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Abstract book

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Session A
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The PLATO Mission – An Overview

Heike Rauer*[1] and Pmc Plato Consortium Team

[1]German Aerospace Center (DLR) – Germany

Abstract

PLATO (PLAnetary Transits and Oscillations of stars) is ESA's M3 mission and designed to detect and characterize extrasolar planets by high-precision, long-term photometric and asteroseismic monitoring of a large number of stars. PLATO will detect small planets around bright stars, including terrestrial planets in the habitable zone of solar-like stars. With the complement of radial velocity observation from ground, planets will be characterized for their radius, mass, and age with high accuracy. PLATO will provide us with a large-scale catalogue of well-characterized small planets up to intermediate orbital periods, relevant for a meaningful comparison to planet formation theories and to better understand planet evolution. It will make possible comparative exoplanetology to place our solar system planets in a broader context. In parallel, PLATO will study (host) stars using asteroseismology, allowing us to determine the stellar properties with high accuracy, substantially enhancing our knowledge of stellar structure and evolution. PLATO is scheduled for a launch date end 2026. Development of the spacecraft and the payload, which includes the serial production of its 26 cameras, has started. This presentation will provide a general overview of the PLATO goals and its expected science and instrument performance.

*Speaker

Why Exoplanets need stars...

Don Pollacco*[1]

[1]University of Warwick – United Kingdom

Abstract

Understanding PLATO stars is vital to our understanding of our planets. This is because we don't actually "see" our planets directly and need to infer properties from measurements of the star. Here we will look at what stellar parameters are needed in the exoplanet analysis and what the expected accuracies/limitations this will leads too.

*Speaker

PLATO Spacecraft: status and overview

Laura León Pérez*[1], Andrea Sacchetti[1], Frank Steier[1], Carsten Reese[1], Oliver Nicolay[1], Anneke Monsky[1], Filippo Marliani[2], Thomas Walloschek[2], and Ian Harrison[2]

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Abstract

The PLAnetary Transits and Oscillations of stars (PLATO) spacecraft is currently in preparation to complete the Spacecraft Critical Design Review by Q1 2024.
This presentation introduces the Spacecraft design, which was consolidated at the Critical Milestone Review in January 2022, and the extensive qualification test campaigns of the Spacecraft Structural Model. The PLATO Spacecraft design is based on a modular concept consisting of the Service Module (SVM) and the Payload Module (PLM) allowing for a high thermal and mechanical decoupling of the two modules and a parallel design and manufacturing approach.

The SVM design is based on standard technologies, while the PLM design is aimed for high thermo-elastic stability. The PLM has been mechanically and thermally qualified, including thermo-elastic deformations measured by multi-channel interferometers. This has demonstrated the satellite performance to be compliant to the challenging pointing stability requirements needed for the PLATO scientific purpose. Along Q2 and Q3 2023, the complete spacecraft structural model (SVM+PLM) will undergo the mechanical qualification test campaign and model correlation activities.
The spacecraft design summary and test results of the qualification test campaigns to date will be included in this presentation.

*Speaker

PLATO Payload and Ground Segment status

Ana Heras*[1]

[1]ESA - ESTEC – Netherlands

Abstract

We will present a summary of the status of the payload and ground segment development. The manufacturing, integration, and tests of the PLATO cameras flight models has started, with the plan to complete the production of the 26 cameras by the end of 2024. Camera Engineering Model tests have confirmed that the optical performance meets the requirements. The Engineering and Qualification Models of the electronic units are under assembly or delivered. In parallel, the definition of the Ground Segment and of the mission operations is progressing nominally towards the next major milestone, the Ground Segment Design Review, that will take place in the first quarter of 2024.

