Book of Abstracts

Edited by : Isabella Pagano, Gaetano Scandariato

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Content

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[1] *in alphabetic order according to the surname of the submitting author.*

Invited Talk

The PLATO mission development process and status: from concept to reality

Author/Speaker: Jose Lorenzo Alvarez, European Space Agency, Netherlands,
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Co-authors:

Abstract
NA

My Notes

Session: PLATO mission - Where we are

Invited Talk

The PLATO Science Goals

Author/Speaker: Heike Rauer, DLR, Institut für Planetenforschung, Germany, heike.rauer@dlr.de

Co-authors:

Abstract

NA

My Notes

Session: PLATO mission - Where we are

Invited Talk

The PLATO Input Catalog

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Co-authors:

Abstract
NA

My Notes

Invited Talk

The PLATO Ground Observation Program

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Abstract
NA

My Notes

Contributed Talk

PLATO Mission Performance

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Abstract

PLATO aims at the detection and characterization of terrestrial planets around solar-type stars as well as at the study of their host star properties. The key performance of PLATO is to detect terrestrial planets orbiting in the habitable zone of these stars. This science goal drives the design and the operations of the mission. The PLATO Payload features a complex multi-telescope configuration consisting of 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. Here we will review the drivers for PLATO Performance and present the most recent description of the status of noise budget and verification of main performance requirements (including field of view and pointing performance) at the time right before the mission critical design review.

My Notes

Invited Talk

PLATO data products, releases, and guest observer's programme

Author/Speaker: Ana María Heras, ESA/ESTEC, Netherlands, ana.heras@esa.int

Co-authors:

Abstract

The PLATO mission will make available to the community a broad range of data products for the stars of the PLATO Input Catalogue. The product levels cover from raw data to clean light curves, including intermediate products, and catalogues with the planetary candidates, stellar asteroseismic parameters, and stellar properties. For a set of approximately 20,000 stars, the so-called Prime sample, the PLATO mission will also deliver data products from the ground-based follow-up observations needed for the confirmation and mass characterisation of exoplanet candidates. PLATO data products will be released to the community every three months. The first products associated with the stars of the Prime sample will be accessible 1.5 years after the time of observation. For the remaining more than 100,000 stars, the data products of each three-month observation period will be available six months later. Furthermore, PLATO will address a variety of complementary science topics through a Guest Observer's Programme. In this framework, ESA will invite the community to apply for observing time through Announcements of Opportunity. The first AO is planned to open nine months prior to launch.

My Notes

Contributed Talk

Viewing the PLATO Field Through the Lenses of TESS

Author/Speaker: Yoshi Nike Emilia Eschen, University of Warwick, United Kingdom, yoshi.eschen@warwick.ac.uk

Co-authors: Daniel Bayliss, Thomas G. Wilson

Abstract
PLATO will begin observing stars in the Southern Field (LOPS2) after launch in late 2026. By this time, TESS will have observed the stars in LOPS2 for at least four years. On average each star in the PLATO field has been monitored for 270 days by TESS already. This data gives us insights into the stars that PLATO will observe and we create a catalogue of all the information we can obtain from TESS for the PLATO targets. TESS monitoring of the PLATO targets allows us to differentiate between quiet and active stars and hence find the most promising stars to detect Earth-like planets. We find these quiet stars by calculating the TESS photometric precision for each Target PLATO Input Catalogue (tPIC) star in LOPS2. We also identify known systems in the LOPS2 field, including 55 confirmed transiting planets, ~300 TESS planet candidate systems and ~2000 eclipsing binaries. To highlight the discovery space where PLATO will have the greatest potential for new detections, we compute respective sensitivity maps for TESS and PLATO of the tPIC stars in the field. We summarise all information we can gather from available TESS data for the PLATO targets into a catalogue summarising the photometric noise of the star, known and candidate planetary systems, eclipsing binaries and detection sensitivites. Pre-launch of PLATO, this TESS-based catalogue will already provide insights of the PLATO target stars and aid to select and focus on the most promising targets.

My Notes

Invited Talk

An integrated approach to detecting and characterising exoplanets in the presence of stellar variability with PLATO

Author/Speaker: Suzanne Aigrain, University of Oxford, United Kingdom,
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Abstract

PLATO's top-level science goal is to discover and characterise a sample of small (terrestrial and sub-Netpune size) transiting planets orbiting in the habitable zone of bright stars, and to measure their radii, masses and ages with accuracies of 3, 10% and 10%, respectively. To achieve this goal requires an exquisite understanding of stellar variability signals, from magnetic cycles to spots, faculae, and (super-)granulation: at the level of precision of the PLATO light curves and its.ground based follow up programme, every star is a variable stars. The most promising solutions to the problem involve data-driven models flexible enough to bridge the gaps in our understanding, but robust enough to avoid over fitting. In this invited talk I will review some exciting recent progress in the mitigation of stellar variability in the detection and characterization of transiting exoplanets, illustrating them with current and archival datasets. I will then outline the current status of our plans to address stellar variability within the PLATO consortium and pipelines.

My Notes

Contributed Talk

AutoRegressive Planet Search Methodology for PLATO Planet Discovery

Author/Speaker: Eric Feigelson, Penn State University, United States, e5f@psu.edu

Co-authors:

Abstract
The AutoRegressive Planet Search (ARPS) methodology is a pipeline for the analysis of space-based transiting data. It performs maximum likelihood fitting of low-dimensional ARIMA models to remove stellar and instrumental variations brief transits are largely unaltered. A novel Transit Comb Filter periodogram is applied to ARIMA residuals. Tests with simulations and real data show ARIMA+TCF is more sensitive to small planets than commonly used detrenders with the Box Least Squares periodogram. Several dozen time series features are used to train a decision tree classifier (Random Forests, XGBoost), followed by a multifaceted vetting procedure. ARPS has been applied to Kepler (KARPS) and TESS (DTARPS) data sets. The TESS application can identified dozens of hot Neptunes and Ultra-Short Period candidate planets. ARPS methodology can be an important complement to other pipeline procedures for PLATO planet discovery.

My Notes

Session: From Stars to Planets

Contributed Talk

Panopticon: a Machine Learning model to detect transits in raw PLATO light curves

Author/Speaker: Hugo Vivien, Laboratoire d'Astrophysique de Marseille, France, hugo.vivien@lam.fr

Co-authors:

Abstract

One of the biggest hurdle in the transit field has been the initial detection of planetary signals within light curves. While this difficulty is multifactorial, it mostly comes from the stellar activity of the host and the shallow nature of exoplanet transits. The stellar activity varies over a range of timescales, with effects both shorter and longer than the transits themselves. This makes removing the activity a complex task that might deform, or even erase, the transits. Detecting the transit themselves – provided they survived the filtering process– remains a challenge, usually relying on methods requiring periodicity. In the context of the future PLATO mission (Rauer et al., 2014), set to launch in 2026, we aim to propose a method able to search for transits directly in the raw light curves. As one of PLATO's stated goal is the detection of Earth analogs, whose transits are both shallow and of long period, an efficient detection method is desirable. We propose a novel Machine Learning model, Panopticon, based on modified Unet architectures (Ron- neberger et al., 2015 Zhou et al., 2018 Huang et al., 2020) to work with 1-dimensional data. This approach extracts features over various timescales, and recombines them using the larger ones to provide context for the smaller ones. This is well suited to analyze the nature of signals evolving over a variety of timescales, as is the case for light curves with stellar activity. The model outputs a likelihood map of the transits, without having to rely on a prior on the number of transits in the input signal. To train and evaluate the model, we generate a dataset of more than 15 000 light curves using the PlatoSim code and its Platonium associated suite (Jannsen et al., 2024), the mission's state of the art simulator. It takes into account the stellar activity and the platform noises, and injects them at pixel level. This dataset is built to be representative of a wide range of planetary parameters and host stars, to be able to benchmark the model over many different scenarios. As it stands, we are able to consistently retrieve planets with transit depth greater than $\sim$ 150 ppm, reaching $\sim$ 100% above 200 ppm. The fraction of false positives (False Alarm Rate FAR) associated with these detections is of $\sim$ 1%. By modifying the threshold on the confidence score of the model for detections, the FAR can be brought down to $\sim$ 0.1% while still reliably detect transits above 200 pmm. Finally, we note that the orbital period of the planet has little to no impact on the retrieval rate. The model already yields promising results, being able to consistently identify transits, independently of periodicity, with a small False Alarm Rate. To enhance the capabilities of the model at the shallower depth regime, we are working on a Physics Informed version of the model making use of the available host star information. In the future we also aim to take into account the centroids curves to provide an early classification of the nature of the signal (planetary, binary or background event). Additionally, we are working on versions of the model for the TESS and Kepler missions to assess its performance on real data.

My Notes

Invited Talk

Mapping Occurrence Rates to Planet Formation and Evolution

Author/Speaker: Anne Dattilo, University of California Santa Cruz, United States, adattilo@ucsc.edu

Co-authors:

Abstract

The current catalog of more than 5000 confirmed exoplanets shows a great diversity of planetary systems: they differ greatly in their sizes, separations, masses, and stellar host characteristics. Transit surveys, including Kepler and TESS, unveiled a large population of small planets orbiting within 1 au of their host stars. By correcting for observational and survey biases, we can study the demographics of this population and constrain their formation and evolution mechanisms. Sub-Neptunes prove to be the most common type of planet in the galaxy, but without a solar system equivalent they have few compositional constraints. The demographic features that define this population are the radius valley and radius cliff, separating the sub-Neptunes population from the smaller super-Earths and larger Neptunes. Theoretical models of their atmospheric evolution can exactly reproduce the radius valley, but not the radius cliff. More precise information is needed about planet masses, insolations, and host star properties to explain the intrinsic population of our galaxy. There are many questions left to be answered about planets' compositions and formation and evolution history. The next generation of space telescopes, including Roman and PLATO, will have the capability to answer some of these questions.

My Notes

Contributed Talk

3.5+ years of characterising exoplanetary systems with CHEOPS

Author/Speaker: Monika Lendl, University of Geneva, Switzerland, monika.lendl@unige.ch

Co-authors:

Abstract

Characterizing Exoplanets Satellite (CHEOPS) is the first ESA space mission dedicated to the study of known exoplanets. The satellite, carrying a 30cm photometric telescope, carried out its 3.5-year nominal mission between December 2019 and September 2023 is currently in it's first extended mission. CHEOPS is performing ultra-high precision photometry of exoplanetary systems with a sensitivity allowing to characterise small planets transiting Solar-type stars. CHEOPS is improving density measurements of low-mass planets, detecting and confirming small planets orbiting bright host stars and resolving the architectures of key exoplanet systems, including PLATO-like systems with long-period small planets. CHEOPS also probes planetary atmospheres through measurements of secondary eclipses and phase-curve observations. I will report on highlights of over 4 years worth of CHEOPS science and discuss how the mission is orienting itself in its first extension lasting until December 2026. I will discuss some lessions learnt from CHEOPS that seem relevant for PLATO and will further emphasise the synergies between the two missions, and how these will be driving exoplanet science throughout the 2020ies.

