistentwiththepredictedtransittimederivedfromthera*
0.18 R$⊕$*andamassof*17.2$+/−4.0*M_E, corresponding to an orbital period of 146.05+/- 0.43days.Thehosts*
typesubgiant(*R* = 1.543± *0.065 R$_⊙$*, *V* = 6.47± *0.01 mag, distance = 33.37 ± 0.04 pc), making it one of the most accessible systems for future follow-up. We also report evidence of a massive outer companion in the system. A joint analysis of RVs, Hipparcos, and Gaia astrometry suggests, at 3σ confidence, that the companion's semi-major axis lies between 16.7 and 38.8 au, with a mass range of 68–284 M$_{J}$. The wide orbit of HD 88986b implies it has likely avoided significant atmospheric loss from stellar radiation, preserving its primordial composition. With an equilibrium temperature of 460 ± 8 K, HD 88986b presents an opportunity to study the atmospheres of cold sub-Neptunes. The system's architecture offers valuable insight into planetary formation and evolution. In this talk, we also report on the current status of follow-up efforts.*

*Speaker

Superhabitable Worlds

Rene Heller [*] [1], *Dirk Schulze-Makuch* [2,3,4,5], *Iva Vilovic* [6], *Jayesh Goyal* [7]

[1] *Max Planck Institute for Solar System Research – Germany*
[2] *Astrobiology Research Group, Zentrum fÃ¼r Astronomie und Astrophysik, Technische UniversitÃ¤t Berlin – Germany*
[3] *GFZ German Research Center for Geosciences, Section Geomicrobiology – Germany*
[4] *Department of Experimental Limnology, Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) – Germany*
[5] *School of the Environment, Washington State University – United States*
[6] *Leibniz Institute for Astrophysics Potsdam (AIP) – Germany*
[7] *School of Earth Planetary Sciences (SEPS), National Institute of Science Education Research (NISER) – India*

There is no reason to believe that Earth-like planets around Sun-like stars are the most promising targets in our search for life beyond the solar system. Although the Earth is inhabited, it might be just an ordinary, or maybe even just a marginally habitable planet from a cosmic perspective. Other, more habitable types of planets or moons ("superhabitable worlds") may very well exist. The Earth itself went through more habitable geologic eons than the one we live in today. We show that over the past 540 million years, variations of some of the Earth's environmental parameters such as oxygen, average surface temperatures, and carbon dioxide are correlated with biomass and biodiversity. Today, the Earth is dangerously close to the inner edge of the solar habitable zone. From an astrophysical perspective, we suggest that water-rich planets slightly larger than the Earth and between the center and the inner edge of the habitable zone around evolved K dwarf stars may be the optimal targets for both the probability of life and its potential observability, e.g. using transit spectroscopy. PLATO will observe several thousand K dwarf stars (mostly in the P5, some in the P4 sample) and potentially discover some of these superhabitable worlds.

*Speaker

Reliable detection of small long-period planets in Kepler data

Oryna Ivashtenko * [1], *Barak Zackay* [1]

[1] *Weizmann Institute of Science [Rehovot, IsraÃl] – Israel*

Kepler spacecraft provided unprecedented photometric precision sufficient to detect Earth-like planets. However, the final Kepler catalog suffers from insufficient reliability for small long-period planets. In our work, we address one of the main reasons for this issue: the inability to distinguish faint signals from systematic false alarms. These false alarms originate from the correlated and non-gaussian noise, which requires special treatment to allow for the detection of low signal-to-noise planets.

We developed an independent search and vetting pipeline aimed at the reliable detection of small long-period planets. Our pipeline implements precise statistical methods similar to the ones used in gravitational wave searches. It takes into account the correlations and the non-gaussianity of the noise and provides a clean background distribution free from the false alarm tail. In addition, it incorporates prior probability in the detection score, which helps to control for the look-elsewhere effect in different regions of the parameter space.

The pipeline was applied to the entirety of Kepler data and resulted in a list of planetary candidates. After the detection, we performed empirical per-target background estimation using data scrambling techniques. We also ran a per-target injection-recovery campaign to estimate the expected statistical score distribution for a real planetary population. Using these two estimates, we calculated every candidate's probability of corresponding to a real planet as opposed to originating from the noise background.

The time-series analysis techniques developed in this work are general and can be applied in PLATO data processing to achieve better reliability for small, long orbital period planets. In my talk, I will present the methods of our pipeline and describe its performance. I will discuss their range of applicability and potential usage in PLATO data analysis.

*Speaker

Effect of stellar spots on the high-resolution transmission spectra of an Earth-like planet in the habitable zone of a Sun-like star

Peralta Jennifer * [1]

[1] *Instituto de Astrofísica e Ciências do Espaço – Portugal*

New-generation telescopes and missions aim to further enhance our understanding of exoplanets, offering hope in the search for habitable rocky planets. A key objective of these efforts is the detection and characterization of terrestrial exoplanets in the habitable zones (HZs) of Sun-like stars. Transmission spectroscopy is a powerful tool to probe the atmospheres of these planets, yet stellar activity remains a major challenge. Variations in the host star, such as those induced by spots and faculae, introduce surface variability that can mimic or obscure atmospheric signals, complicating the interpretation of transmission spectra. While this issue has been extensively explored in low-resolution studies, its impact on high-resolution transmission spectroscopy remains less understood. Understanding and mitigating this stellar contamination is crucial for the success of future missions and instruments dedicated to detecting and studying Earth-like planets in HZs.

In this work, we investigate the impact of non-occulted stellar spots on high-resolution transmission spectra for an Earth-like planet in the HZ of a Sun-like star, focusing on the Na D1 line. By using the newly developed 4th version of the Spot Oscillation and Planet (SOAP) code, we studied the behavior of stellar noise by simulating a range of stellar surface configurations and rotational velocities. We show that spot-induced signals can significantly alter absorption depths and introduce asymmetries, with the amplitude and shape of these features strongly dependent on spot coverage, position, and stellar rotation. These findings provide insights into mitigating stellar contamination in future observations with instruments such as ANDES at the ELT, supporting the goals of PLATO in refining our understanding of habitable worlds.

*Speaker

PLATOSpec, support for the PLATO mission

Petr Kabath * [1], *Marek Skarka* [2], *Artie Hatzes* [3], *Eike Guenther* [4], *Leonardo Vanzi* [5], *Jan Janik* [6], *Rafael Brahm* [7], *Paevl Pintr* [8]

[1] *Astronomical Institute of Czech Academy of Sciences – Czech Republic*
[2] *Astronomical Institute of the Czech Academy of Sciences – Czech Republic*
[3] *ThÃ¼ringer Landessternwarte Tautenburg (TLS) – Sternwarte 5, 07778 Tautenburg, Germany*
[4] *Thuringer Landessternwarte Tautenburg (TLS) – Germany*
[5] *Pontifica Universidad Catolica de Chile – Chile*
[6] *Masaryk Uiversity – Czech Republic*
[7] *Universidad Adolfo IbÃ¡Ã±ez – Chile*
[8] *Institute of Plasma Physics, Czech Academy of Sciences – Czech Republic*

PLATOSpec is a new spectrograph successfully installed and commissioned at La Silla in December 2024. The instrument is operated by an international consortium led by the Astronomical Institute of the Czech Academy of Sciences and contributed by Pontifica Universidad Catolica (Chile), Thueringer Landessternwarte Tautenburg (Germany), Universidad Adolfo Ibanez (Chile), Masaryk University (CZ) and the TOTPEC center (CZ).