*Speaker

Session B1

Stellar inferences: Seismic analyses

Seismic detection of solar-like oscillations and power spectrum analyses	Othman Benomar (Review)
Seismic detection of stellar activity cycles	Anne-Marie Broomhall (Invited)
Detection and measurement of strong magnetic fields in the core of red giant stars	Sebastien Deheuvels (Invited)
Next generation peakbagging tools for Plato.	Martin Nielsen

Seismic detection of solar-like oscillations and power spectrum analyses

Othman Benomar*[1]

[1]NAOJ, Mitaka – Japan

Abstract

Asteroseismology has revolutionized our understanding of stellar astrophysics. By allowing us to measure characteristics of modes, asteroseismology reveals the stellar interior and allows us to probe the star's physics.
In this talk, we will review the successes and difficulties of seismic detection using CoRoT, Kepler, and TESS instruments, with a particular focus on solar-like stars, which includes F, G, and K giant stars. We will discuss the challenges faced by the asteroseismic community regarding the detection of pulsations, the mode identification, and the measurement of stellar rotation for these stars.

While detecting pulsations is nowadays a relatively simple and reliable process, mode identification, which is essential for determining the physical properties of the modes (e.g., regions probed in the interior), remains a delicate, complex, and sometimes a time-consuming issue. The measurement of stellar internal rotation all along the HR-diagram is crucial for understanding the evolution and angular momentum transport in stars.
The PLATO mission will present new challenges for asteroseismology, such as the need to process data volumes that are several times greater than previous missions combined. In this context, the development of new advanced tools that can overcome the data scale issue is crucial to achieve the scientific goals of the mission. We will briefly discuss the methods and tools that will be required to achieve this with PLATO.

*Speaker

Seismic detection of stellar activity cycles

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Abstract

The properties of the Sun's internal acoustic oscillations (p modes) are known to vary through the solar magnetic activity cycle. Easiest to detect are the changes in p-mode frequencies, which vary in phase with the level of magnetic activity. However, variations in powers, damping rates and excitation rates have also been observed and such variations imply that the internal magnetic field is impacting the convection. Similar behaviours, for at least the oscillation frequencies and powers, have also been observed in a number of Kepler stars. This talk will provide details of how these variations have been detected previously, and will discuss the potential of PLATO for detecting similar variations in the future.

*Speaker

Detection and measurement of strong magnetic fields in the core of red giant stars

Sebastien Deheuvels*[1]

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Abstract

Magnetic fields are at the heart of most burning questions in stellar physics. In particular, they are expected to play a central role in the transport of angular momentum and chemical elements in stellar interiors. While surface magnetic fields have been detected and characterized in stars across the HR diagram, internal magnetic fields have long remained inaccessible to direct observations. Over the last decade, the seismology of red giants has proved to be a very powerful tool to test stellar physics, mainly thanks to the detection of mixed modes, which probe both the envelope and the deep core. Here, we present the first direct detections of magnetic fields in the cores of red giants. Magnetic fields induce perturbations in the oscillation modes. In particular, they break the symmetry of rotational multiplets. Besides, strong fields can also modify the usual regularity of g-mode periods. We detected both of these effects in the dipole mixed modes of over 20 red giants observed with the Kepler satellite and we have shown that their characteristics closely match those expected in the presence of strong core magnetic fields (Li et al. 2022, Deheuvels et al. 2023). We thus measured field intensities ranging from a few tens to a few hundreds of kilogauss in the core of these stars, and we placed constraints on the topology of these fields. These results constitute a key step toward a consistent modeling of the effects of magnetic fields in stellar evolution models.

*Speaker

Next generation peakbagging tools for Plato.

Martin Nielsen*[1], Guy Davies[1], Emily Hatt[1], Ong Joel[2], and Bill Chaplin[1]

[1]University of Birmingham [Birmingham] – United Kingdom
[2]Institute for Astronomy [Honolulu] – United States

Abstract

To fully leverage the data from the thousands of solar-like oscillators expected from Plato we need new methods for performing asteroseismic analysis. Here we present the pipeline proposed for the Plato asteroseismic analysis. This probabilistic method can produce generative models of the spectra of solar-like oscillators for main sequence, sub-giant and low-luminosity red giants. Our method accurately accounts for the frequency dependent coupling between each combination of gravity and pressure dominated modes through the different evolutionary phases. This approach significantly increases the complexity of the spectrum models, and we therefore employ a PCA-based dimensionality reduction method to simplify the sampling process. This utilises the large quantities of previous measurements of many of the model parameters, to construct a prior probability density in a lower-dimensional latent space. Extending this beyond Plato, this methodology can allow us to build more elaborate models of solar-like oscillators, such as including treating rotation and magnetic field effects.