My Notes

Contributed Talk

TOI-837 b as a Benchmark for Future Characterisations with PLATO

Author/Speaker: Oscar Barragán, University of Oxford, United Kingdom,
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Co-authors:

Abstract

We present the detailed characterisation of TOI-837 b, a transiting exoplanet orbiting a 35 +/- 5 Myr star. Utilising an integrative approach combining TESS photometry, ground-based observations, and HARPS spectroscopy, this study presents the precise determination of TOI-837b's radius, mass, and (a relatively high) density. Given the precise age estimate of the system, we can estimate that the planet's density is indicative of a substantial core comprising 60% of the planet's total mass. This composition and density are unexpected for a planet of this age and are in tension with evolutionary models. As TOI-837b emerges as a cornerstone in exoplanet science, this research highlights the critical need for high-precision stellar parameters and age determination to unlock the mysteries of planet formation and evolution. With PLATO on the horizon, TOI-837b exemplifies the profound impact that precise stellar ages can have on exoplanet characterisation.

My Notes

Contributed Talk

Fast semi-analytical N-body interactions in planet formation population synthesis models

Author/Speaker: Antoine Petit, Observatoire de la Cote d'Azur, France, antoine.petit@oca.eu

Co-authors:

Abstract

Fitting planet formation models to exoplanet demographics necessitates to generate hundred of thousands of systems. Yet, modelling every planet formation processes (growth, migration), in a single simulation is still beyond our computational capabilities. The population synthesis approach aims at combining fast semi-analytical recipes modelling the important physical processes at play, to keep an affordable computational cost. The bottleneck of the current state-of-the-art simulations is the N-body interactions between planetary embryos. In this work we propose a framework to replace N-body integrations in population synthesis models by semi-analytical recipes derived from recent breakthroughs in our understanding of planet dynamics. We self-consistently model resonances, instability timescales, planet scattering and collisions. We combine this approach with state-of-the-art planet growth and migration modelling. We statistically reproduce results obtained in N-body simulations, for a fraction of the computational cost. We discuss how this approach allows to use the exoplanet population planetary system formation and architecture.

My Notes

Contributed Talk

PoET: tackling the problem of stellar noise for the PLATO ground-based observation program

Author/Speaker: Nuno Santos, IA/Univ. Porto, Portugal, nuno.santos@astro.up.pt

Co-authors:

Abstract

High resolution spectroscopy will play a key role in the ground based follow-up of PLATO targets. On the one hand, radial velocities will be fundamental for the measurement of planet masses, with ~10 cm/s precision needed to detect Earth analogs. On the other hand, transmission spectroscopy measurements will allow to characterise their atmospheres. These objectives remain, however, severely challenged by astrophysical signals from the host stars (often dubbed as "noise"), whose oscillations, granulation, and magnetic activity distort the observed spectra. In this talk I will quickly review the problem behind "stellar noise" and discuss the most widely used methods to deal with it, as well as their limitations. I will then present PoET (the Paranal Solar Espresso Telescope) and its science case. Expected to start observations in 2025, PoET will connect to the "planet hunter" ESPRESSO spectrograph (ESO-VLT) and provide both disk resolved and disk integrated ("sun-as-a-star") observations of the Sun. This unique dataset will be obtained in the ultra-high resolution mode (R>200 000) and cover the full optical domain (380-780 nm) in one single shot. Using the Sun as a proxy for other solar-type stars, PoET data will allow to map our star and understand in unprecedented detail the contribution of each solar feature to spectral variability that affect the detection and characterisation of exoplanets. In turn, this will inform about the best approaches to tackle this problem. The learned lessons will provide valuable information for the analysis of PLATO follow-up data for other solar-type stars. PoET spectra will further allow to tackle other problems in solar and stellar physics that are of relevance to PLATO, including the detailed stellar characterisation in the presence of stellar activity.

My Notes

Invited Talk

Exoplanet Demographics: Today, and in the PLATO Era

Author/Speaker: Alessandro Sozzetti, Istituto Nazionale di Astrofisica (INAF), Italy, alessandro.sozzetti@inaf.it

Co-authors:

Abstract

The goal of exoplanet demographics is to determine the occurrence rate of planets as a function of as many of the physical parameters that may influence planet formation and evolution as possible, over as broad of a range of these parameters as possible, and to establish the existence of trends and correlations between them, or lack thereof. I will provide an overview of the state-of-the-art of exoplanet demographics across orders of magnitude in orbital separation, mass, and radius, and outline the impact of the PLATO mission in the field during the coming decade.

My Notes

Contributed Talk

Temperate exoplanets: golden targets for linking detection and modeling

Author/Speaker: Solène Ulmer-Moll, Université de Genève, Switzerland, solene.ulmer-moll@unige.ch

Co-authors:

Abstract

Most detected transiting planets have orbits which would fit within that of Mercury. This host star proximity means that the properties of these planets undergo significant changes due to stellar irradiation and interactions. In contrast, temperate planets with longer orbital periods are less affected, offering crucial insights into their formation and migration histories. Characterizing transiting temperate planets is a key missing piece in the exoplanet puzzle. In this talk, I report the detection and characterization of three new transiting temperate Jupiters with orbital periods larger than 100 days, thanks to a three-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. This work is also a stepping stone for PLATO as the follow up of single transit candidates will be key in order to detect transiting Earth analogs.

My Notes

Contributed Talk

Circumbinary planet populations: Status and expectations for PLATO

Author/Speaker: Hans Deeg, Instituto de Astrofísica de Canarias, Spain, hdeeg@iac.es

Co-authors:

Abstract

The current sample of Circumbinary Planets (CBPs) remains very small, comprising only 14 well-characterised planets discovered through transits by Kepler and the TESS mission, along with a few more found using alternative methods. Additionally, there is ongoing debate regarding CBP detections from timing variations in eclipses of post common envelope binaries (PCEBs). CBPs discovered through transits exhibit common features, notably orbits close to the inner stability limit and the absence of very short-period central binaries as CBP hosts. While some features of this sample align with formation models, others, such as the period-range of the central binaries or the coplanarity between binary and planet orbits, may be an outcome of the small sample-size of known CBPs. Our current overview over CBP systems is similar to the early years of general exoplanet discoveries, and CBP systems with less common parameters might simply not have been found yet. PLATO's potential to provide significant advances in CBP detections will be discussed in terms of the numbers of detected CBPs, and in terms of the increased diversity of future CBP systems. Intriguing is the potential existence of CBPs with strongly inclined orbits relative to the binary system. These pose challenges for their detection and confirmation, which may require substantial follow-up observations. The detection of CBPs is not part of PLATO's official EAS (exoplanet analysis system) pipeline, and a community challenge is being prepared with the aim to find the most effective methods used for detecting a wide variety of CBPs, over which an overview will be presented. For this challenge, PLATO light-curves of CBP systems will be simulated and made available to the scientific community. We will then invite researchers to utilize their algorithms in a blind detection challenge to identify and characterize the hidden CBPs in the simulated data.

My Notes

Contributed Talk

The emerging field of planets in binaries

Author/Speaker: Julia Venturini, University of Geneva, Switzerland, julia.venturini@unige.ch

Co-authors: Arianna Nigioni

Abstract
Half of the Sun-like stars in our galaxy have a stellar companion. The number of detected planets orbiting binary stars is rapidly increasing thanks to the follow-up of TESS planet candidates by GAIA and direct imaging, which detect stellar companions in systems known to host planets. Important questions regarding the origin and demographics of planets in binaries are starting to be explored, namely, how does the presence of a stellar companion affects the outcome of planet formation? How does the occurrence rate of planets depends on binary separation? Is there a radius valley for planets orbiting binary stars? In this presentation I will summarise the latest findings about S-type planets (planets orbiting one of the two stars in a binary system), and I will introduce a global planet formation model that we are developing for binaries, showing some preliminary results. In addition, I will briefly explain a new CHEOPS programme for S-type planets and I will close by discussing the theoretical and observational implications of S-type planets for PLATO.

My Notes

Invited Talk

Architecture of (nearly-)resonant systems : challenges and constraints on processes of formation and evolution of planetary systems

Author/Speaker: Adrien Leleu, Université de Genève, Switzerland, adrien.leleu@unige.ch

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Abstract

Sub-Neptunes, i.e. planets with a radius in the 1-4 Earth radius range, are estimated to exist in close-in orbits around 30 to 50% of all Sun-like stars. A leading model for the formation of this population is the "breaking the chain" model. In this model, close-in systems of sub-Neptunes form in resonant chains due to the migration of planets in the protoplanetary discs. After the disc dissipates, most resonant chains become dynamically unstable. The chains that survived then evolved by tides over Gyrs timescales. Resonant configurations, although representing only a few per cent of the transiting systems, could therefore be key to understanding the process of formation and evolution of about half of planetary systems. For such systems, the long observation baseline of transit surveys such as Kepler and PLATO enables the characterisation of their architecture, including the planetary masses, by observing the effect of the planet-planet gravitational perturbation by the transit timing variation (TTV) method. For transit surveys, this additional observable comes 'for free'. However, TTVs can be challenging: for shallow transits, the use of non-adapted methods can lead to non-detection of planets or erroneous TTV measurements, which in turn bias the estimated masses. For some configurations, the mass can be affected by mass/eccentricity degeneracy. Finally, non-transiting planets can also affect the observed TTVs. I will first discuss these challenges and the state-of-the-art ways to alleviate them. I will then describe how they potentially impact major statistical results of the 2010s, notably the apparent paucity of exoplanetary systems inside MMRs, and the apparent low density of TTV-characterised planets. I will then discuss how PLATO can tackle these issues, and evocate new science cases that will be enabled by the brightness of PLATO's targets and its ability to estimate the age of the systems.

My Notes

Contributed Talk

Resonance structures of multi-planet systems before PLATO era

Author/Speaker: Ewa Szuszkiewicz, University of Szczecin, Poland, ewa.szuszkiewicz@usz.edu.pl

Co-authors:

Abstract
Multi-planet systems are important for understanding how the planets form and evolve. The information about the planetary system evolutionary scenarios is encrypted in one of the robust observational features, namely mean-motion resonances. We present a new method in which the resonance structure can be used to characterise the planetary architectures during different phases of planetary system evolution and in the different stellar environments. This method has a potential to help in the interpretation of PLATO findings.

My Notes

Invited Talk

Coupling Planetary and Ecosystem Modeling to Asses Habitability and Inhabitation in the Solar System and beyond

Author/Speaker: Stephane Mazevet, Observatoire de la Côte d'Azur, France, directeur@oca.eu

Co-authors: A. Affholder, B. Sauterey, Régis Ferrière

Abstract

With thousands of exoplanets now identified, the characterization of habitable planets and the potential identification of inhabited ones is a major challenge for the coming decades. To address this challenge, we developed an innovative approach to assess habitability and inhabitation by coupling for the first time the atmosphere and the interior modeling with the biological activity based on ecosystem modeling. We applied the approach to various situations where habitability and inhabitation are in question: the possibility of methanogenic activity at the Enceladus ocean floor [1], the impact of methanogenic activity on the composition of the early Earth and early Mars atmospheres and its influence on the long term climate[2,3]. During this talk, we will focus on the evolution of earth-like planets around G-type stars and strategies that can be elaborated to validate the concept of habitable planets so as to inform the design of future space missions[4,5].

[1] A. Affholder, F. Guyot, B. Sauterey, R. Ferrière, S. Mazevet, "Bayesian analysis of Enceladus's plume data to assess
methanogenesis", Nature Astronomy 5 (2021), p. 805-814.

[2] B. Sauterey, B. Charnay, A. Affholder, S. Mazevet, R.F errière,"Co-evolution of primitive methane-cycling ecosystems and early Earth's atmosphere and climate", Nature Communications 11 (2020).

[3] B. Sauterey, B. Charnay, A. Affholder, S. Mazevet, R. Ferrière,"Early Mars habitability and global cooling by H2-based
methanogens", Nature Astronomy (2022).