The PLATOSpec instrument is offering a spectralresolving power of 79,000 and an observable wavelength range from 380-700 nm. The precision in radial velocities is about 3 m/s. The instrument is used mainly for exoplanetary science but also for stellar physics. We present an update on the PLATOspec project status. Furthermore, first results from the six months of science verification and possible future applications are also presented.

*Speaker

Habitable Worlds in our Galaxy

Ravi Kumar Kopparapu * [1]

[1] *NASA – United States*

As the European Space Agency's PLATO mission approaches its anticipated 2026 launch, the scientific community stands on the cusp of a transformative era in exoplanet research. PLATO's capability to detect and precisely characterize terrestrial planets within the habitable zones (HZs) of solar-like stars offers an unprecedented opportunity to evaluate planetary habitability on a large scale.
This presentation will discuss approaches required to assess a planet's habitability, emphasizing the integration of observational data and theoretical models. We will revisit the concept of the habitable zone (HZ), its utility in identifying potential habitable worlds, the occurrence of such planets, and follow-up observations required to assess the habitability, and inhabitance of a living planet.

By synthesizing PLATO's high-precision photometric data with ground-based spectroscopic observations and advanced modeling techniques, we aim to enhance our understanding of the conditions that make planets habitable. This comprehensive approach will not only aid in identifying promising exoplanet candidates but also in understanding the broader processes that govern planetary habitability.

*Speaker

Atmospheric evolution of low-mass planets: the role of the host star

Daria Kubyshkina * [1]

[1] *Universität Bern = University of Bern = Université de Berne – Switzerland*

Numerous observations of exoplanets over the past decade revealed a wide spread in density among low-mass exoplanets. This spread can be attributed to the diversity of planets' composition, and, in particular, their atmospheres. The size and type of planetary atmospheres in mature systems depend on many factors, such as the formation path, planetary size and orbit, its primordial composition, and amount of high-energy radiation received through the planet's lifetime. The evolution of the atmosphere is tightly bound with the evolutionary path of a planet's host star, which, in turn, can vary greatly depending on stellar type and initial rotation rate.
In my talk, I will briefly review the various mechanisms of volatile loss from planetary atmospheres and discuss their implications for planetary evolution. Using our evolutionary models as an example, I will demonstrate the role of the host star and discuss the criteria a planet should meet to form an atmosphere of a specific type.

*Speaker

Using the Sun to assess PLATO follow up prospects

Ben Lakeland * [1], *Annelies Mortier* [1], *Tim Naylor* [2], *Nadège Meunier* [3], *Raphaëlle Haywood* [2], *Federica Rescigno* [1]

[1] *University of Birmingham – United Kingdom*
[2] *University of Exeter – United Kingdom*
[3] *IPAG – Université Grenoble Alpes – France*

PLATO is expected to detect tens of Earth-sized transiting exoplanets orbiting in the Habitable Zone of solar-type stars. In order to robustly validate and characterise these "Earth-twins", ground-based radial-velocity (RV) follow-up campaigns are vital. Next-generation RV spectrographs will have the instrumental precision and stability to detect the tens-of-cm/s signal of an Earth-twin, yet overcoming the intrinsic RV variability of the host star currently makes the detection of such planets impossible. A wide range of techniques to mitigate the impact of stellar variability has been developed. The majority of these focus solely on the effect of isolated magnetically active regions on the stellar surface such as spots or plages. I used Sun-as-a-star observations from SDO and HARPS-N to isolate and characterise the RV variability emerging from outside these regions on the Sun. The results show that the underlying magnetically inactive solar surface shows a consistent level of variability throughout the magnetic cycle. This level often far exceeds the variability emerging from magnetically active regions and is an order of magnitude larger than the expected RV signals of an Earth-twin. In this talk I will present this work and how I identify granulation and supergranulation as the dominant driver of this RV variability. These results underscore the importance of understanding and mitigating all forms of stellar variability in order to enable the validation and characterisation of the true Earth analogs that PLATO will find.

*Speaker

Exocomets. Challenge in detection of exocomets as monotransits.

Alain Lecavelier Des Etangs * [1]

[1] *Institut d'Astrophysique de Paris (IAP) – Université Paris VI - Pierre et Marie Curie, INSU, CNRS : UMR7095 – 98bis, bd Arago - 75014 Paris France, France*

Transiting extrasolar comets have been observed for 40 years. The gas component of the evaporating comets has been first revealed using spectroscopy. Recently, the photometric accuracy of Kepler and TESS allowed to detect the dust tails of the transiting exocomets, with transit light curves looking very similar to what was predicted 25 years ago.
Using TESS photometry, we discovered 30 exocomets transiting Beta Pictoris and derived the comets nuclei sizes. The observed size distribution is strikingly similar to the one of the comets and asteroids in the Solar system, showing the importance of collisions and fragmentations in the late stages of the planetary formation.
More recently, we made an automated search for exocometary transits in the Kepler and TESS data. This led to the discovery of a few dozen of new exocometary systems. In light of these results, it can be anticipated that PLATO will provide a deep view into the content of planetary systems, including minor bodies like exocomets.

*Speaker

The Geneva Resonant State Workshop TTV challenge : results on the accuracy of TTV characterisation

Adrien Leleu * [1], *Rosemary Mardling* [2], *Judith Korth* , *Jose Almenara Villa* , *Antoine Petit* [3], *StÃ©phane Udry*

[1] *Université de Genève – Switzerland*
[2] *Monash university – Australia*
[3] *Joseph Louis LAGRANGE – Université Nice Sophia Antipolis (1965 - 2019), Institut National des Sciences de l'Univers, Observatoire de la Cote d'Azur, Université Côte d'Azur, Centre National de la Recherche Scientifique – France*

Transit timing variations (TTVs) were shown to be a very effective way of measuring the masses and eccentricities of exoplanets, reaching precision of a few percent for the mass of Earth-sized planets in the case of the Trappist-1 system, and often reaching better than 10% precision in systems of super-Earth and sub-Neptunes, for orbital periods up to tens of days. They were also used to estimate the mass of planets up to _˜100 days in the Kepler mission. However, in some orbital configurations, TTVs can be subject to degeneracies (for example mass-eccentricity degeneracy) and model dependency (for example the effect of non-transiting planets), which can both bias our estimate of the masses of exoplanets. The current challenge is therefore to identify the configurations that could be subject to these biases, and to establish tests to either ensure the accuracy of our mass estimates, or identify the need for additional observations (transits or RVs). To tackle this issue we organised a data challenge, with systems injected both in transit timings for a TTV analysis and in raw lightcurve for photo-dynamical analysis, with a 4 year observational baseline. The injected configurations had systems of two planets or more in the Earth to mini-Neptune range, with orbital periods up to a few hundred days. I will present how the data was generated, and how the results of the participants compare with the injected orbital elements and masses. I will also discuss the existing tests to ensure the accuracy of TTV characterisation. These results will notalby help the MAPS working group to establish criteria for the robustness of TTV mass determination by PLATO, as well as help to focus the effort of the ground based follow-up.