*Speaker

Session B2

Stellar inferences: Seismic inferences of stellar properties

Modelling of solar-like oscillators: ensemble analyses and detailed inferences	Gaël Buldgen (Review)
Mixed modes	Masao Takata (Invited)
Constraints from Glitches	Kul Deep Verma (Invited)
Mixed-mode period spacing as a probe of magnetic fields in red giant cores	Lisa Bugnet
A star seen as a multi-cavity acoustic interferometer: a novel approach to develop seismic diagnostic	Charly Pinçon
Towards a Comprehensive Characterization of Grid Interpolation in the context of Grid-based Modelling	Miguel Clara
Hare&Hounds Exercise for Stellar Ages and Masses in the Context of FGK Stars with and without Asteroseismology.	Diego Bossini
Sound speed inversions of an ensemble of low-mass main-sequence stars	Lynn Buchele
Circumventing surface effects for a precise and accurate stellar characterization in the PLATO era	Jérôme Bétrisey

Modelling of solar-like oscillators: ensemble analyses and detailed inferences

Gaël Buldgen*[1]

[1]Observatoire Astronomique de lÚniversité de Genève – Switzerland

Abstract

In this review, I will discuss the various existing techniques used to carry out asteroseismic modelling of main-sequence solar-like oscillators. I will present the existing solutions to study large samples for which a limited amount of data is available, the limitations of these approaches and dive into more detailed inference techniques achievable for the best existing targets. For such detailed approaches, the choice of seismic constraints, the combination of on-the-fly computations and grid-based inferences, the non-seismic parameters as well as the effects of physics variation are of relevance to the details of accuracy and precision that can be achieved. For such rich datasets, I will cover both techniques relying evolutionary model fitting or inversion techniques based on the variational formalism and discuss perspective for future approaches.

*Speaker

Mixed modes

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Abstract

Mixed modes of stellar oscillations are normally defined as eigenmodes that consist of two different types of waves, acoustic waves in the envelope and gravity waves in the core. These modes play a major role in seismology of red giants because they allow us to access to both of the core and envelope structure of the stars. In fact, they have led to some highlights including those about evolutionary status, rotation and magnetic fields. In this presentation, some recent topics of mixed modes are introduced. The targets include not only red giants, but also subgiants and main-sequence stars.

*Speaker

Constraints from Glitches

Kul Deep Verma*[1]

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Abstract

The pressure waves trapped inside a solar-type star sense almost the whole medium, and hence their measured properties such as the oscillation frequencies carry detailed information about different layers in the stellar interior. In particular, the frequencies contain small but detectable signatures of the so-called acoustic glitches, the regions of abrupt variation in the sound speed or its derivatives, which can be used to tightly constrain the properties of the regions they originate. For instance, the glitch signatures can be used to measure the locations of the helium ionization zone and the base of the envelope convection zone independent of the stellar evolution models. In this talk, I will summarize the constraints we can obtain on the internal stellar structure and fundamental stellar properties by analysing the helium and convection zone glitch signatures using different theoretical formalisms. Subsequently, I shall demonstrate how the measured helium glitch properties can be used together with the frequency ratios and other classical observables with all the correlations properly taken into account to infer stellar properties including the mass, radius and age precisely. This approach largely avoids the issues related to the surface-effect and, as we shall see, it provides more accurate inference of the stellar helium abundance, and hence also the stellar mass and age.