[4] S. Mazevet, A. Affholder, B. Sauterey, A. Bixel, D. Apai and R. Ferriere « Prospects for the characterization of habitable planets », Comptes rendus de l'académie des sciences, physique, pp. 1-16. doi : 10.5802/crphys.154. (2023).

[5] A. Affholder, B. Sauterey, D. Apai, R. Ferrière, S. Mazevet « Interior convection regime determination of atmospheric CO2 abundance and habitability of terrestrial exoplanets » Under review

My Notes

Contributed Talk

Planetary system architecture through the eyes of USP planets

Author/Speaker: Kristine Lam, DLR, Germany, kristine.lam@dlr.de

Co-authors:

Abstract
Ultra short period (USP) planets have orbital periods of less than one day. While their origins are unknown, it was proposed that these peculiar planets could have been formed further out in the protoplanetary disk and migrated inwards through some dynamical interactions to short orbital distances from the star. We present the discovery of a USP (P=0.38d) super-Earth planet transiting a M dwarf star TOI-2290. Observations revealed the planet has a mass of 2.75 +/- 0.52 M_earth, a radius of 1.29 +/- 0.08 R_earth, and a high bulk density of 7.04 +/- 1.87 g/cm^3. TOI-2290b is consistent with an interior composition made up of at least 50% iron core. Unlike many systems hosting a USP planet, TOI-2290b appears to be the only planet orbiting the host star. Hence, there remains a possibility of finding an outer companion or a requirement for an alternative formation pathway to explain the origin of the single transiting planet TOI-2290b. PLATO will revisit a number of USP planet systems as well as discover a large number of small, transiting planets that include many USPs. The new data will provide us a more comprehensive insight on architectures of USP systems and allow for better constraints on formation and evolution theories of such systems.

My Notes

Contributed Talk

HIP41378 multi-planetary system: a testbed for long-period planets analysis with PLATO

Author/Speaker: Salomé Grouffal, Aix-Marseille University, France, salome.grouffal@lam.fr

Co-authors:

Abstract

HIP41378 is a fascinating system hosting at least 5 exoplanets discovered by the K2 mission in 2016. The study of this system is a unique opportunity to prepare the PLATO mission for 3 main reasons: the host is a bright (V=8.9) asteroseismic target typical of the P1 sample, the planets are transiting, and they have long orbital periods (from 2 weeks to 1.5 years). Particularly, HIP41378f, a 'Super-Puff' planet with a Saturn-like size and a mild temperature, stands out due to its unusually low density (~0.2 g/cm3), which is not fully understood yet. Comparative planetology within the system will be crucial to comprehend its nature. Ground-based follow-up observations over several years have led to a new understanding of the system's configuration. This system's analysis requires the combination of multiple observation techniques, including high-precision photometry and radial velocity measurements, transit-timing variations analysis, the Rossiter-McLaughlin effect, and stellar variability correction. These techniques will be essential for analyzing PLATO's planetary systems. In this talk, I will provide an update on the latest findings on this system, including the strategy adopted for the worldwide observation campaign focused on the long-duration transit of HIP41378f. It will also highlight the new challenges presented by the characterization of long-period planets, contrasting with short-period planets. The lessons learned from the study of this unique system will guide the observational and analysis strategy for the PLATO mission.

My Notes

Invited Talk

System architectures: formation or evolution?

Author/Speaker: Christoph Mordasini, University of Bern, Switzerland, Switzerland, christoph.mordasini@unibe.ch

Co-authors:

Abstract

Planetary system architectures represent an additional class of observational constraints to planet formation and evolution theory besides the ones coming from the overall demographics of (individual) planets and the precise characterisation of specific planets. Examples are the frequency of mean motion resonances, correlations regarding the presence of different planet types within one system or compositional patterns like those in systems with planets on both sides of the radius valley. In this talk, I will discuss our current understanding of physical processes that are important in shaping planetary system architectures both during the initial formation and the long-term evolution phase, and how PLATO could help to constrain them in the future.

My Notes

Session: Advances in planet formation

Contributed Talk

Linking the primordial composition of stars to the present-day composition of their rocky exoplanets

Author/Speaker: Vardan Adibekyan, IA/Univ. Porto, Portugal, vadibekyan@astro.up.pt

Co-authors:

Abstract

Stellar atmospheres serve as a crucial gateway to understanding the primordial composition of planetary systems. As planet-forming disks dissipate within a few million years, stellar observations become the primary means to probe their remnants. While conventional models assume a direct correspondence between the compositions of rocky exoplanets and their host stars, recent work by Adibekyan et al. (2021) challenges this assumption. They showed that while there is a relation between the composition of rocky planets and their host stars, the relation is not one-to-one. However, their study had limitations: neglecting volatile elements (e.g. water) in planetary interiors and relying on present-day stellar abundances as proxies for primordial disk compositions, overlooking stellar evolution effects such as atomic diffusion. Over the past two years, the EXO-Terra project has addressed these limitations and expanded the dataset by approximately 50%. Through comprehensive analysis, we aimed to refine the understanding of the star-planet compositional link. I propose an oral presentation to share the findings of the EXO-Terra project, which directly align with the scientific objectives of PLATO, encompassing both stellar and planetary science cases.

My Notes

Contributed Talk

Linking stellar compositions with planet formation: Stellar formation and evolution models with accretion

Author/Speaker: Masanobu Kunitomo, Observatoire de la Côte d'Azur/Kurume University, France, kunitomo.masanobu@gmail.com

Co-authors: Tristan Guillot, Gaël Buldgen, Patrick de Laverny, Alejandra Recio-Blanco

Abstract

Traditionally, star formation and planet formation have been studied independently. However, we now know that the first phase of stellar evolution is affected by the accretion from protoplanetary disks. Planet formation theory predicts that the composition of the gas accreted by the star must have been variable: the growth and inward drift of dust in the disk leads to a "pebble wave" of increased metallicity, followed by a phase in which the exhaustion of the pebbles and the formation of planets leads to the accretion of metal-poor gas. We discuss several results that we obtained with this approach: The low-metallicity accretion is imprinted onto our Sun's core, which has a higher metallicity and consequently a higher temperature than predicted by standard models and yields neutrino fluxes in agreement with observations. The Sun's anomalously low abundance in refractory species compared to solar twins may also be explained with this model by invoking that the Solar System's giant planets are rock-rich, i.e., have a high rock-to-ice ratio. The process can also account for the low rock-to-ice ratio of lambda-Boo stars (metal-poor A-type stars) and should yield a higher scatter in the atmospheric metallicity of high-mass stars (with effective temperatures above ~7000 K). We finally discuss how we test our models with PLATO: asteroseismology will constrain the compositional gradient in the stellar interior, leading to a better understanding of the star-planet chemical connection and the processes governing planet formation.

My Notes

Invited Talk

Recent developments in the theory of planet migration

Author/Speaker: Richard Nelson, Queen Mary University of London, United Kingdom, r.p.nelson@qmul.ac.uk

Co-authors:

Abstract
The migration of planets through disc-planet interactions is likely to be important during planet formation. Evidence for migration is provided by systems of multiple exoplanets in which planets are in mean motion resonances and by the orbital configurations of circumbinary planets. However, attempts to reproduce the known population of exoplanets by planetary population synthesis models that include migration have not been successful, in part because inwards migration is too efficient. In this talk, I will review our current understanding of planet migration and describe recent developments in the context of protoplanetary discs where the turbulent viscosity is weak and radiative processes play an important role.

My Notes

Contributed Talk

Understanding the formation of small planets by searching for their cold giant siblings. The fundamental role of PLATO

Author/Speaker: Aldo Stefano Bonomo, Istituto Nazionale di Astrofisica (INAF), Italy, aldo.bonomo@inaf.it

Co-authors:

Abstract

The exoplanet population with relatively short orbital periods around solar-type stars is dominated by small planets (SPs), i.e. super-Earths and sub-Neptunes. These planets are, however, missing in our Solar System, and the reason for that is unknown. By studying the impact of cold Jupiters (CJs) on the formation and/or migration of SPs, several theoretical works have predicted either an anti-correlation or a weak or strong correlation between CJs and SPs, thus reaching somehow contradictory results. Here we report on the search for and occurrence rate of CJs in a large sample of Kepler, K2 and TESS transiting systems with high-precision radial velocities. We find an occurrence rate of CJs in small-planet systems f(CJ|SE)~15%, which is considerably lower than previously reported by other groups, and revisit recent claims of a possible SP-CJ correlation at super-solar stellar metallicities. The considerably larger sample of transiting SP systems suitable for RV follow-up as provided by PLATO will be crucial to improve our measure of f(CJ|SE) as a function of planet composition and multiplicity, and stellar parameters. This in turn may provide fundamental clues on both the formation of short-period SPs and their absence in our Solar System.

My Notes

Session: Advances in planet formation

Contributed Talk

Astrometric accelerations of stars with candidate transiting planets: blended eclipsing binaries or close companions to planet hosts

Author/Speaker: Silvano Desidera, Istituto Nazionale di Astrofisica (INAF), Italy, silvano.desidera@inaf.it

Co-authors:

Abstract

Stars with astrometric signatures such astrometric acceleration from Gaia or Gaia-Hipparcos proper motion anomaly are known to host additional companions at close separations. In some cases these signatures are due to substellar and even planetary-mass companions, otherwise they are due to stellar companions at separation from a few AU to about 100-200 au. Such companions in some cases are detected by Gaia or they can be revealed by high spatial resolution observations (speckle imaging, adaptive optics). Such stellar companions could be bright enough to be the host of a diluted eclipse mimicking the planetary transit on the main target. At such close projected separations, photometric diagnostics from the high quality photometric light curves obtained from space (e.g. variations of centroid during a transit) can not be used to disentangle the host of the transit. A systematic analysis of all the TESS Targets Of Interest (TOIs) with significant proper motion anomaly revealed a variety of cases, including planetary mass companions in few-au orbit beside the close-in transiting planet, stellar companions close enough to significantly perturb the environment of the inner transiting planet(s), false positives due to diluted eclipsing binaries orbiting the TOI nominal target, and inconclusive cases. A statistical evaluation including also stars with Gaia astrometric orbits and astrometric acceleration shows the negative impact of the presence of close companions on the presence of bona-fide transiting planets. Perspectives to exploit the presence of astrometric acceleration of the targets of the PLATO mission to optimize the follow-up strategy and to identify both cases of special interest (additional planets in wide orbits, close stellar companions) and astrophysical false positives will be discussed.

My Notes

Invited Talk

Constraining Planet Formation and Evolution with PLATO: Importance of Heat Transport

Author/Speaker: Tristan Guillot, OCA, France, tristan.guillot@oca.eu

Co-authors:

Abstract
By characterizing precisely both exoplanet and parent star and their age, PLATO will bring a new perspective to the study of exoplanets and the understanding of their evolution and formation history. For planets with large atmosphere, their progressive cooling and contraction may be constrained. The possibility to measure secondary eclipses and infer eccentricities of close-in planets means that the role of tides and dissipation in both orbital and thermal evolution may be tested. The prevalence of planets with hydrogen atmosphere with possibly high molecular weight also means that convection inhibition must be considered and quantified. I will discuss the latest developments on the subject and the consequences for the analysis of the PLATO data.