*Speaker

Probing the Six-Planet Architecture of HIP 41378 through TTVs with CHEOPS and TESS

Pietro Leonardi * [1,2], *Luca Borsato* [3], *Pagliaro Leonardo* [1], *Daria Kubyshkina* [4], *Jo Ann Egger* [5]

[1] *UniversitÃ degli Studi di Padova = University of Padua – Italy*
[2] *UniversitÃ degli Studi di Trento = University of Trento – Italy*
[3] *INAF - Osservatorio Astronomico di Padova – Italy*
[4] *Institut fÃ¼r Weltraumforschung = Space Research institute [Graz] – Austria*
[5] *UniversitÃ¤t Bern = University of Bern = Université de Berne – Switzerland*

In multi-planet systems, gravitational interactions can induce transit timing variations (TTVs), with amplitudes significantly enhanced near mean-motion resonances (MMRs), making them easier to detect. In rare cases where both TTVs and radial velocity (RV) measurements are available, joint analysis can break degeneracies and yield robust planetary and system characterization. Detecting and validating small, long-period planets through these methods remains a major challenge, especially in complex multi-planetary configurations.
In this context, the multi-planet system HIP41378 hosts five transiting planets with periods ranging from 15 to over 540 days, offering a unique opportunity to investigate wide, dynamically complex systems.

We present an intensive space-based photometric follow-up of HIP41378, combining 15 new CHEOPS observations with eight TESS sectors, as well as data from K2, Spitzer, HST, and HARPS spectra. Using the N-body integrator within TRADES, we dynamically modeled the TTVs and RV signals of the two inner sub-Neptunes. These planets, HIP41378 b (Pb=15.57 days, Rb=2.45 R⊕) and HIP41378 c (Pc=31.71 days, Rc=2.57 R⊕), are nearly (_˜1.8%) in a 2:1 period commensurability. We report a clear detection of anti-correlated TTVs with amplitudes of 20 minutes for planet b and greater than 3 hours for planet c.

Our precise determination of the masses, eccentricities, and radii of these planets enabled us to constrain their volatile-rich compositions and reconstruct the evolutionary histories of their primordial atmospheres.

We dynamically confirm the planetary nature of HIP 41378 g, a non-transiting planet with a period of _˜64 days and a mass of _˜8 M⊕, located near a 2:1 commensurability with planet c. Finally, we provide new insights into the three outer planets (P> 300 days), constraining the period of HIP41378 d and identifying several aliases for HIP41378 e. Our analysis suggests that the system could be placed in a double resonant chain, highlighting its complex dynamical architecture.

*Speaker

Planet Occurrence Rates Around M Dwarfs: the HARPS sample analysis and a Path Toward Habitable Zone Refinement

Lucile Mignon * [1], *Guillaume Chaverot* [2], *NadÃ¨ge Meunier* [2], *Xavier Delfosse* [2]

[1] *Institut de PlanÃ©tologie et d' Astrophysique de Grenoble – Centre National de la Recherche Scientifique – France*

[2] *Institut de Planétologie et d'Astrophysique de Grenoble – observatoire des sciences de l'univers de Grenoble, Université Grenoble Alpes – France*

After more than 20 years of operation, HARPS remains one of the most precise, stable, and consequently prolific planet-searcher spectrographs. While not originally optimized for M dwarfs due to their faintness in the optical, HARPS has collected high-quality radial velocity (RV) data on more than 200 of these low-mass stars. In this talk, we will present the results of a systematic and homogeneous analysis of this unique dataset, including velocity extraction using a template-matching method optimized for M dwarfs and the computation of detection limits across all targets.

Our findings reaffirm the high occurrence rate of low-mass planets around M dwarfs-more than one planet per star-echoing results from transit surveys such as Kepler and TESS. We also report a 40% occurrence rate of terrestrial planets within the Habitable Zone (HZ), adopting the commonly used conservative definition from Kopparapu et al. (2013, 2014, and aligning with already published rates. To contextualize our results, we will provide a comparative overview of occurrence rates derived from both RV and transit surveys across spectral types F to M, with a particular emphasis placed on the occurrence of Earth-like planets within HZs.

Finally, we will share preliminary insights into how varying the definition of the Habitable Zone influences occurrence statistics. This question is especially timely in the context of the upcoming PLATO mission and its reliance on ground-based RV follow-up: could refining our definition of the HZ enhance our ability to detect true Earth analogs?

*Speaker

Mauve: a three-year UV-Vis survey dedicated to monitor stellar activity and variability

Fatemeh Zahra Majidi * [1]

[1] *Blue Skies Space – United Kingdom*

Mauve is a satellite equipped with a 13-cm telescope and a UV-Visible spectrometer (with an operative wavelength range of 200-700 nm) conceived to measure the stellar magnetic activity and
variability. The science program will be delivered via a multi-year collaborative survey program, with thousands of hours each year available for long baseline observations of hundreds of stars, unlocking a significant time domain astronomy opportunity. Mauve's mission lifetime is 3 years with the ambition of 5 years, and will cover a broad field of regard (–46.4 to 31.8 degrees in ICRS)
during this period. Booked to launch in October 2025, Mauve's science team will form prior to the
launch date, defining the observation strategy and targets.
This facility was conceived to support pilot studies and new ideas in science and is fully dedicated to time-domain astronomy. The main surveys to be executed by Mauve are long baseline observations of Flare Stars (eruptive Wolf–Rayet stars, UV Ceti stars, etc.), RS CVn variables, Eclipsing Binaries, Herbig Ae/Be stars, Exoplanet hosts, Hot Stars, etc. Besides these major science
themes, the spectrometer's data can be utilized to support and complement existing and upcoming facilities as a pathfinder, or conduct simultaneous/follow-up observations.