*Speaker

Mixed-mode period spacing as a probe of magnetic fields in red giant cores

Lisa Bugnet*[1]

[1]Institute of Science and Technology [Klosterneuburg, Austria] – Austria

Abstract

The detection of buried magnetic fields in evolved solar-like stars has very recently been made possible through the measurement of their impact on the oscillations of stars. It is fundamental to detect more of these magnetized red giants, to understand the angular momentum transport along the evolution of solar-like stars, and how the internal magnetic field impacts the dynamo field in the convective envelope. However, the task of internal magnetic detection in a significant number of evolved stars remains challenging as the mixed-mode frequency pattern is highly complex and affected by rotational effects, while modes of different radial orders are often intertwined. This talk aims to build a bridge between theoretical prescriptions on magnetized oscillations and asteroseismic data analysis to facilitate a future automatized search of magnetized stars. We investigate the effect of magnetic fields inside evolved stars with solar-like oscillations on the estimation of the period spacing of gravity-mode components of simulated mixed gravito-acoustic modes. We demonstrate that the strong dependency of the amplitude of the magnetic signature on oscillations with the frequency leads to biased estimates of gravity-mode period spacings towards lower values. Therefore, we derived a new corrected stretching function of the power spectrum density to account for the presence of magnetic signatures on their frequencies. We then show that a global analysis of the oscillation frequency pattern through various period spacing estimates and across a broad frequency range leads to measurements of magnetic field amplitudes inside the core of red giants, leading to the first asteroseismic global parameter proven to carry detectable magnetic signatures. This method can be applied widely to the thousand red giants observed with good frequency resolution by *Kepler* and paves the way towards the understanding of deep magnetic activity in stars.

*Speaker

A star seen as a multi-cavity acoustic interferometer: a novel approach to develop seismic diagnostic

Charly Pinçon*[1]

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Abstract

A star seen as a multi-cavity acoustic interferometer: a novel approach to develop seismic diagnostic

The seismic data collected by the space-borne missions CoRoT, *Kepler,* and TESS, have already brought stringent constraints on the structure of low- and intermediate-mass stars. Beyond the improvement in the determination of fundamental stellar parameters (e.g., mass, radius, age), asteroseismology has also given insights into the internal dynamics of these stars, as for instance rotation or convective-radiative boundary mixing, opening a new era for the theory of stellar structure and evolution. These advancements have been made possible thanks to the development of seismic diagnostics, which enable us to analyze, predict and interpret the oscillation spectra of stars. However, all the richness of these observations has not been fully explored yet. As a striking example, we can note the recent measurement of internal magnetic fields in a few red giant stars observed by the satellite *Kepler*, and more surprises are still expected for the future. With the PLATO mission in our line of sight, it is now time to pave the way toward a more detailed probing of the oscillation spectra, at the limit of the measurement capabilities. In this work, we show how the general formulation of the stellar eigenfrequency spectra proposed by Pinçon & Takata (2022) can help develop new or reinforce previous seismic diagnostics. In this general picture, a star is described as a multitude of resonant cavities separated by reflective barriers (i.e., evanescent coupling regions or sharp variations in the reference propagation medium). The wave reflection-transmission problem around these so-called barriers is studied using either simple analytical toy models or numerical solvers when considering a realistic acoustic structure. We demonstrate how useful and practical is this approach. In particular, the case of mixed mode in subgiant stars, which represent thousands of targets in the PLATO prime sample, and in red giants stars will be addressed.

*Speaker

Towards a Comprehensive Characterization of Grid Interpolation in the context of Grid-based Modelling

Miguel Clara*[1,2], Margarida Cunha[1], Tiago Campante[1,2], Sebastien Deheuvels[3], Daniel Reese[4], and Pedro Avelino[1]

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[4]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Institut National des Sciences de l'Univers, Observatoire de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique, Université Paris Cité – France

Abstract

Grid-based modelling techniques have been shown to enable the determination of stellar properties with a significant accuracy, justifying their use in the context of data exploitation from space missions like Kepler, TESS or PLATO as a way to better constrain stellar evolution models.

In this context, the subgiant phase is both particularly interesting and challenging. Indeed, changes to the stellar structure allow the emergence of mixed modes, whose frequencies are characterized by a fast evolution with age, which can potentially allow the determination of stellar properties with great precision. However, current modelling techniques consider stellar grids that lack the necessary resolution to properly account for the fast mode frequency evolution, and require an interpolation algorithm to cover the parameter space in between the grid models when applying model-data comparison methods. The errors resulting from the interpolation of non-radial modes across different masses in a typical grid of subgiant models can be as high as a few tens of muHz (this is up to 2 orders of magnitude higher than the observational errors in some stars).