My Notes

Contributed Talk

Towards the mysterious origins of warm Jupiters

Author/Speaker: Alexis Smith, DLR Berlin, Germany, alexis.smith@dlr.de

Co-authors:

Abstract

Although PLATO is focussed on the detection of small, rocky planets in the habitable zone, there is much still to learn about giant planets, and PLATO will make a significant contribution here. One unsolved problem is the origins of warm Jupiters (WJs). If they formed beyond the snow line, far from their host stars, then migration is required to bring them to their current orbits. It is unclear, however, which migration mechanism(s) are the most important. Obliquity (the angle between the stellar rotation and planetary orbital axes) is a key tracer of migration history. Dynamically violent, high-eccentricity migration leads to planets in significantly misaligned orbits with large obliquities, whereas disc-driven migration should result in orbits coplanar with the stellar equator. In contrast to the hot Jupiters, the imprint of dynamical migration in WJs should not be erased through tidal interactions with the convective zone of their stars, because they are tidally detached. Only around 60 transiting warm Jupiters are currently known, only 16 of which have a measured obliquity. Recent papers predicting the yield of PLATO suggest that the number of giant planets with periods between 10 and 50 days is likely to be doubled by the PLATO nominal mission. We have a VLT/ESPRESSO programme to measure the obliquities of an unbiased sample of eleven WJs, which will greatly increase the size of the measured sample. Our first observations were made earlier this year, and here we present those data, and our preliminary interpretation.

My Notes

Invited Talk

The evolution and composition of exoplanets: from low-mass multiplanetary systems to gas giant interiors

Author/Speaker: Lorena Acuña, Max Planck Institute for Astronomy, Germany, acuna@mpia.de

Co-authors:

Abstract
In the midst of the era of JWST, CHEOPS and ground-based spectrographs such as ESPRESSO, we are obtaining unprecedented data, spanning from atmospheric metallicities of sub-Neptunes to tidal deformation of hot Jupiters. However, a deeper characterization requires radii of low-mass planets around Sun-like stars, precise ages at all spectral types, and Love numbers at colder equilibrium temperatures. In this talk, I will discuss the state of the art in exoplanet evolution and composition, and how PLATO's upcoming data together with modelling tools will enable the community to make progress in various open questions. These include the origin of the radius valley that separates Super-Earths and sub-Neptunes, the evolution of low-mass multiplanetary systems, and the formation and interior structure of gas giants.

My Notes

Contributed Talk

The surprising range of characteristics found in Neptune-sized Exoplanets

Author/Speaker: Luigi Mancini, Dipartimento di Fisica, Università di Roma "Tor Vergata", Italy, lmancini@roma2.infn.it

Co-authors:

Abstract

Sub-Neptune and Neptune-sized Exoplanets exhibit a more and more surprising wide diversity of masses and bulk density. Determining their internal composition is, actually, a key parameter that can provide insights into whether these planets are predominantly composed of volatile materials or if they have significant amounts of denser substances such as water or rocky materials. Such information is, therefore, fundamental for understanding their formation and evolution, especially for those that lie in the hot-Neptune "desert" where the vicinity with their parent stars can induce atmospheric escape processes. Also in the context of possible planetary atmosphere characterization with the JWST, it is very important to measure the mass of these planets with a precision of ~5sigma. Such precision requires a long RV monitoring of the parent stars and the use of very high-resolution spectrographs. The TESS space telescope is providing many transiting-planet candidates, orbiting bright stars, that are excellent targets for high-precision spectroscopic follow-up observations, which allow us to physically characterize these planets and explore their parameter space. In this context, we will present an update on our project concerning the high-cadence RV monitoring of a list of Neptune-sized Tess planet candidates. This project is currently split into two observational programs: the first is performed by using HARPS-N at the TNG and is focussed on hot-Neptune TESS candidates, while the second involves the use of HARPS at the ESO 3.6m telescope and a list of warmer Neptunes has been selected.

My Notes

Contributed Talk

Constraints on transit-detected system architectures from formation and evolution studies

Author/Speaker: Anne-Sophie Libert, University of Namur, Belgium, anne-sophie.libert@unamur.be

Co-authors:

Abstract

Many tightly-packed transit-detected systems harbor complex dynamical evolution governed by two-body resonances and/or chains of resonances. I will discuss recent results showing how formation and evolution studies can be useful to constrain the orbital parameters of these systems, which generally suffer from significant observational uncertainties. More precisely, I will show how i) periodic orbits can serve as dynamical clues to validate the parametrization of detected systems, ii) TTVs keep track of the migration history of planetary systems and provide signatures of three-body resonances accessible by future monitoring of the systems, and iii) the offsets in resonant chains are shaped by planetary migration and tides raised by the star. Joint work with E. Agol, K.I. Antoniadou, C. Charalambous, and J. Teyssandier.

My Notes

Contributed Talk

Exploring the links between exoplanet architectures and birth environments through the discovery and characterisation of young exoplanets

Author/Speaker: Matthew Battley, University of Geneva, Switzerland, matthew.battley@unige.ch

Co-authors:

Abstract

Although over 5000 validated exoplanets are currently known, there are still large gaps in our understanding of how planets form and evolve. Young exoplanets (<1Gyr) hold the key to answering many of these outstanding questions, existing in one of the most interesting eras of exoplanet evolution, where their orbital locations, compositions and atmospheres are rapidly evolving. Such exoplanets can be found in a wide range of birth environments, including dense stellar clusters, diffuse stellar associations, loose co-moving groups of stars and around field stars. The accelerating expansion in the population of young exoplanets is beginning to reveal intriguing patterns about the comparative exoplanetary populations in these different birth environments. One particularly interesting feature is that the radius distribution of exoplanets orbiting young field stars is considerably more diverse than the radii of those in clusters, associations and moving groups, suggesting that different evolution pathways may exist for these two populations. In order to study such patterns in more detail it is imperative that we build a sample of well-characterized young exoplanets at precise ages across all birth environments. Here I will briefly review the state of the young exoplanet field and emerging features of the population before introducing the YOUNGSTER programme, a multifaceted approach to detecting and characterising new young exoplanets in a range of birth environments. This programme combines a purpose-built young star detrending pipeline to separate the signals of new young exoplanet candidates from the challenging activity of their young host stars, multi-colour spectroscopic follow-up of transiting young exoplanet candidates and machine-learning classification of young stellar variability. While the purpose-built detrending pipeline has already revealed dozens of new young exoplanet candidates requiring further follow-up, pilot programs on HARPS/NIRPS and CARMENES are beginning to reveal how we can leverage variations in activity signal at different wavelengths to differentiate between stellar and planetary signals. The techniques developed through this programme will aid current and next generation observing facilities like PLATO to discover and characterise smaller planets around more active hosts. Combining these planets with the imporved ages of stars observed with PLATO will provide keystone systems with which to anchor planet formation and evolution theories.

My Notes

Contributed Talk

The HD110067 sextuplet - detection of a unique resonant planetary system which could unlock planet formation

Author/Speaker: Hugh Osborn, Bern, Switzerland, hugh.osborn@unibe.ch

Co-authors:

Abstract

Planetary formations naturally forms resonant chains of planets, but few such systems persist for more than 1Gyr due to evolutionary events such as destabilisation, planet-planet scattering, mass loss, etc. Therefore systems in resonant chains, especially pristine first-order chains of three-body Laplace resonances, are key windows for the charactersation of unmodified exoplanets. A system of six sub-Neptunes orbiting HD110067 was recently detected using TESS & CHEOPS photometry, and further characterised with HARPS-N & Carmenes RVs. This is the brightest system with more than 3 transiting planets yet found, and the most characterisable resonant system amenable to JWST atmospheric characterisation. Here I present the discovery of the HD110067 system, our ongoing characterisation efforts, and the potential for the system to provide tight constraints on planetary C/O ratio and bulk water composition as a function of orbital period from future JWST observations.

My Notes

Session: Exoplanets Evolution

Invited Talk

HARPS-N insights for PLATO: exoplanets in a chemical and formation history context

Author/Speaker: Annelies Mortier, University of Birmingham, United Kingdom,
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Co-authors:

Abstract

The thousands of exoplanet discoveries have shown us that planets are ubiquitous, come in various sizes and architectures and are found orbiting different stars. Exploring this broad variety of exotic worlds, studying planets both like and unlike our own, allows us insights in the mechanisms of planet formation and evolution. In this talk I will take you on a tour of exoplanets characterised by the HARPS-N Science Team over the last decade. I will discuss variety across chemical environments, the role of long-period planets, and how observational biases can distort our view of the true underlying population.

My Notes

Session: Exoplanets Evolution

Invited Talk

The M Dwarf Planet Radius Distribution from Kepler to PLATO

Author/Speaker: Eric Gaidos, University of Hawaii at Manoa, United States, gaidos@hawaii.edu

Co-authors:

Abstract

The radius distribution of Earth- to Neptune-size exoplanets contains two dominant peaks assigned to populations of predominantly rocky and volatile-rich objects, respectively, separated by a valley at 1.7 Earth-radii. Understanding the exact composition, formation, and evolution of such objects is a major challenge in current exoplanet research. Previous work has compared radius distributions with younger vs. older solar-type host stars and found change consistent with the predicted loss of volatile envelopes from ``sub-Neptunes", leaving rocky cores as ``super-Earths" over hundreds of Myr or Gyr. We performed a similar analysis with a refined sample of single Kepler M dwarf planet hosts with ages assigned using a new gyrochronology. M dwarfs provide an opportunity to study the phenomenon's dependence on stellar mass and irradiance. We find the same peaks in the radius distribution, and a significant decline in the sub-Neptune population between the <3.8 Gyr and >3.8 Gyr halves of the sample. Unexpectedly, we also find that the location of the radius valley does not depend on irradiance and that sub-Neptunes persist on closer rather than more distant orbits, suggesting a mechanism that keeps these planets inflated at elevated irradiance, e.g. a runaway water greenhouse. The robustness of these results is limited by the small Kepler sample size, and we show how PLATO will be able to deliver more M dwarf planets on more distant orbits and with rotation-based ages to clarify this intriguing discovery.

My Notes

Session: Exoplanets Evolution

Contributed Talk

Mapping Galactic exoplanetary architectures with ESA PLATO and NASA Roman

Author/Speaker: Eamonn Kerins, University of Manchester, United Kingdom, eamonn.kerins@manchester.ac.uk

Co-authors:

Abstract

ESA PLATO and NASA Roman are both scheduled for launch in 2026, and both will undertake ground-breaking exoplanet surveys that will be transformative for studies of exoplanetary architecture. As the recently appopinted ESA Scientist to the Roman Galactic Exoplanet Survey, I will outline the Roman exoplanet science goals and highlight powerful PLATO-Roman science synergies. Roman will have similar sensitivity and resolutiuon to Hubble, but with over 100x the field of view. Over a nominal 5-year lifetime it is expected to detect up to 200,000 transiting planets spanning across Galactic distances, as well as around 1,400 cool planets using microlensing. This sample will provide a "far-field" counterpart to PLATO's "near-field" exoplanet catalogue. Roman data will be world public within days of observation. The complemetarity of PLATO and Roman datasets offers an unparalled opportunity to map out exoplanetary architecture across Galactic distance scales. In particular, I argue that a joint PLATO-Roman analysis can provide the first reliable measurement of the number of habitable zone planets throughout the Galaxy.