*Speaker

Search for Earth Analogues: Characterising Exoplanets Amid Stellar Variability

Luca Malavolta * [1]

[1] *Dipartimento di Fisica e Astronomia, UniversitÃ di Padova (DFA - UniPD) – Vicolo dell'Osservatorio 3 35121 - Padova (PD), Italy*

The ambitious objective of the PLATO mission to accurately determine the masses and radii of Earth-like planets located in the Habitable Zone of Solar-type stars, or Earth analogues, faces a significant challenge from the signals produced by the host stars. Stellar variability, including phenomena such as spots, faculae, (super-)granulation, and magnetic cycles, can distort or even overwhelm photometric and spectroscopic signatures of Earth analogues. In this talk, I will review the efforts made by the scientific community to develop data-driven models aimed at mitigating the effects of stellar variability, the advancement of new instruments to observe the Sun as a star and establish it as a benchmark.
Related to these topics, I will also present initiatives with the goal of enhancing collaboration within the PLATO Mission Consortium and maximize mission scientific return.

*Speaker

Using TTVs to measure the masses of low-mass planets in the habitable zone of Sun-like stars with only a handful of consecutive transits.

Rosemary Mardling * [1]

[1] *Monash university – Australia*

*While radial velocity amplitudes decrease with orbital period making planet masses increasingly difficult to measure, TTV amplitudes *increase* in proportion to the orbital periods of interacting planets, so that the signal of a pair at 1 year is around 40 times that of a pair at 10 days. On the other hand the resonant part of the TTV signal of near-commensurate systems is sometimes hundreds of orbital periods long, making its detection impractical for long-period systems. In contrast, the period of the so-called "chopping" part of the signal, which results from the cycle of near-conjunctions of such systems, is much shorter at P_chop=n(n+1)P_b for a system close to a (n+1):n commensurability. Moreover its amplitude only depends on the mass of the perturbing planet and not on the eccentricities when the latter are small, thereby avoiding the mass-eccentricity degeneracy inherent in the TTV inverse problem. Thus while the amplitude of this effect is generally much smaller than the standard resonant amplitude, its detection becomes feasible for long-period pairs, and is optimal when one takes 3 or 4 transits at a time (especially if the observing window covers the jump in signal near conjunction). I will discuss the potential of this method for measuring the masses of small planets in the habitable zone of Sun-like stars given the PLATO observing baseline.*

*Speaker

Atmospheric Evolution and Potential Habitability of Sub-Neptunes: A Comparative Study in the PLATO Era

Ylenia Mascolo [*] [1], *Tiziano Zingalès* [1], *Antonio Maggio* [2], *Danai Polychroni* [3], *Daniele Locci* [2], *Diego Turrini* [3]

[1] *Università degli Studi di Padova = University of Padua – Italy*
[2] *INAF - Osservatorio Astronomico di Palermo – Italy*
[3] *INAF - Osservatorio Astrofisico di Torino – Italy*

The identification of planets that might have habitable conditions is one of the main objectives of exoplanet science. While rocky planets are primary candidates, sub-Neptunes may also host conditions favourable for life, depending on their atmospheric composition and evolution. In this work, we analyze the atmospheres of four sub-Neptune exoplanets: K2-18b and GJ-1214b, orbiting young (< 3 Gyr) M-type stars, and TOI-836c and GJ-9827d, orbiting older (_˜ 5 Gyr) K-type stars. By comparing the atmospheric characteristics of these planets, we aim to identify common evolutionary pathways for sub-Neptunes and evaluate how chemical processes, stellar age and type, drive their atmospheres toward potentially habitable conditions.
We use transmission spectra from JWST observations, applying the TauREx retrieval framework to explore equilibrium chemistry and free chemistry, temperature-pressure profiles, and cloud coverage. To determine whether these planets have evolved secondary compositions or primordial hydrogen-rich atmospheres, a prerequisite for habitability prospects, a major focus is detecting chemical species like H2O, CH4, CO2, CO, NH3, and HCN.
This study directly aligns with the goals of the PLATO mission, which will provide precise constraints on planetary ages, radii, and host star properties, allowing a better interpretation of atmospheric evolution. The long-term observations of PLATO will also help identify promising targets for atmospheric follow-up, expanding the sample of sub-Neptunes studied in a comparative framework. Our findings could be applied to understand how the sample of sub-Neptunes evolves under different conditions.

[*]Speaker

Young planetary systems: a pathway from TESS to PLATO

Domenico Nardiello * [1]

[1] *Universita degli Studi di Padova – Italy*

The accurate knowledge of the ages of stars hosting planets is important for understanding the formation and evolution of planetary systems. The age measurements of stars in the Galaxy is challenging, and usually this parameter is affected by large uncertainties. An exception are systems like stellar clusters, associations and co-moving groups: for their almost coeval members whose origin is common, ages can be measured with high accuracy through the use of both theoretical models and empirical ways (e.g. gyrochronology).
Short-period planets orbiting young stars (ages < 1 Gyr) with well-constrained ages are rare, and even rarer are outer planets (orbital period > 100 days) around such stars. This scarcity is due to the difficulties in detecting and characterizing such planets because of the strong stellar activity that masks planetary signals in both photometric and spectroscopic time series.
In this talk, the most important results obtained by our group in the last years by combining TESS and spectroscopic data of young stars will be presented. About 10% of the stars in the LOPS2 field, which will have light curves provided by PLATO, are younger than 1 Gyr. Preliminary studies on the impact of the stellar activity on the detection of small, long-period planets are therefore essential. An overview of what we expect from observing young stars with the upcoming PLATO mission in terms of new detections of small, long period planets will be shown. These results will enhance our understanding of how external exoplanets evolve in the early stages after their formation.

*Speaker

Tackling Supergranulation in Earth-Twin Surveys using the HARPS-N Solar Data

Miss Niamh O'sullivan * [1]

[1] *University of Oxford – United Kingdom*

In recent years supergranulation has emerged as one of the biggest challenges for the detection of Earth-twins in radial velocity (RV) planet searches. Supergranulation introduces RV variations on timescales of 1-2 days with amplitudes of 0.5-1 m/s, considerably larger than the expected 10 cm/s signal from Earth-like planets. I will present new work focused on mitigating the impact of supergranulation using Gaussian Processes in the time domain. I will apply this new method to HARPS-N solar data sets, and show how this method has led to the discovery of a â€˜supergranulation cycle', in phase with the activity cycle of the Sun. I will also discuss observational strategies that can be employed to characterise supergranulation in other stars, a critical step in the search for Earth-twins. Finally, I will show that by modelling the supergranulation signal in this way, we can improve the detection of planets with smaller RV signals, bringing us closer to identifying Earth-like exoplanets.