In this presentation, we characterize the problem of frequency interpolation in the subgiant phase, and explore several possibilities to improve on the current procedures. We discuss the advantages of considering central density as the age proxy of interpolation over age, and cubic polynomial interpolation over linear, while interpolating along and across evolutionary tracks with different masses, quantifying the errors obtained with the different algorithms. We also discuss possible improvements resulting from the application of a variable transformation to the system, proposing a new age proxy for interpolation.

*Speaker

Hare&Hounds Exercise for Stellar Ages and Masses in the Context of FGK Stars with and without Asteroseismology.

Diego Bossini*[1]

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

Abstract

Accurate and precise determination of the global properties, such as ages and masses of stars, is a fundamental step in order to characterize the host-planet systems. The advanced techniques offered by Asteroseismology have given us fundamental additional constraints that enormously increased our ability to model those stars. However the derived quantities are usually presented in literature case-by-case (i.e. once a planet candidate is detected). This results in a non-homogeneous census of stars, caused by the use of different optimization methods coupled with several input physics adopted in stellar models. Therefore many tests have been performed with the aim of identifying and assessing the impact on the derived stellar properties of several pipelines. Nevertheless many of the targets in the PLATO mission will not benefit from the advantage of having asteroseismic data. In this talk we present the team effort by the Stellar Age-Mass-Radius sub-WG of the Ariel Consortium for evaluating the accuracy of FGK stars on mass and age using several pipelines to estimate stellar properties, by data comparison with pre-computed grids of evolutionary tracks. A forward modeling hare-and-hounds (H&H) exercise was conducted using 5 optimizations pipelines (BASTA, CLES-on-the-fly, Isochrone Placement, PARAM, AIMS/SPinS) and 5 different stellar evolution grids (BaSTI, CLES, GARSTEC, MESA, PARSEC), deriving stellar properties from sets of observational constraints with and without seismology. This will in turn allow us to evaluate the accuracy of the results and reliability of the associated error bars. A benchmarking exercise and the release of consolidated stellar properties was also conducted.

*Speaker

Sound speed inversions of an ensemble of low-mass main-sequence stars

Lynn Buchele*[1,2], Earl Bellinger[3], Saskia Hekker[1,2], and Sarbani Basu[4]

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[2]Heidelberg University – Germany
[3]Max-Planck-Institut für Astrophysik – Germany
[4]Yale University [New Haven] – United States

Abstract

Even the best asteroseismic models of solar-like oscillators show significant differences from the observed oscillation frequencies. Structure inversions seek to use these frequency differences to infer the underlying structure differences. While used extensively to study the Sun, sound speed inversion results for other stars have so far been limited. Applying sound speed inversions to a broader set of stars allows us to probe stellar theory over a larger range of conditions, as well as look for overall patterns that may hint at deficits in our current understanding. To that end, we present inversion results for 15 main-sequence stars with radiative cores. We find several cases where the inversions reveal significant differences between the sound speed profile of the star and that of its model. Furthermore, we note a trend across the ensemble for the sound speed in the cores of our stellar models to be lower than those in actual stars. We examine whether changing the microphysics of our models improve them.

*Speaker

Circumventing surface effects for a precise and accurate stellar characterization in the PLATO era

Jérôme Bétrisey*[1], Gaël Buldgen[1], and Daniel Reese[2]

[1]University of Geneva – Switzerland

[2]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Institut National des Sciences de l'Univers, Observatoire de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique, Université Paris Cité – France

Abstract

Asteroseismic modelling will be part of the pipeline of the PLATO mission and will play a key role in the mission precision requirements on stellar mass, radius and age. It is therefore crucial to compare how current modelling strategies perform, and discuss the limitations and remaining challenges for PLATO, such as the so-called surface effects, the choice of physical ingredients, and stellar activity. In this context, we carried out a systematic study of the impact of surface effects on the estimation of stellar parameters (Bétrisey et al. submitted to A&A). In this work, we demonstrated how combining a mean density inversion with a fit of frequencies separation ratios can efficiently damp the surface effects and achieve precise and accurate stellar parameters for ten *Kepler LEGACY* targets, well within the PLATO mission requirements.