My Notes

Contributed Talk

Unveiling the internal structure and formation history of the three planets transiting HIP 29442 with CHEOPS

Author/Speaker: Jo Ann Egger, Universität Bern, Switzerland, jo-ann.egger@unibe.ch

Co-authors:

Abstract
We present new CHEOPS data for the two inner super-Earths (P=3.5 and 6.4 days) and one outer sub-Neptune (P=13.6 days) of the compact HIP 29442 system, allowing us to significantly improve the radius precision and accuracy of all three planets. Especially for the 6.4 day planet, this significantly changes the inferred nature of the planet and leads us to conclude that caution is required when determining the radii of small planets from multi-year TESS photometry when the per-transit SNR is low and there are significant gaps between observations. Together with the very precise masses from Espresso, these precise radius measurements make HIP 29442 an ideal system to probe the internal structure of its planets. As there are always multiple compositions that can explain the observed mean density of a planet, we apply Bayesian inference to obtain probability distributions for each planet's internal structure. We developed a new and improved internal structure framework that allows us to model each planet with either separate water and H/He layers or a uniformly mixed water and H/He envelope. It also includes a set of equations of state that allows for both molten and solid mantle and core layers and different options for compositional priors. In addition, we studied possible formation and evolution pathways of the system by comparing it to synthetic systems produced with the latest version of the Bern model.

My Notes

Session: Relevant Stellar Science

Invited Talk

Exoplanets in Multi-Star Systems

Author/Speaker: David Ciardi, NASA Exoplanet Science Institute - Caltech/IPAC, United States, ciardi@caltech.edu

Co-authors:

Abstract

Over the past two decades, an extraordinary revolution has ensued in our understanding of planetary systems beyond our own, driven largely by the transit missions Kepler and TESS - and soon to be with PLATO. Because the transiting missions have relatively poor spatial resolution, high resolution imaging has become standard practice in the vetting of planetary candidates as the community works towards confirmation of a planetary transit as the source of the observed signal. Our group has become one of the largest providers of such high-resolution imaging, with near-infrared adaptive optics imaging on Keck and Palomar and with optical speckle imaging on Gemini North and South. The high resolution imaging, in combination with Gaia, has enabled us to characterize the stellar multiplicity of the planetary sytems discovered by Kepler and TESS - and will be crucial to the discoveries of PLATO. In particular, the identification of nearby (bound and unbound) stellar companions is necessary to obtain the correct planetary radius as unseen companions make detected planets look smaller and small planets harder to detect - affecting our ability to characterize planets correctly, find small planets, and accurately predict the frequency of small planets. I will give an overview of our decade-and-half-long program, the role our program plays in the confirmation of planets, and an assessment of the stellar multiplicity and characteristics of the planets found in those systems.

My Notes

Contributed Talk

Characterizing planets around stars with negligible activity is not as easy as you may think

Author/Speaker: Luca Malavolta, Università degli Studi di Padova, Italy, luca.malavolta@unipd.it

Co-authors:

Abstract

The installation in 2012 of the high-resolution, ultra-stable spectrograph HARPS-N at the Telescopio Nazionale Galileo has represented a pivotal point for the mass determination of super-Earths and mini-Neptunes from the Northern Hemisphere. In synergy with Kepler, TESS and CHEOPS space missions, the HARPS-N Collaboration has provided accurate densities for over 50 transiting small planets and masses for several non-transiting planets, with periods ranging between a few hours to decades. With time, we have realised that stellar activity is the main limiting factor towards reaching and surpassing the ten cm/s barrier for characterising Earth analogues. One may naively think that old stars quieter than the Sun could represent a viable alternative to a complex and still incomplete modelling of stellar activity, but our experience proves otherwise. After a brief introduction of the HARPS-N Collaboration, in this talk I will present two emblematic cases of planets with contrasting mass measurements, despite the nearly undetectable activity levels of the stars and the use of extremely-precise spectrographs: the Ultra-Short Period super-Earth TOI-561b and the Cold Jupiter Kepler-68e. I will then corroborate, with other examples, how observational strategy and rigorous data analysis techniques routinely employed by the HARPS-N Collaboration ensured reliable and accurate determinations of the architecture of the planetary systems, which were later confirmed by additional observations. The decade-long follow-up on active and quiet stars by the HARPS-N Collaboration has yielded valuable lessons that will play a critical role in achieving the scientific goals of the PLATO mission.

My Notes

Contributed Talk

Detecting and Sizing a Distant Earth with PLATO: A Feasibility Study Based on Solar Data

Author/Speaker: Andreas Krenn, Space Research Institute, Austrian Academy of Sciences, Austria, andreas.krenn@oeaw.ac.at

Co-authors: M. Lendl, S. Sulis, M. Deleuil, S. J. Hofmeister, N. Jannsen, L. Fossati, J. De Ridder, D. Seynaeve, R. Jarolim, A. M. Veronig

Abstract
Earth-sized extrasolar planets orbiting in the habitable zones of solar-like stars are prime targets to look for evidence supporting the existence of life on other planets in the Universe. However, until now neither radial velocity nor transit photometry techniques were precise enough to detect and characterise a potential signal stemming from an Earth-twin. With the launch of the PLATO (PLAnetary Transits and Oscillations of stars) mission, planned in 2026, this will change. To test the expected performance of the instrument and gain insights on how to correctly deal with PLATO data, we have simulated PLATO light curves of the Sun transited by Earth. We used real data observed by the Solar Dynamic Observatory (SDO) to quantify the effects of stellar activity, especially of granulation and oscillations. We then injected artificial Earth-Sun-like transit events and inserted this combination of stellar and planetary signals into the PlatoSim-simulator. We ended up with a final light curve product, which contains the stellar activity noise, the instrumental noise and the planetary signal. In our study we present the results of employing a transit search algorithm on these light curves. We also test a variety of popular detrending techniques to check how well they perform at retrieving the injected transit depth, with the aim of learning on how to best detrend future PLATO light curves. Finally, we provide a statical study on how stellar and planetary parameters, such as stellar magnitude and impact parameter, affect the exoplanet detection rate and the precision of the retrieved transit depths.

My Notes

Contributed Talk

Extraction of quasi-periodic signals in noisy data: application to the detection of exoplanets in transit surveys

Author/Speaker: Yannick Eyholzer, Observatory of Geneva - University of Geneva, Switzerland, yannick.eyholzer@unige.ch

Co-authors:

Abstract

The detection of exoplanets rely heavily on space-based transit surveys such as Kepler, TESS and PLATO. In these surveys, detecting and characterising small planets pose challenges due to their low signal-to-noise ratio (SNR). Traditional methods, such as the BLS, exploit the periodic nature of orbits to enhance the SNR. But these methods are fundamentally limited when gravitational perturbations between the planets disturb the periodic nature of their orbit. These perturbations lead to transit timing variations (TTVs), causing smearing of the transits and reduction of the detection significance. This can lead to an underrepresentation and inaccurate characterization of small planets embeded in compact systems. Consequently, there is a necessity for flexible approaches that capture signals of dynamically active small planets. Prominent examples of such approaches include for example QATS [Carter et al. 2013, ApJ, 765:132] and RIVERS [Leleu et al. 2021, A&A, 655:A66], as these methods enable the detection of non-stricly periodic signals. After exposing the problem of detecting quasi-periodic signals, I will present adapted methods and my ongoing work to improve them. I will also present a comparison of the performance of these methods on the retrieval of 850 low SNR KOIs.

My Notes

Session: Relevant Stellar Science

Contributed Talk

What to expect from PLATO stellar rotation and activity measurements ?

Author/Speaker: Sylvain Breton, INAF - Osservatorio Astrofisico di Catania, Italy,
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Co-authors:

Abstract

Space-based photometry allows observing activity-induced brightness modulations at the surface of solar-type and low-mass stars, opening the door to surface rotation measurements and activity monitoring in such targets. The PLATO stellar analysis pipeline will provide such measurements for as many targets as possible, including exoplanet host-stars for which they will be important inputs to mitigate the impact of stellar activity in planet characterisation. In this talk, I will present the scientific abilities of the rotation and activity analysis module that will be implemented in the PLATO pipeline. The module will combine Fourier analysis, autocorrelation of time series and machine learning classifiers to measure both stellar surface rotation and long-term modulations related to stellar magnetic activity. The ROOSTER random forest methodology guarantees the completeness and the robustness of the automated analysis of rotation. I will extensively describe the data products of the module that will be of interest for exoplanetary science, such as the average stellar rotation period and the photometric activity index. Finally, I will present the performances achieved by the algorithms when homogeneously applied on a set of realistic simulated light curves. These simulations include spot evolution and migration, magnetic activity cycle, convective granulation, PLATO systematics, and random camera noise. Their analysis shows that PLATO should already be able to provide rotation periods and photometric activity indexes for a large sample after six first months of observation, and that the quality of these measurements will be refined as longer time series are acquired.

My Notes

Contributed Talk

Bridging the GAIA-PLATO Horizon: Kinematic and Chemical Signatures of Exoplanet Hosting Stars as Windows into Planetary Formation and Evolution

Author/Speaker: Swastik Chowbay, Indian Institute of Astrophysics, India, swastik.chowbay@iiap.res.in

Co-authors:

Abstract

The GAIA space mission has revolutionized our understanding of the Milky Way, offering an unparalleled data set for over 1 billion stars and celestial bodies, thereby setting a new benchmark for precision in stellar and exoplanetary science. This advancement is particularly synergistic with the goals of the PLATO (PLAnetary Transits and Oscillations of stars) mission, which aims to discover and characterize Earth-like planets in habitable zones and perform detailed analyses of host stars. In this context, our study leverages the latest Gaia Data Release 3 (DR3), incorporating photometric, astrometric, and spectroscopic data, to explore the kinematic and chemical signatures of 2611 exoplanet-hosting stars, thus providing insights into their formation histories and evolutionary states, areas of keen interest for PLATO. By integrating spectroscopic observations from GAIA's Radial Velocity Spectrometer, we reveal a distinct correlation between planetary mass and stellar composition, where stars hosting massive planets exhibit higher metallicity but lower α-element abundances compared to those with smaller planets. This chemical dichotomy underscores the critical role of stellar metallicity in planet formation, a parameter that PLATO's precise stellar characterizations will further illuminate. Our kinematic analysis uncovers significant differences in galactic space velocity and orbital parameters between systems with small and giant planets, reflecting underlying age discrepancies. Specifically, we identify a statistically significant variation in Zmax (0.06 kpc) and eccentricity (0.03), suggesting that planetary system architecture may be influenced by the age and dynamical history of the host star. This finding aligns with PLATO's objective to determine accurate ages for host stars, offering a deeper understanding of planetary system evolution. Furthermore, employing MIST-MESA isochrone models to estimate stellar ages, we find that stars hosting giant planets are generally younger than those with smaller planets. This age trend not only supports the core-accretion theory for giant planet formation but also parallels the broader narrative of chemical and dynamical evolution within the galaxy, topics that are central to the PLATO mission's exploration of exoplanetary systems and their stellar environments. In conclusion, our study bridges GAIA's groundbreaking dataset with the forthcoming endeavors of the PLATO mission, highlighting the importance of integrated stellar and exoplanetary research in unraveling the complexities of planet formation and evolution within our galaxy.