*Speaker

Unlocking cool transiting planets across the sky: a temperate sub-Neptune discovered using K2, TESS & CHEOPS

Hugh Osborn * [1,2]

[1] *Universität Bern – Switzerland*
[2] *ETH Zurich – Switzerland*

Small temperate planets transiting sunlike stars, be they rocky terrestrials or water-rich sub-Neptunes, are difficult to find. However, compared to the more easily-detectable temperate planets around M-dwarfs, such worlds are important as they are less likely to be sculpted by atmospheric erosion from high-energy radiation, and much more likely to escape tidal locking. While PLATO will detect such long-period transiting planets, it will likely do so for only 5% of the sky, and therefore is limited by transit probability to fainter stars than an equivalent all-sky mission. TESS, which is observing the whole sky, is unfortunately incomplete beyond P=30d and therefore unable to typically detect temperate planets. I will present how TESS photometry, when combined with past and future missions K2 & CHEOPS, can allow access to long-period planets across the sky including those orbiting bright sunlike stars for which characterisable in radial velocities & transmission spectroscopy is possible. Specifically I will present a newly-confirmed sub-Neptune with an expected surface temperature of only 285K. This planet produced transits in K2 & TESS, with targeted CHEOPS photometry confirming an orbit of P=214d and a radius of 3.4Re. It orbits a late-G type star which hosts three additional transiting planets, and which is brighter than the only equivalent FGK host of a temperate sub-Neptune: Kepler-22b.

*Speaker

The PLATO mission stellar science pipeline

Rhita-Maria Ouazzani * [1], *Kevin Belkacem* , *Marie-Jo Goupil* , *Jordan Philidet* , *Christian Renié* , *Olivier Roth*

[1] *Laboratoire d'Instrumentation et de Recherche en Astrophysique – Institut National des Sciences de l'Univers, Observatoire de Paris, Centre National de la Recherche Scientifique, Sorbonne UniversiteÌ, CY Cergy Paris Université – France*

Through the high-precision, long-term photometric monitoring of these stars, combined - for the brightest among them - with their thourough asteroseismic analysis, PLATO will ultimately enable us to determine their radius, mass and age with an unprecedented precision and accuracy. This presentation will give an overview of the Core Program from the stellar science perspective, the output that the community can expect from the stellar analysis pipeline, and its expected performances.

*Speaker

Radial-velocity follow-up of PLATO M-dwarfs with NIRPS

LÃ©na Parc * [1], *François Bouchy* [2], *Rene Doyon* [3], *Nirps Consortium*

[1] *Observatoire Astronomique de l'Université de Genève – Switzerland*
[2] *Université de Genève – Switzerland*
[3] *Université de Montréal – Canada*

M-dwarfs, the most abundant stars in the Galaxy, are key targets for exoplanet searches due to their high planet occurrence rates and favorable properties for transit and radial-velocity detection. Their small radii make them ideal for detecting Earth-sized planets within the habitable zone. However, their relative faintness in the visible spectrum has traditionally limited radial-velocity (RV) follow-up with optical instruments.
The PLATO mission, with its P4 sample of nearby M-dwarfs, will expand the number of known transiting exoplanets around these stars. Since the habitable zones of M-dwarfs lie close to the host star, the orbital periods of potentially habitable planets are relatively short, making them ideal candidates for mass measurements through RV monitoring.

We present NIRPS (Near InfraRed Planet Searcher), a new high-resolution near-infrared spectrograph installed at the ESO 3.6m telescope. NIRPS is specifically designed to overcome the limitations of optical instruments for M-dwarfs by operating in the near-infrared, where these stars emit most of their flux.

We highlight the strategy, performances and first results of NIRPS from the Guaranteed Time Observations (GTO) WP2 program, dedicated to the RV follow-up of TESS transiting M-dwarfs. These results pave the way for an efficient synergy with PLATO, offering a robust framework for the confirmation and characterization of small planets in the habitable zones of nearby cool stars.

*Speaker

Probing, weighing and dating stars with the PLATO mission

Jordan Philidet * [1], *Kevin Belkacem* [1], *Rhita-Maria Ouazzani* [1], *Christian Renié* [1], *Olivier Roth* [1]

[1] *Laboratoire d'Instrumentation et de Recherche en Astrophysique – Institut National des Sciences de l'Univers, Observatoire de Paris, Centre National de la Recherche Scientifique, Sorbonne UniversiteÌ, CY Cergy Paris Université – France*

The primary target (or Core Program) of the PLATO mission consists of a large sample of about 250,000 main-sequence and subgiant stars. Through the high-precision, long-term photometric monitoring of these stars, combined – for the at least 15,000 brightest among them – with their thorough asteroseismic analysis, PLATO will ultimately enable us to determine their radius, mass and age with a precision and accuracy never-before reached, and will also offer us unprecedented insight into the physics of stellar interiors. This presentation will give an overview of the knowledge we hope to gain about stars from PLATO, and how it will benefit the exoplanetary science community as a whole (not only in terms of stellar characterisation, but also as regards our knowledge about stellar activity and magnetism).

*Speaker

The NASA Landolt mission

Peter Plavchan * [1]

[1] *George Mason University [Fairfax] – United States*

The NASA Landolt mission is an astrophysics PIONEERS program small satellite that will provide significant improvement in the accuracy of photometric measurements of absolute stellar fluxes. This will be accomplished with a NIST-calibrated suite of single-mode fiber-fed laser beacons. The satellite will be placed in a near-geosynchronous orbit with a one-year primary mission with launch no earlier than October 2028. After commissioning, Landolt will point to scheduled ground-based observatories including designated ground stations and a guest observer program for calibration observations. Landolt has a level 1 mission requirement to improve the photometric accuracy to $<$ 0.5% at visible and near-infrared wavelengths for $>$ 60 target stars. Such measurements can only be achieved by a space-based orbiting artificial "star", where the emitted physical photon flux is accurately known. Accuracy of absolute flux zero points is now the leading error budget term in the characterization of stars, be they standard stars or exoplanet hosts. Landolt will enable the refinement of dark energy parameters, improve our ability to assess the properties of terrestrial worlds, and advance fundamental constraints on stellar astrophysics and evolution.

*Speaker

PLATO's planets at a glance: interior structure inference using neural networks

Anna Julia Poser * [1], *Philipp Alexander Baumeister* [1], *Nicola Tosi* [2], *Heike Rauer* [1,2]

[1] *Freie Universität Berlin – Germany*
[2] *German Aerospace Center – Germany*

PLATO is expected to deliver a significant catalogue of small to intermediate-sized exoplanets with well-constrained parameters, such as planetary mass, radius, and age (1, 2). Combined with stellar properties, the PLATO dataset will allow fundamental questions to be addressed, such as the internal structures of terrestrial and mini-gas planets, their radius and compositional evolution under their star's irradiation, and the metallicity of gas-rich planets. Characterizing planetary interiors is also key to evaluate their potential habitability and to prioritize targets for atmospheric follow-up observations.
To analyse the large number of expected detections efficiently, rapid interior characterization methods are required. ExoMDN is a machine-learning-based tool for rapid interior inference that is available to the community (3). However, in its current implementation, ExoMDN is limited to treat planets up to _˜25 Earth masses, and does not yet cover the full diversity expected in the PLATO dataset. Our work builds on this foundation by adapting the underlying mixture density network framework and extending it to cover a broader range of planet types expected in the PLATO dataset, including volatile-dominated icy and gas giants.