We applied and compared two modelling approaches, directly fitting the individual frequencies, or coupling a mean density inversion with a fit of the ratios, to six synthetic targets with a patched 3D atmosphere from Sonoi et al. (2015) and ten actual targets from the *LEGACY* sample. The fit of the individual frequencies is unsurprisingly very sensitive to surface effects and the stellar parameters tend to be biased, which constitutes a fundamental limit to both accuracy and precision. In contrast, coupling a mean density inversion and a fit of the ratios efficiently damps the surface effects, and allows us to get both precise and accurate stellar parameters. The average statistical precision of our selection of *LEGACY* targets with this second strategy is 1.9% for the mass, 0.7% for the radius, and 4.1% for the age, well within the PLATO requirements. Using the mean density in the constraints significantly improves the precision of the mass, radius and age determinations, on average by 20%, 33%, and 16%, respectively.

This high precision is very promising for PLATO and leaves some margin for other unaccounted systematics such as the choice of the physical ingredients of the stellar models or the effects of stellar activity.

*Speaker

Session B3

Stellar inferences: Stellar Rotation & Activity

Measuring stellar rotation and magnetic activity from photometric time-series	Angela Santos (Review)
Asteroseismology as a way to calibrate Rossby number and gyrochronology relations for field stars	Enrico Corsaro (Invited)
Stellar flares with PLATO	Stefanie Raetz
A landscape of main sequence star activity	Lucie Degott
Evolution of magnetic activity of solar-like stars with age: deriving magneto-(gyro-)chronology relations for PLATO	Savita Mathur

Measuring stellar rotation and magnetic activity from photometric time-series

Angela Santos*[1]

[1]Instituto de Astrofísica e Ciências do Espaço, U. Porto – Portugal

Abstract

In the last decade or so, space-based photometric data have become pivotal for measuring stellar rotation and magnetic activity in solar-like stars. The presence of active regions at the stellar surface leaves a signature in the stellar brightness. Particularly, the crossings of dark magnetic spots, which co-rotate with the surface, lead to quasi-periodic brightness variations, known as rotational modulation. In addition, white-light flares, which are sudden increases of brightness, can also shed light on the magnetic properties of the stars and the environment around them. Therefore, photometric observations, such as those collected by Kepler, TESS, and future PLATO, can enable us to retrieve information on surface rotation and magnetic activity. This is in addition to the seismic signatures that will be addressed in Session B of this conference. In this talk, I will review the different diagnostics and methodologies that have been developed to retrieve rotation periods and proxies of magnetic activity from long-term brightness variations. I will also discuss the limitations of the methods and observations, particularly observational biases. The instrumental artifacts and their impact on the rotational analysis will also be addressed. Additionally, I will summarize what we have learned with previous space-based photometric missions and open questions that still remain, for which PLATO can help provide answers.

*Speaker

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Asteroseismology as a way to calibrate Rossby number and gyrochronology relations for field stars

Enrico Maria Nicola Corsaro*[1]

[1]INAF - Osservatorio Astrofisico di Catania – Italy

Abstract

In this talk I will discuss how asteroseismic-based results on stellar structure and evolution can be used to infer important properties on the stellar dynamics for a wide range of stars in the main sequence. In particular, I will show the recent results about the calibration of a relation to predict the stellar convective turnover time, hence its Rossby number, starting from our knowledge of the color index. This is a powerful relation that can be used to obtain insights on the dynamo action that operates inside the stars. In the remainder of the talk, I will present a preliminary attempt to calibrate gyrochronology relations using ages from stars in the field, and by comparing the result with one based on cluster stars. With the advent of the ESA PLATO mission we will have the opportunity to refine and improve these relations by exploiting a much larger sample of seismic stars that can be used for calibration and testing, hence to infer more reliable results for a wider range of stellar fundamental properties of e.g. mass, age, and metallicity.