My Notes

Poster

Broadband Linear Polarimetry of Exoplanet Upsilon Andromedae b: Constraints on the Orbital and Physical Parameters

Author/Speaker: Yasir Abdul Qadir, University of Turku, Finland, yasir.abdulqadir@utu.fi

Co-authors: A. V. Berdyugin, V. Kravtsov, V. Piirola, T. Sakanoi, M. Kagitani, J. Poutanen

Abstract

Recent advancements in astronomical polarimetry have enabled the detection and characterization of exoplanets, providing insights into their orbital parameters, atmospheric composition, and reflective properties. By combining polarimetric studies with spectroscopy and photometry, a comprehensive understanding of exoplanets, including non-transiting hot Jupiters like Ups And b, can be achieved. The polarimetric observations of the Ups And star system were conducted over a period of nearly three years, capturing data at different orbital phases of Ups And b. We used T60 telescope in combination with high-precision DiPol-2 polarimeter, which provided an exceptionally high accuracy. To identify periodic signals in our unevenly sampled polarimetric data, we employed the Lomb-Scargle periodogram method. Our findings revealed a polarimetric signal precisely at half of the known orbital period of Ups And b, as expected from the polarimetric data of an exoplanet. By applying the Rayleigh-Lambert scattering model, we derived constraints on the exoplanet's orbital parameters, including inclination angle, longitude of periastron, and longitude of the ascending node. Combining these results with previous spectroscopic studies, we determined the planetary mass, mean density, and surface gravity of Ups And b. Additionally, our analysis of Transiting Exoplanet Survey Satellite (TESS) photometric data for Ups And provided further evidence suggesting the presence of starspots, which likely affected the observed polarimetric signal of the exoplanets. Consequently, accurately quantifying the scattering atmosphere radius and planetary albedo of Ups And b proved to be elusive. In conclusion, high-precision polarimetry can serve as a useful tool for studying exoplanets, allowing for the deduction of their orbital parameters and atmospheric properties. This study highlights the significant potential of astronomical polarimetry in characterizing various types of exoplanets. By incorporating multiple observational techniques, we can enhance our understanding of the complex nature of explanatory systems.

My Notes

Poster

Gleaning the interiors of ultra-hot Jupiters from phase curve observations

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Co-authors:

Abstract
Planets orbiting close to their stars are strongly influenced by stellar tidal forces which deform the shape of the planet. Measuring the deformed shape of such exoplanets allows to better constrain planetary properties such as their true radii and densities. Furthermore, measuring deformation can reveal crucial information about the interior structure of such planets since the degree of deformation is related to the interior differentiation that is parameterized by the second-degree fluid Love number. Phase curves of transiting planets provide a unique opportunity to measure the planetary deformation from precise light curves. In this talk, I will present the phase curve model of deformed planets that allows estimating the Love number of the planet with improved precision. I will further present an application of this model to real observations of WASP-12b. Finally, I will show how the photometric precision expected from PLATO can help in better constraining the Love number and the implications for interior structure models.

My Notes

Poster

TIaRA – a tool for predicting exoplanet discovery yields from transit surveys.

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Abstract

We have developed the Transit Investigation and Recoverability Application (TIaRA) pipeline, a tool for making sensitivity maps for transit surveys based on the timestamps and precision of the photometry. We combine these with occurrence rates derived from Kepler to estimate yields for transit surveys. We apply TIaRA to the TESS Southern Ecliptic Hemisphere, and predict 2271(+241−138) detectable planets from the Year 1 and 3 SPOC FFI light-curves. By comparing our results to the TOI catalogue, we estimate (with a 3-sigma confidence level) that 75% of planets with periods over 25 days have yet to be discovered. We plan to apply TIaRA to simulated PLATO light-curves to calculate transiting exoplanet yields in a similar manner.

My Notes

Poster

Potential climates and habitability on Gl 514 b: a super-Earth exoplanet with high eccentricity

Author/Speaker: Lorenzo Biasiotti, Università di Trieste, Italy, lorenzo.biasiotti@inaf.it

Co-authors:

Abstract
The recently discovered super-Earth Gl 514 b, orbiting a nearby M0.5-1.0 star at 7.6 pc, is one of the best benchmark exoplanets for understanding the potential climate states of eccentric planets. The elongated (e = 0.45+0.15 −0.14) orbit of Gl 514 b, which only partially lies in the Conservative Habitable Zone, suggests a dynamically young system, where the spin-orbit tidal synchronization may not have yet occurred up to the present time. In the present work, we use a seasonal-latitudinal energy balance model, EOS- ESTM, to explore the potential impact of both constrained and unconstrained planetary, orbital and atmospheric parameters on the Gl 514 b habitability, mapped in terms of surface temperature. We test three distinct CO_2-dominated atmospheres by varying the CH_4 concentration values (0%, 0.1% and 1%) and the total surface pressure. As a general trend, we find that habitable conditions are favoured by high-CH_4 and high-pressure regimes. Habitability also increases for high axis obliquities (at least until the appearance of an icebelt), long rotation periods, and high ocean fractional coverage. If the ocean fraction is low, then also the argument of periastron becomes relevant. Our results are robust against changes of the continental distribution. Thus, we conclude that Gl 514 b can potentially maintain temperate surface conditions with modest seasonal temperature variations under a wide variety of planetary, orbital and atmospheric conditions. Despite no transit have been detected yet, the results found in this work should motivate the community to invest time in future observations.

My Notes

Poster

Light Curve Imaging for Exoplanet Detection With Deep Learning

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Co-authors:

Abstract

The growing volume of data from space missions renders manual exoplanet candidate identification impractical. Machine learning offers a solution, but conventional methods struggle with signal noise inherent in observations. This work proposes a conceptual trial for a novel deep learning approach to exoplanet classification using convolutional neural networks (CNNs). We introduce a technique of imaging light curves before feeding them into CNNs, effectively increasing the data dimensionality and allowing application of powerful computer vision techniques. Our approach ranks plausible planet signals higher than false-positive signals 97.22% of the time in our test dataset. Although exceeding the performance of the AstroNet model on different datasets other than Kepler mission's data, such as K2's and TESS' data, further improvement is ongoing. We emphasize the importance of generalizability to upcoming missions like PLATO and propose further exploration of this imaging method in future research.

My Notes

Poster

Occultation and phase curve studies of three hot Jupiters

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Co-authors:

Abstract

Ultra-hot Jupiters (UHJs) orbiting pulsating A/F stars represent an important subset of the exoplanetary demographic, as they are excellent candidates for the study of exoplanetary atmospheres, as well as being astrophysical laboratories for the investigation of planet-to-star interactions. Hereafter we show three examples how we separate the stellar variability from planetary phase curves in two systems containing pulsating host star (WASP-169, KELT-9) and for comparison purposes, one system with non-pulsating host star (WASP-186). We present our methodology based on the wavelet-technique. We study the TESS light curves of two planetary systems with A-type host stars (KELT-9, WASP-167) and one system with F-type host star (WASP-186). We developed a new ellipsoidal variability model to take non-synchronous stellar rotation into account. We model simultaneously the ellipsoidal, Doppler beaming and reflection effect to obtain constraints on the geometric albedo and the planetary intrinsic luminosity, while placing a special emphasis on noise separation. A basic model was implement to determine the dayside, nightside and intrinsic temperatures of the planets. That allowed us to give limits for the heat redistribution factor and the Bond-albedo. Transit parameters of the planet seen in previous studies are confirmed. We find that a resonant ∼1/2P stellar signal (which may originate from planet-to-star tidal interactions) interferes with the phase curve analysis in case of WASP-167. For WASP-167b, after considerate treatment of this signal, we find Mp=0.34±0.22 MJup. We measure a dayside temperature of 2790±100 K, classifying WASP-167b as an Ultra-Hot Jupiter (UHJ). We find a 2sigma upper limit of 0.51 on its Bond albedo, and determine the geometric albedo at 0.34±0.11 (1sigma uncertainty). With an occultation depth of 106.8±27.3 ppm in the TESS passband, the UHJ WASP-167b will be an excellent target for atmospheric studies, especially those at thermal wavelength ranges, where the stellar pulsations are expected to be be less influential. We also present the TESS phase curve of the massive (∼16±4.2 MJ) eccentric (e ∼ 0.33) ultra-hot Jupiter (P ∼ 5 days) WASP-186b. We detect for the first time the occultation of the planet (secondary eclipse) as well as the phase curve parameters via a joint light curve – radial velocity modelling. We derive an occultation depth of 190 ± 51 ppm at p = 0.001 significance level. We provide a 1σ upper limit on the Bond albedo (0.30), a 1σ lower limit on the heat redistribution efficiency (0.84), and measure an intrinsic temperature of 2766±131 K (corresponding to ∼ 7·10−4 L⨀). We use the latter to estimate the tidal dissipation of WASP-186b at Q_P = 107(+118,−107), a value similar to Saturn. We also estimate26 T_day = 2852 ± 114 K and T_night = 2771 ± 130 K. Finally, we also studied the TESS light curve of KELT-9 with the same method. Updated planet parameters are given. We found that the planet dayside temperature is 4798 ± 80 K while its nightside temperature is 2767 ± 241 K. We were able to constrain the intrinsic heat of the planet which corresponds to an effective temperature of 2394 ± 817 K. This intrinsic heat is not originating from the absorbed part of the incoming flux of ohmic dissipation theory nor from the heat produced by gravitational contraction and it is unlikely that it is the residual heat of the formation. However, this amount of intrinsic heat is in perfect agreement with the predictions of the obliquity tide-theorem for the tidally produced heat if we assume that the planetary Q/k2 ratio is strictly between 4 · 10^5...4 · 10^6. We also found the upper limit for Bond-albedo AB < 0.23 and the lower limit for the heat redistribution factor f > 0.88. We put these results into context via studing how the

dayside, nightside temperatures of the planets depend on the equlibrium temperature of the planets, and also how the star-planet distance influences the heat-production of exoplanets via obliquity tides.

My Notes

Poster

From DAVINCI to PLATO: two sister missions to study potentially habitable terrestrial exoplanets using Venus as our next-door laboratory.

Author/Speaker: Piero D'Inceccco, INAF - Astronomical Observatory of Abruzzo, Italy, piero.dincecco@inaf.it

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Abstract
As the Venus decade approaches, one of the outstanding questions to be addressed by the future missions that will investigate the hellish twin sister of the Earth, is what can Venus tell us about terrestrial potentially habitable exoplanets. Recent studies indicated that some exoplanets - both terrestrial and gaseous - may be characterized by dense atmospheres possibly rich in CO2, just like Venus. In the case of terrestrial exoplanets orbiting in the habitable zone of their solar system, this similarity gives us the opportunity of using Venus as a next door laboratory for the analysis of the geologic evolution of Earth-like exoplanets, to make assumptions about their habitability and - by comparison - to possibly reconstruct their geologic past. As Venus may have been habitable for a long time during its geologic past, other terrestrial exoplanets may have been or still be habitable too. To this regard, in 2026 the European Space Agency will launch the PLAnetary Transits and Oscillations of stars (PLATO) mission will study Earth-like exoplanets orbiting in the habitable zone of Sun-like stars. Five years later, in 2031, NASA will launch the Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (DAVINCI) mission, with one of its main objectives being that of investigating the vertical composition and structure of the atmosphere of Venus, to reconstruct its evolutionary history. In this perspective, the PLATO mission and DAVINCI mission can thus be considered as sister missions, with the PLATO mission looking for and analyzing potentially habitable terrestrial exoplanets, and the DAVINCI mission being the most reliable terrestrial exoplanets analog mission.

My Notes

Poster

On exoplanet habitability by merging asteroseismic and space climate tools

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Co-authors:

Abstract

We present our synergic strategy that merges the potential of asteroseismology with solar space climate techniques in order to characterize solar-like stars and their interaction with hosted exoplanets. The method is based on the use of seismic data obtained by the space missions TESS Transiting Exoplanet Survey Satellite, coupled with stellar activity estimates deduced from ground-based campaigns. Our investigation allows us to obtain not only a highly accurate characterization of the mother star but also to study the stellar wind action on its exoplanet. This information, coupled with the precise age estimation by asteroseismology determines how long an atmosphere could resist the action of stellar wind, directly quantifying the portion of the atmosphere that could be eroded.