We are developing a tool for fast inference of planetary interiors based on PLATO observables: mass, radius, equilibrium temperature, and age. This framework aims to provide the first input for more detailed characterizations of PLATO planets, and to support the target selection for atmospheric characterization and future mission planning. We present the conceptual design and current implementation status of this tool, tailored to the diversity of the PLATO planet population.
References: (1) Rauer et al., Exp Astron 59, 26 (2025) (2) Matuszewski et al., A&A 677, A133 (2023) (3) Baumeister and Tosi, A&A 676, A196 (2023)

*Speaker

Cold Ocean Planets: Habitable Extrasolar Worlds Wrapped in Ice

Lynnae Quick * [1]

[1] *NASA Goddard Space Flight Center – United States*

In our quest to find habitable planets we have long searched for other Earths, however, our solar system teaches us that habitable worlds come in a variety of flavors. The icy moons of the giant planets represent locales where geophysical processes stir liquid water, energy, and organics throughout, facilitating habitable environments in their subsurface oceans and in perched water pockets within their icy shells. Cryovolcanism is one such geophysical process that could influence the habitability and evolution of water-rich extrasolar planets. Similar to our solar system's icy moons, the presence of cryovolcanic eruptions on ice-covered, water-rich exoplanets could indicate the presence of internal liquid reservoirs, possibly subsurface oceans. Furthermore, the internal cycling of liquid water and heat during cryovolcanic eruptions may facilitate the formation of habitable niches within them. Total internal heating rates and depths to possible subsurface oceans have been constrained for a subset of planets that were previously characterized as terrestrial planets but that may best described as Cold Ocean Planets. These low-mass exoplanets have equilibrium surface temperatures and/or densities that are consistent with icy surfaces and a substantial water content. While these planets are likely to be covered in ice, estimated internal heating rates from tidal and radiogenic sources are large enough that they may harbor subsurface oceans and exhibit explosive cryovolcanic activity in the form of geyser-like plume eruptions. The identification of water vapor absorption features, especially given the expected time-variability of water vapor output during cryovolcanic eruptions, could serve as indirect evidence of the presence of subsurface oceans on these planets and would be a tale-tell sign of their habitability. In this talk I will discuss prospects for cryovolcanic activity on ice-covered ocean worlds and consider the potentially important role that this process may play in creating habitable conditions on planets throughout the universe.

*Speaker

Unveiling Hidden Planets in PLATO's LOPS2 Field

Vito Saggese * [1,2], *Giovanni Covone* [1]

[1] *University of Naples Federico II = UniversitÃ degli studi di Napoli Federico II – Italy*
[2] *Istituto Nazionale di Fisica Nucleare – Italy*

PLATO (PLAnetary Transits and Oscillations of stars) is an upcoming ESA mission designed to detect and characterize exoplanets, particularly around Sun-like stars, through high-precision photometry. This study focuses on investigating the dynamical properties of multi-planetary systems within the PLATO LOPS2 field, extending previous analyses based on TESS data. Advanced numerical simulations were employed to evaluate PLATO's capability to refine the parameters of known planetary systems and detect additional planets that may not have been identified by TESS. A sample of multi-planetary systems within the LOPS2 field was thoroughly analyzed, mapping the stability regions of their orbits and exploring the potential role of transit timing variations (TTVs) as a means of detecting previously undetected planets, thereby assessing PLATO's sensitivity to TTVs. The simulations considered a wide range of orbital configurations, suggesting that PLATO, with its extended observational baseline and high-precision photometry, could significantly improve the detection of hidden planets and refine the understanding of the dynamical properties of known systems. The results indicate that PLATO, in combination with TESS, will provide complementary insights into planetary systems. This synergy between the two missions is expected to greatly advance the understanding of planetary system architectures and evolution, thereby contributing significantly to the field of exoplanet discovery and characterization.

*Speaker

Long-Period Exoplanet Detection in PLATO Light curves using Machine Learning

Yesenia Helem Salinas * [1]

[1] *Pontificia Universidad Católica de Chile – Chile*

The detection of long-period exoplanets remains a significant challenge in the field of exoplanet science due to the scarcity of observed transits, the increased variability of stellar signals over long timescales, and the sheer volume of photometric data. In this work, we present a machine learning (ML) approach inspired by recent advances in natural language processing (NLP) to process long-duration light curves as sequential data. Our goal is to distinguish planetary transit signals from intrinsic stellar variability, with a specific focus on enabling the detection of long-period transiting planets. As an initial step, we are developing a pretraining strategy based on Transformer architectures, aimed at learning general representations of stellar variability directly from raw light curves. These representations will later be fine-tuned for the task of transit signal detection by dividing the light curves into small segments, without requiring preprocessing steps such as phase folding. We have previously applied Transformer-based models to successfully identify exoplanet candidates in TESS data, including single-transit events in 30-minute cadence light curves, indicative of long-period planet candidates. In this new approach, we extend the analysis to TESS observations spanning more than 27 sectors, which provide longer temporal baselines and thus longer light curve. These longer sequences provide a intermediate step toward our goal: developing a robust detection pipeline for PLATO, where light curves will be even more extended for identifying transits of long-period exoplanets. This ongoing work aims to establish a scalable and generalizable detection pipeline that can be applied to real PLATO data once available.

*Speaker

Hot Jupiter Secrets: What Extreme Exoplanets Teach Us About Alien Climates

Soumya Sengupta * [1]

[1] *Institut de Ciéncies de L'Espai – Spain*

The Jupiter-like exoplanets tidally locked to their host stars are the most studied to date. We have investigated them through three approaches:

> ***Atmospheric Circulation***: *The extreme day-night temperature contrast drives vigorous circulation in Hot Jupiters (HJs), substantially altering dayside emission spectra and T-P profiles through heat redistribution, as quantified for* ***HJ XO-1b***.
>
> ***Radius Inflation***: *Ionized atmospheres generate magnetic fields, producing Ohmic dissipation in radiative/convective zones. Our* ***MESA*** *simulations parameterize this heating with atmospheric flow velocities, explaining observed radius inflation.*
>
> ***Spectral Separation***: *For ultra-hot Jupiters, we generalize* ***Chandrasekhar's diffuse reflection theory*** *to unify emission and scattering, enabling precise separation of planetary spectra from stellar contamination.*

Conclusion: *While Hot Jupiters themselves are uninhabitable, the physical processes we characterize – atmospheric heat redistribution, magnetic field generation, and emission spectroscopy techniques – provide fundamental insights for studying potentially habitable tidally locked planets. Our:*

> *Circulation models inform climate predictions for Earth-like exoplanets in similar tidal configurations*
>
> *Ohmic heating parameterization helps assess magnetic shielding of habitable-zone worlds*
>
> *Spectral separation method is directly applicable to future biosignature detection in exoplanet atmospheres*

*Speaker

A systematic bias in template-based RV extraction algorithms

André M. Silva * [1,2]