My Notes

Poster

Venus as an Exoplanet: Effect of varying stellar, orbital, planetary and atmospheric properties upon composition, habitability and detectability

Author/Speaker: John Lee Grenfell, German Aerospace Centre (DLR), Inst. Planetary Science, Dept. Extrasolar Planets and Atmospheres, Rutherfordstr. 2, 12489 Berlin, Germany, Germany, lee.grenfell@dlr.de

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Abstract

The newly selected Venus missions EnVISION and VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) offer new opportunities for studying Venus but will also contribute to furthering our knowledge of Venus as an exoplanet. Hot rocky planets are favored targets due to generally more frequent transits than cooler Earth-like objects. In this work we simulate Venus as an exoplanet varying stellar, orbital, planetary and atmospheric parameters and study the effect upon atmospheric composition, climate and spectral detectability with the JWST (James Webb Space Telescope), the ELT (Extremely Large Telescope) and the LIFE (Large Interferometer For Exoplanets) telescope.

My Notes

Poster

Singletrans a new tool for the search of mono transits in light curves

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Co-authors:

Abstract

The quest for exoplanet discoveries has been significantly advanced by searching stellar light curves from space missions like CoRoT, Kepler, K2, and TESS. Traditional detection pipelines, employing methods such as the Box Least Squares (BLS), search these light curves for periodic transits. However, these methods often overlook single transits, especially those with shallow depths of smaller planets. Addressing this challenge, we introduce SINGLETRANS, a novel wavelet-based algorithm developed to enhance the detection of these elusive single transits. Searching the archived data of space-missions, it enables the detection of potential candidates with single transits and extended orbital periods. Single transits candidates in the PLATO field detected in archival data can help in the preparation of the mission. After the launch of PLATO single transits detected in the first 'quarters' of the PLATO light curves can help to identify long period planets in the following 'quarters' of the mission. Additionally, SINGLETRANS is capable detecting quasi-periodic transits, which is crucial for identifying circumbinary planets and transits with strong transit timing variations (TTV). We will present results from our injection tests and findings from our search in CoRoT, Kepler, K2 and TESS data.

My Notes

Poster

Exploring PLATO's exoplanet neighbourhoods: The WEAVE-twilight survey

Author/Speaker: Thomas Hajnik, IoA, University of Cambridge, United Kingdom, th721@ast.cam.ac.uk

Co-authors: N. A. Walton, D. Terrett, S. Hughes, S. Pico, D. Murphy, G. Dalton

Abstract

In the past decade, correlations between stellar elemental abundances of planet hosting stars and their orbiting bodies have been extensively explored in multiple studies (e.g. Adibekyan+, 2012a; Santos+, 2017a & b; Teske+, 2019; Tautvaišienė+, 2022). There is a broad consensus on the prevalence of giant-planets around metal-rich stars (e.g. Fischer and Valenti, 2005; Adibekyan+, 2012a; Tautvaišienė+, 2022) as well as documented overabundances of α-elements in planet hosts (Adibekyan+, 2012b; Tautvaišienė+, 2022). But so far, no definitive evidence of relationships between stellar abundance patterns or anomalies and planet-hosting stars has been found (Liu+, 2020; Tautvaišienė+, 2022; Behmard +, 2023). However, there are indications that planet system architectures could leave their imprints in the depletion of refractory elements (e.g. Yun+, 2024). In addition, observations of protoplanetary disks show a wide variety of morphologies (Andrews+, 2018, Garufi+, 2024), which may influence chemistry, occurrences, and architectures, further complicating the picture of planetary formation. PLATO will discover thousands of planets around stars between 8 and 13 visual magnitudes (Matuszewski+, 2023). When it comes to chemical abundance measurements, bright stars (< 11 V mag) are currently underrepresented in large scale high-resolution spectral surveys. These are often neglected in favour of fainter objects which allow for longer integration times and a higher number of targets. Using short exposures (approx. 30s) WEAVE is capable to observe bright stars between 6 and 11 V mag during twilight-hours, without reaching full-well capacity. Therefore, a novel observing mode has been developed, allowing for efficient observations of multiple fields in short succession. As a pilot study for this new mode, WEAVE-twilight will focus on stars from PLATO's Long-duration Observation Phase (LOP) fields (Nascimbeni et al., 2021 & in prep. 2024), hereby maximising its output regarding new and known exoplanet host stars. Initial tests will be conducted in April 2024, with first data expected in early to mid 2025. Focusing on F, G and K stars between 6 < V < 11 mag, it will contribute approximately 3000 high-resolution spectra for stars in this brightness range, resulting in a unique homogeneous abundance catalogue for up to 16 elements (C, O, Al, Ca, Mg, Mn, Na, Sc, Si, Ti, V, Y, Co, Cr, Fe and Ni). Combining these with Gaia proper motions and PLATO follow-up RV measurements will allow for the precise chemodynamical characterisation of thousands of bright stars and hundreds of potential new exoplanet hosts in the northern PLATO LOP field. This talk aims to provide an overview of the project, discussing the novel observing mode for WEAVE, its benefits to the observing community, the science yield of the proposed twilight survey, and possible future prospects.

My Notes

Poster

PLATOSPec first results from PLATO support facility

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Co-authors:

Abstract
We will present the PLATOSpec project which is designed as ground-based support spectrographs of PLATO space mission. The instrument will be located at E1.52-m telescope at La Silla, Chile. PLATOSpec will have spectral resolving power of 70k and it will be efficient in blue wavelength range to characterise stellar variability. Here, first results from interim spectrograph PUCHEROS+, which is installed within the PLATOSpec project, will be presented. We will present also further plans for reaching better precision to support also validation process of smaller planets.

My Notes

Poster

Binary-planets formation

Author/Speaker: Cecilia Lazzoni, INAF-OAPd, Italy, cecilia.lazzoni@inaf.it

Co-authors:

Abstract

New-generation of high contrast instruments (SPHERE/VLT, GPI/Gemini, SCExAO/Subaru) can be used to unveil features, in the form of giant moons or disks, within the Hill radius of directly imaged substellar objects.

Following a dedicated study on SPHERE observations, we detected a candidate satellite companion of 1 MJup on a 10 au orbit around the low-mass brown dwarf DH Tau B (10 MJup).

More suitable assumptions are needed to model the formation of such giant satellites/planetary pairs, such as gravitational capture.

In this scenario, the two planets, which we assume are formed independently in the circumstellar disk via gravitational instability, become a bound pair due to close encounters during which energy is dissipated through tidal interactions.

Results show that the formation rate for planet-planet pairs can reach a 14% in the gravitational instability scenario, similar to what was presented by previous works such as in Ochiai+2014 for the core accretion models.

My Notes

Poster

DIAmante space-based photometry of the PLATO South Field

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Co-authors:

Abstract

The first long pointing field of PLATO has been recently selected (LOPS2). Accurate characterization of this region of the sky is of great relevance for the preparation and future success of PLATO. It is possible to derive space-based photometry of stars in LOPS2 before the launch of PLATO given that the TESS satellite has repeadetly observed it during the past years. The DIAmante pipeline is based on the difference imaging approach and has already provided accurate photometry of PLATO targets in the past. When coupled with traditional and innovative transit search techniques it has permitted the identification of hundreds of new transiting candidates (Montalto et al. 2020, 2023; Melton et al. 2023a,b,c). Here I present the preparation of a novel set of DIAmante photometric measurements focused on LOPS2. The stars in the field have been selected form Gaia DR3 and include both PLATO targets and contaminant sources down to a preselected PLATO magnitude limit. This set is broader than the one in the target PLATO Input Catalog (PIC; Montalto et al. 2021) both in terms of magnitude limit and in terms of spectral type coverage. The analysis of these light curves with different algorithms will be crucial for the characterization of PLATO targets and their contaminants, for the identification additional targets of scientific interest for PLATO and for the future interpretation of PLATO results.

My Notes

Poster

Optimization of ground-based observing plans for PLATO

Author: Juan Carlos Morales, Institut de Ciències de l'Espai (ICE, CSIC) & Institut d'Estudis Espacials de Catalunya (IEEC), Spain, morales@ieec.cat

Co-authors: Pau Ballber Balagueró, Jordi Portell, Ignasi Ribas, Julien Poyatos (Speaker), Néstor Campos, Eduard Masana, Nami Molawi, Stephane Udry

Abstract

The PLATO mission is expected to discover thousands of planetary systems hosting rocky and gas giant planets that will provide insights into the formation and evolution of such systems, with particular focus on planets orbiting in the habitable zone of their host stars. The exoplanets detected by PLATO by means of the transit method will have to be confirmed with additional observations from ground observatories in order to discard false positive scenarios. Besides such additional observations will also be critical to further characterise the properties of the exoplanets such as their mass. This means that several observational facilities providing for instance high-contrast imaging, and photometric and spectroscopic monitoring of the planet candidate host stars will have to be coordinated. The Ground- based Observations Program (GOP) of PLATO is in charge of the preparation of the tools to analyse the data, the infrastructure to coordinate all the observations, and the gathering of the observational facilities that will participate in the project. At the Institute of Space Studies of Catalonia (IEEC) we are developing the software for the interfaces and communications between the different subsystems, the associated data handling, and the scheduling of the observations. The GOP Operational Centre (GOPOC) will be defined and operated by the IEEC as well, which will act as the physical interface between observing facilities and the PLATO data centre, also providing the necessary computing resources and temporary storage for these observations and their planning. From the one hand, fluent communication will have to be maintained between the PLATO subsystem providing planet candidates, the PLATO data centre, the observatories carrying out the validation observations, and the quality control subsystem. On the other hand, an efficient distribution and planning of the observations on the different facilities will be essential to make the most from every resource. We are developing an automatic scheduling system that will take into consideration the properties of the planets and the vetting strategy, and the capabilities of the facilities to produce optimised plans. This is based on our experience producing scheduling tools for projects aimed at exoplanet discovery and characterization for which monitoring of radial velocities, or follow-up of transits are needed, as part of the Scheduling Telescopes as Autonomous Robotic Systems (STARS) project developed at IEEC. In this talk we will outline the status of this communication and scheduling systems and we will provide details that might be of interest to the community that will be involved in the PLATO follow-up program.

My Notes

Poster

Participation to the PLATO Ground-Based Observation Programme

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Co-authors:

Abstract

The ESA PLATO (PLAnetary Transits and Oscillations of stars) mission aims at the detection and characterisation (radii, mass, density, age) of terrestrial exoplanets in orbits up to the habitable zone around Sun-like stars. To achieve these goals, an optimised complementary Ground-based Observations Programme (GOP) is set up with the purpose to provide the spectroscopic, photometric and imaging observations needed to i) establish the true planet origin of the detected signal (vetting of false positives), and il) accurately measure the mass of the transiting planets (with a goal of 10% precision), that are then combined with the precise radil and system age derived from the PLATO data. The GOP is a fully integrated part of the PLATO mission. Its challenge is to optimally organise observations matching the target needs and determine the corresponding best observing strategy. It will involve the operation of instruments of various types and sensitivities, from small up to the largest telescopes. Participation to these observation activities is fully open to the ESA community and provides a unique opportunity to contribute to the success of the mission. We present here a summary of how the GOP is structured and operated, and provide information about how people can participate to the observational efforts, and what are the requirements and benefits for such a participation.

My Notes

Poster

Searching and investigation of exomoons with using Kepler and TESS databases

Author/Speaker: Anastasiia Nahurna, Taras Shevchenko National University of Kyiv, Ukraine, annaya@knu.ua

Co-authors: Yuliana Kuznyetsova, Iryna Kulyk

Abstract

The study of exoplanet satellites, commonly referred to as exomoons, holds promise in the fields of exoplanet formation, astrobiology, and planetology. Research on planets within the Solar System suggests that satellites play a crucial role in fostering internal activity on Earth-like planets. Consequently, the potential presence of an exomoon orbiting an exoplanet becomes a significant point of interest for investigating the internal differentiation and structure of these celestial bodies. One widely accessible approach involves analyzing the transit of exoplanets across their host star's disk. However, the challenge arises from the limited accuracy of current data, where measurement errors can surpass the subtle deviations in the light curve indicative of an exomoon's presence. In this study, we aim to search for exomoons focusing on confirmed exoplanets with recorded transits in the Kepler and TESS databases. To enhance the exomoon detection capabilities we are taking into account critical factors such as the precise orbital period of the planet, limb darkening, and the star's asteroseismic activity. Addressing these issues constitutes both a challenge and an objective of our research. Looking ahead, we intend to incorporate data from upcoming space telescopes and explore additional detection methods. Specifically, we are interested in examining advanced techniques such as tidal heating of exoplanets (THEM) and others relying on non-transit data types.

My Notes

Poster

Validation of Stellar Radii for M-dwarf Targets in the PLATO Input Catalogue

Author/Speaker: Loredana Prisinzano, INAF-Osservatorio Astronomico di Palermo, Italy, loredana.prisinzano@inaf.it

Co-authors:

Abstract

The ESA M-class PLAnetary Transits and Oscillation of Stars (PLATO) mission will acquire light curves of pre-selected targets included in the PLATO Input Catalogue (PIC). PLATO primarily targets solar-type stars, but low mass stars will also be observed being of great interest within the exoplanet field. One of the target samples outlined in the Science Requirement Document is the P4 sample, consisting of a minimum of 5000 cool late-type M-dwarfs with magnitudes brighter than V=16. The current release of the PIC (version 2.0.0, June 2023) provides also estimates of fundamental stellar parameters, such as effective temperatures, radii, and masses, for M-type stars. Accurate determination of these parameters is crucial for characterizing host stars and subsequently deriving precise masses and radii of orbiting exoplanets. In particular, deriving accurate radii for the M-type stars represents a significant challenge. Direct measurements are feasible only through interferometry, while various methods involving theoretical assumptions often yield radius estimates inconsistent with empirical observations. In this presentation, we will introduce the scientific requirements outlined by the PLATO consortium Working Group 130 for the selection of the P4 sample, as carried out by Working Group 340. In addition we will detail the methodologies employed for the parameter derivation and explore the possible effects of metallicities on the adopted empirical relations. Validation of the adopted stellar parameters is performed through comparison with independent methods from the literature used to determine stellar radii.

My Notes

Poster

Do low metallicity multiple-star system contain giant planets? Large exoplanet relation with stellar Metallicity around G class star.

Author/Speaker: Sumit Roy Pronoy, Shahjalal University of Science & Technology, Bangladesh, sumitroypronoy@gmail.com

Co-authors:

Abstract

Introduction: As more accurate Telescopes and missions are developed, the number of exoplanet detections keep increasing. The characterization of these planets and their statistical investigations are important steps to understand the formation of the planet and planetary system. Additionally metallicity plays a critical role in planet formation mechanisms. An updated version of the parameters for stars and planets from the NASA Exoplanet Archive is used to investigate the relationship between the planet radius and stellar metallicity of massive exoplanets orbiting around G-class stars. Here, we concentrate on planets with radii greater than 6 $R_\oplus$(earth radius), that appear to suggest a probable inverse relationship between radius and Staller metallicity. With declining metallicity and rising planet size, this correlation steepens. Moreover in the case of multiple star system the slope steepens more. Though it has relatively small data points around 95, It contains both low R-squired value(0.07) and low P-value(0.006). Till now the calculation of uncertainty values and the effect of other parameters like density, age, temperature are being analyzed. We separated the values for radial velocity method and transit method of The planet detection. In the case of redial velocity the slope value and p value are respectively -2.19 and 0.028. interestingly in this case, there are just one data with uncertainty value among 65 data points. observed inverse exponential relation may not be fully explained by observational biases alone. More accurate data will be needed for further confirmation.

My Notes

Session: Poster Presentations

Poster

Transmission spectroscopy of WASP-7 b with UVES

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Co-authors: Stefan Czesla, Sara Khalafinejad, Paul Mollière

Abstract

Context. Transmission spectroscopy is a prime technique to study the chemical composition and structure of exoplanetary atmospheres. Strong excess absorption signals have been detected in the optical Na I D1, 2 Fraunhofer lines during transits of hot Jupiters, which are attributed to the planetary atmospheres and allow us to constrain their structure. Aims. We study the atmosphere of WASP-7 b by means of high-resolution transit spectroscopy in the sodium lines. Methods. We analyzed a spectral transit time series of 89 high-resolution spectra of the hot Jupiter WASP-7 b that was observed using the Ultraviolet and Visual Echelle Spectrograph (UVES). We used the telluric lines for an accurate alignment of the spectra and carried out a telluric correction with molecfit. Stellar magnetic activity was monitored by investigating chromospheric lines such as the Ca II H and K, and hydrogen Hα lines. Finally, we obtained transmission spectra and light curves for various lines. Results. The star shows no identifiable flares and, if any, marginal changes in activity during our observing run. The sodium transmission spectra and corresponding light curves clearly show signs of the Rossiter-McLaughlin effect and the stellar center-to-limb variation that we modeled using synthetic spectra. A statistically significant, narrow absorption feature with a line contrast of 0.50 ± 0.06% (at ~8.3σ level) and a full width at half maximum of 0.13 ± 0.02 Å is detected at the location of the Na I D2 line. For the Na I D1 line signal, we derived a line contrast of 0.13 ± 0.04% (at ~3.2σ level), which we consider a tentative detection. In addition, we provide upper limits for absorption by the hydrogen Balmer lines (Hα, Hβ, and Hγ), K I λ7699 Å, Ca II H and K, and infra-red triplet lines.

My Notes

Poster

The PLATO Stellar Variability Working Group (PSVWG)

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Abstract
PLATO aims to detect and characterize small exoplanets around bright stars, down to Earth analogues (i.e. Earth-sized terrestrial planets in the habitable zone of Sun-like stars), with accuracies of 3% and 10% on planet size and mass, respectively. Stellar variability (acoustic modes, granulation, magnetic activity and cycles) is one of the main limitations to the detection and characterization of transiting exoplanets. The objectives of the working group are: 1/ to define and understand the limitations of current state-of-the-art methods for modeling or mitigating stellar variability, and 2/ to provide guidance to PLATO working packages (WP) in the design of algorithms concerning stellar variability. The PSVWG is made up of experts from the Exoplanet Science (WP.11), Stellar Science (WP.12), Target/Field Characterisation & Selection (WP.13) and Ground-based Observation (WP.14) programs. Would you like to find out more about our activities? Come and meet us!

My Notes

Poster

PLATO's photometric retrieval of the tidal deformation of cool stars

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Abstract

The PLAnetary Transits and Oscillations of stars (PLATO) telescope is going to study a large number of extrasolar planetary systems. Given the design of the mission, PLATO will produce long-duration uninterrupted high precision photometry of a significant number of host stars and as a result, PLATO is best suited for phase curve studies of transiting exoplanets. We present a scientific motivation for the observation of short-period, massive transiting exoplanets to better characterization of the host star. The shape and motion of the host star is significantly affected by its planetary companion. The effect becomes larger as the planet to star mass ratio increases. The phase curve of a short-period hot-Neptune or a hot-Jupiter provides information on the tidal shape and orientation of the host star, in addition to its rotational velocity. In this context, we predict the performance of PLATO over such systems with particular focus on the detection of ellipsoidal variations. We studied such systems and computed the signal to noise of the resultant gravity darkening parameter that provides information on the tidal deformation of the star. The study of ellipsoidal variations is going to shine more light on the current stellar models with the need for a refinement on the stellar parameters with spherically asymmetric models.

My Notes

Poster

Habitability study of the exoplanets by characterizing their atmospheres

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Co-authors:

Abstract

It is the optimal time to characterize the Earth-like exoplanets to detect biosignatures beyond the Earth because such exoplanets will be the prime targets of big-budget missions like JWST, HabEx, LUVOIR, ELT, HWO, etc. We modelled the phase curves of albedo and disk-integrated polarization by using appropriate scattering phase matrices and integrating the local Stokes vectors over the illuminated part of the disks along our line of sight. For this, we solved the 3D vector Radiative-Transfer equations numerically. We also provide models for the Transmission and Reflection spectra for present and prebiotic(3.9 Ga) Earth-like exoplanets orbiting within the Habitable-Zone of stars of different spectral types. Potential biosignatures molecules acting as greenhouse agents are incorporated in our models. Various combinations of solid and liquid materials such as ocean, coast, land consisting of trees, grass, sand or rocks determine the surface albedo of the planet. Geometric albedo for nine potentially habitable planets, including Proxima Centauri b, TRAPPIST-1d,e and Teegarden's Star-b, are also included. We employ the opacity data derived by using the open-source package Exo-Transmit and adopt different atmospheric Temperature-Pressure profiles depending on the properties of the terrestrial exoplanets. We present the effects of globally averaged surface albedos (consisting of ocean, coast, land etc.) on the reflection spectra and phase curves as the surface albedo significantly dictate these observational quantities. We also note the effects of clouds and inclination angle on the observable parameters. Synergic observations of the spectra and phase curves will certainly be useful in extracting more information and reducing the degeneracy among the estimated parameters of terrestrial exoplanets. Thus, our models will play a pivotal role in driving observations for the search of habitable worlds.

My Notes

Poster

A low-mass sub-Neptune planet transiting the bright active star HD 73344

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Abstract

Planets with radii between 2-4 times that of Earth, closely orbiting solar-type stars, offer a unique window into the transition from rocky to giant planets.They are prime targets for atmospheric characterization using missions such as JWST and ARIEL. However, only a limited number of such planets, with accurately measured masses, are known to orbit bright stars. In this study, we confirmed the detection of a candidate planet orbiting at Pb~15 days around the very bright star HD 73344 (Vmag~6.9) using photometric observations from K2, TESS and Spitzer. In addition, we analyzed the large amount of radial velocity (RV) observations we made during an intensive multi-year campaign with the SOPHIE/OHP and HIRES/Keck spectrographs. Despite the transiting planet orbits a bright star at a short period, challenges posed by stellar activity hindered precise mass measurements despite intensive RV monitoring efforts. We propose a new observing strategy, targeting the star at high cadence, and show that this can provide better constraints on stellar variability and improve mass characterization. The latter will be essential if we are to characterize the atmosphere of planets around F-type stars using transmission spectroscopy.

My Notes

Session: Poster Presentations

Poster

On the effect of star spots on transit detection in the context of PLATO

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Abstract

The effects of star spots on the detectability of transiting exoplanets is not well understood across stellar types and transit depths. I will present work done on simulating light curves for a range of stellar parameters and planet orbital parameters relevant to the upcoming PLATO mission. These simulations include realistic, time-evolving, star spot distributions across the stellar surface, and include transit signals across the spotted stellar surface. We performed injection recovery tests and transit modelling on simulated light curves with and without the spot model to investigate the effect of the star spot induced variability on the detectability of transit signal, and biases in the recovered orbital parameters due to modifications in the transit shape induced by the star spots.

My Notes