[1] *Centro de Astrofisica da Universidade do Porto – Portugal*
[2] *Departamento de Física e Astronomia da Faculdade de Ciências – Portugal*

In RV blind-searches, or in the follow-up of transiting exoplanets, observations are carried out over multiple months. This allows to properly sample the orbital period of the orbiting companions and to characterize any stellar signals. However, certain science cases-such as atmospheric characterization via transmission or emission spectroscopy, or asteroseismology-require high-cadence observations over much shorter timescales, often limited to a single night or a few consecutive nights

In this talk, we reveal a previously unidentified systematic bias in RV extraction when using template-matching (TM) algorithms with stellar models constructed from observations that were collected within a short time-span. The presence of this bias is shown in two template matching pipelines, present in the data of multiple state-of-the-art spectrographs, and it has different amplitudes for different stars. We demonstrate that the effect can be recovered on a larger sample of 19 targets, totaling 4124 ESPRESSO observations spread through 38 nights. In this sample, we consistently find a systematic quasi-linear bias affecting the RV extraction with slopes that vary from -0.3 m/s/h to $∼ $−52m/s/h.Wehypothesizethatcontaminationfrommicrotelluricfeatures, andotherfixed-patternnoisesources, isthelikelyrootcauseofthiseffect, whichcouldhaveimplicationsforhigh−precisionRVstudies, particularlyinshort − timescaleobservingcampaigns.

*Speaker

Exploring Habitable Worlds: Polarization and Spectral Signatures of Terrestrial Exoplanets

Manika Singla * [1]

[1] *Physical Research Laboratory [Ahmedabad] – India*

The next generation of missions, including ***PLATO****,* ***JWST****,* ***Thirty Meter Telescope****,* ***Extremely Large Telescope****, and* ***Habitable Worlds Observatory****, offers unprecedented opportunities to characterize Earth-like exoplanet atmospheres and assess their habitability. In this study, we model* ***polarization phase curves, reflection spectra, and transmission spectra*** *to explore the atmospheric properties of terrestrial exoplanets. Our focus includes present and prebiotic Earth-like exoplanets orbiting F, G, K, and M-type stars, as well as known exoplanets such as* ***Proxima Centauri b, Teegarden's Star b, Trappist -1e, etc****. We consider diverse planetary surfaces (e.g., water worlds, snow-covered surfaces) and atmospheric conditions (e.g., clear skies, cloudy atmospheres, elevated greenhouse gases).*
Using ***3D vector radiative transfer equations****, we compute polarization phase curves with appropriate scattering phase matrices, while* ***1D multiple scattering radiative transfer equations*** *are employed to derive reflection and transmission spectra.* ***Temperature-Pressure (T-P) profiles*** *are generated using hydrostatic equilibrium and energy balance equations. Our results reveal the influence of* ***surface albedo****,* ***cloud cover****,* ***greenhouse gases****, and* ***inclination angle*** *on observational quantities. We identify absorption features of key biomolecules and demonstrate the significant role of diffusely transmitted radiation, particularly in cloudy atmospheres at shorter wavelengths. Clouds, surface albedo and inclination angle are found to be critical factors in polarization due to scattering, providing valuable diagnostic information.*
These findings highlight the potential of synergistic observations of spectra and phase curves to enhance atmospheric characterization. Our models will be instrumental in guiding future observations with ***PLATO*** *and other missions, advancing the search for habitable worlds and improving our understanding of exoplanetary environments.*

*Speaker

PLATO Vetting, Grading, and Ranking algorithms

Sophia Sulis * [1], *Magali Deleuil* *

2

[1] *Laboratoire d'Astrophysique de Marseille – Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France – France*
[2] *Laboratoire d'Astrophysique de Marseille – Aix Marseille Univ, CNRS, LAM, Laboratoire d'Astrophysique de Marseille, Marseille, France – France*

This poster presents the specifications of TransitPipe2, the module of the Exoplanet Analysis System (EAS) dedicated to the Vetting and Grading of transit events detected by the pipeline.The software development itself is carried out by IAC team based on these specifications.
The Vetting process follows a structured sequence: it first focuses on the identification and elimination of instrumental false positives, then addresses astrophysical false positives, such as eclipsing binaries located either on the target star or in the background, and finally conducts a Bayesian analysis to compare different scenarios explaining the transit-like signals, leading to the validation or rejection of each transit-event. At every stage, rigorous statistical methods are applied to evaluate the significance of the diagnostic test. Transit events that successfully pass through this vetting sequence are subsequently graded, with each candidate receiving a score reflecting its probability of planetary origin and a priority ranking for complementary ground-based observations.
A preliminary evaluation of the expected performance of the TransitPipe2 specifications, based on realistic simulated datasets generated with PLATOSim, demonstrates the module's ability to effectively discriminate planetary signals from various sources of false positives.

*Speaker

Ripples beneath the waves: finding Earth-size planets in the presence of stellar variability

Geert Jan Talens * [1], *Luca Malavolta* [2], *Suzanne Aigrain* [1]

[1] *Department of Physics [Oxford] – United Kingdom*
[2] *Dipartimento di Fisica e Astronomia, UniversitÃ di Padova – Italy*

PLATO's main goal is to detect Earth-size planets in the habitable zones of FGK stars. Even with the excellent signal to noise and nominal 2-year baseline PLATO will provide, however, detecting these small planets will be challenging due to the presence of systematics and stellar variability with amplitudes exceeding the expected transit depth. It will be necessary to account for these effects and to use a mature and well-understood combination of detrending and transit search algorithms. To address these issues, we simulated 2000 PLATO lightcurves spanning 2 years. We use stellar parameters from PIC 2.1 to generate lightcurves of a representative sample of PLATO targets and inject Earth-size planets on habitable zone orbits. Obscuring the planetary transits are the effects of variability due to star spots, oscillations and granulation, as well as noise and systematics generated with PSLS. In order to investigate the impact of different lightcurve filters on the detectability of the transit signals in different regimes of parameter space, we applied a variety of detrending methods to the simulated lightcurves, including the biweight, Huber spline and YSD-lowess filters. We then ran a comparison between two different transit search algorithms, namely TLS and a custom search code that accounts for the effect of filtering on the transit shape. I will present the findings of this initial study, which guides the tuning of the PLATO consortium's transit detection pipeline.

*Speaker

Constraining the Habitable Zone of Sun-like Stars with a Carbonate-Silicate Cycle Model

Ben Taysum * [1]

[1] *Deutsches Zentrum für Luft- und Raumfahrt [Berlin] – Germany*

The Carbonate-Silicate Cycle (CSC) on Earth is a crucial natural thermostat for the planet's climate. In the cycle, carbon dioxide (CO2) is captured from the atmosphere by falling rainwater. Reactions with silicates in the planet surface cause ions such as Ca2+ and HCO3 to wash into the oceans where calcium carbonate (CaCO3) forms and precipitates to the seafloor. Over geological timescales tectonic regimes can bury this deposited CaCO3 into the crust. As an effective greenhouse gas, CO2 plays an important role in regulating planetary surface temperatures – an active CSC regime on a rocky world could be capable of expanding the range of the habitable zone of a planetary system. As the proximity to the parent star increases, planet surface temperatures are naturally expected to rise. However, the increasing rainout-rate of CO2 increases the precipitation and burial rates of CaCO3 in the oceans – the partial pressure of CO2 is then expected to fall (assuming a constant outgassing flux), lowering the greenhouse efficiency of the atmosphere and lowering the rate that surface temperatures rise. I have equipped a robust and comprehensive chemistry-climate coupled one dimensional steady-state atmosphere model (1D-TERRA) with the capability of modelling the impacts of an active CSC on an Earth-like planets habitability. I demonstrate the models ability to reproduce global mean ocean parameters for the modern Earth, and how the CSC is capable of regulating planet temperatures making it easier for liquid water oceans to develop at the edges of the habitable zone of Sun-like stars.

*Speaker

Atmospheric carbon depletion as an empirical tracer of a planet's habitability

Amaury Triaud * [1]

[1] *University of Birmingham [Birmingham] – United Kingdom*

So far the concept of habitability, the ability of a planet to retain water in its liquid phase, remains a mostly theoretical construct. While there are many biosignatures to empirically assess the presence of biological activity on an exoplanet, there are no practical "aqua-signatures" to assess the presence of liquid water at the surface of an exoplanet. Obtaining aquasignatures is important in order to prioritise exoplanets to search for biosignatures, but also to test the limits of habitability, the duration of habitable periods on a given planet, and measure what fraction of habitable planets develop biological activity. In this talk, I will propose to define a concept of "aqua-signatures", and propose to actively seek aquasignatures. I will also propose one of them, namely that the fractional amount of carbon in a planet's atmosphere can be used to assess the presence of large bodies of liquid water on an exoplanet and show what type of current observations can be used to make empirical assessments of a planet's atmosphere.

*Speaker

Unveiling transiting temperate giants in multi-planetary systems

SolÃ¨ne Ulmer-Moll * [1]

[1] *Leiden Observatory [Leiden] – Netherlands*

Most detected transiting planets have orbits of a few tens of days, exposing them to intense stellar irradiation and interactions that significantly alter their properties. In contrast, colder planets with longer orbital periods are less affected, offering crucial insights into their formation and migration histories. I report the detection and characterization of two multi-planetary systems hosting a transiting temperate Jupiter with orbital periods larger than 100 days (first discovered as monotransits) and an inner non-transiting planet, thanks to a four-year ground and space-based photometric and radial velocity survey. Combining precise masses, radii, and ages with a state-of-the-art planetary evolution model, I infer the metal enrichment of the newly discovered temperate giants and explore their influence on the mass-metallicity correlation of giant planets.

*Speaker

Setting the Stage for PLATO's Discoveries: Advances in Our Understanding of Space Weather in Habitable Zone Systems

Aline Vidotto * [1]

[1] *Universiteit Leiden [Leiden] – Netherlands*

Understanding the impact of space weather on exoplanet habitability is crucial for assessing their potential to support life. The space weather environment surrounding an exoplanet is shaped by its host-star's outflows, energetic radiation, and magnetism. In this talk, I will present key findings from Star-Planet Interactions and Space Weather research that shed light on how habitable worlds are shaped. I will address two key questions: How does the space weather environment surrounding a habitable-zone exoplanet differ from that of Earth? And, if a planet, at any moment in its life, is affected by a harsh space weather, can its magnetic field offer a positive effect for its habitability? By exploring these topics, we will gain a better understanding on the complex interactions between stars and their planets, ultimately informing our search for life beyond Earth.

*Speaker

Direct imaging of exoplanets in the context of PLATO: from validation of candidates to the direct detection of Earth analogs

Arthur Vigan * [1]

[1] *Laboratoire d'Astrophysique de Marseille (LAM) – INSU, CNRS : UMR7326, Aix Marseille Université – Pole de l'étoile Site de ChÃ¢teau-Gombert 38, rue Frédéric Joliot-Curie 13388 Marseille cedex 13, France*

Direct imaging of exoplanets has gradually advanced over the past two decades, thanks to significant technical improvements in adaptive optics and coronagraphy. These advancements have enabled the detection and characterisation of numerous sub-stellar companions, most of them in young planetary systems. In parallel, the detection of ever smaller transiting planets has progressed as the number of dedicated telescopes and space missions has increased, culminating in the upcoming launch of PLATO. Although direct imaging and transit methods probe largely different regions of parameter space, they have found common ground in the validation of small planet candidates, thanks to the high-contrast imaging capabilities of AO-equipped instruments. The most exciting prospects lie in the future, with the anticipated detection of terrestrial planets in the habitable zone-potential targets for upcoming space-based imaging missions. Even though most of PLATO's targets will not be ideal for imaging due to their distance, the demographic data it provides will inform us about the number of potential discoveries from a large-scale direct imaging mission and will help us define an appropriate target sample.

*Speaker

Revisiting the star-planet composition link: a tale of devolatilization

Reinarz Yared * [1], *Lorena Acuña*

[1] *Max Planck Institute for Astronomy – Germany*

Rocky exoplanets present diverse compositions and internal structures. Previous work has assumed that the composition of planets is similar to that of their host star. But it is debated whether planets have higher iron to silicon ratios. The apparent iron enrichment has been traditionally explained by mantle stripping or collisions. An alternative explanation is devolatilization of the planetary abundance ratios with respect to the host star, where volatile elements like oxygen and sulfur are progressively depleted relative to refractory elements such as iron and magnesium. In this work, we explore whether these elemental molar ratios are consistent with an Earth-like devolatilization trend.
We revisit the estimation of the core mass fraction of 13 rocky exoplanets with masses between 0.5 and 10 Earth masses, focusing on planets where stellar abundances of Fe, Si, Mg, O, and S have already been measured. To conduct this analysis, we use interior structure retrievals with the Marseille Super-Earth Interior model, which allows us to estimate compositional parameters, including the molar ratios of iron, magnesium, silicon, oxygen, and sulfur from mass and radius measurements.

We find that in our sample, 8 planets follow an Earth-like devolatilization trend within a 1 sigma confidence interval. The other 5 planets present lower devolatilization slopes or show no devolatilization at all.
Our work suggests that rocky exoplanets present a variety in trends of refractory elemental ratios, being indicative of a wide diversity in mantle mineralogies and other properties relevant for habitability, such as mantle solubility. A main limiting factor in our ability to constrain the relative refractory compositions between rocky planets and their host star is the small sample of rocky exoplanets whose host stellar abundances are constrained and the lack of variety in their orbital distances. PLATO will expand this sample by detecting earth-like worlds at larger orbital distances.

*Speaker

Author Index