*Speaker

Stellar flares with PLATO

Stefanie Raetz*[1], Beate Stelzer[1], Giovanni Bruno[2], Krisztián Vida[3], Dax Feliz[4], Keivan Stassun[5], and Róbert Szabó[3]

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[4]American Museum of Natural History – United States
[5]Vanderbilt University, Department of Physics and Astronomy – United States

Abstract

Stellar flares are powerful localized eruptions caused by magnetic reconnection events in a star's magnetosphere that can be seen across the entire electromagnetic spectrum. Over short timescales of minutes to a few hours, they emit energies up to 10ˆ38 erg.
Flares are important diagnostics for our understanding of coronal physics as well as the evolution of planetary atmospheres. While flares with energies > 10ˆ34 erg can lead to an erosion of the ozone layer of the planet's atmosphere when they occur frequently enough, a minimum flare frequency and energy might be required to trigger chemical reactions that are necessary for the development of life.
The PLATO mission with its unprecedented precision, short cadence and long observational baseline, is ideally suited to study stellar white-light flares in up to now unrivaled detail. Flares will be identified
within the PLATO pipeline MSAP1 with a code developed by the PLATO WP 123 700 ("Stellar flares") both in order to remove stellar variability from the light curves and to extract astrophysically important information. The first prototype of the code was already delivered to the PDC.
In this talk I provide a brief summary of the work carried out in the PLATO WP and I will show examples of applications of the flare detection algorithm we develop for MSAP1 to selected stellar samples, e.g. the 10pc M dwarf sample or the Kepler Superflare sample. Furthermore, I will show how the derived flare properties help to estimate the effects of flaring on the habitability of exoplanets.

*Speaker

A landscape of main sequence star activity

Lucie Degott*[1,2], Frederic Baudin[1], and Reza Samadi[2]

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Abstract

Stellar activity remains poorly understood: we need to improve our understanding of spot characteristics (total area, lifetime...), of magnetic cycles and its dependence on the internal structure of stars and more generally the different stellar parameters and their evolution.

We propose to characterize this activity using the signature of the magnetic structures in the light curves of the Kepler mission, in the Fourier domain. For this, we revisit the model of Harvey et al. (1985) in order to take into account all the components present in the power spectra (surface covered by the spots, their lifetime, the transits...). After validating this model with simulated light curves, we present the results from thousands of Kepler light curves of main-sequence stars used by McQuillan (2014). The results show the emergence of different regimes of activity related to rotation period, mass, Rossby number, with very good statistics.

This opens new perspectives for the study of stellar activity in the frame of the future PLATO mission thanks to its capacities in photometric precision and stellar characterization.

*Speaker

Evolution of magnetic activity of solar-like stars with age: deriving magneto-(gyro-)chronology relations for PLATO

Savita Mathur*[1,2], Zachary R. Claytor , Angela R.g. Santos , Rafael A. Garcia , Louis Amard , Lisa Bugnet , Enrico Corsaro , Alfio Bonnano , Sylvain Breton , Diego Godoy-Rivera , Marc H. Pinsonneault , and Jennifer Van Saders

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[2]Universidad de La Laguna (ULL) – S/C de Tenerife Spain, Spain

Abstract

It is known that for a star like the Sun, rotation and magnetic activity evolve with age. Indeed, in 1972, Skumanich showed that on the main sequence, a solar-like star spins down and becomes less magnetically active with age. Such evolution opened the possibility to use rotation and magnetic activity as stellar clocks, known as gyrochronology for the former and magneto chronology for the latter. While these relations have been based on spectroscopic indexes such as CaHK and spectropolarimetric observations from surveys, the sample used is still small with up to a few thousands of stars.

The recent catalog of rotation periods and photometric magnetic activity proxies for more than 55,000 stars observed by the Kepler mission is a goldmine to study the evolution of magnetic activity of solar-like stars. Using stellar models that include angular momentum evolution, we computed ages for the full sample of stars. We investigated relations between Sph, a photometric magnetic activity index, stellar ages as well as other stellar fundamental parameters (such as luminosity, metallicity, rotation periods). Such analysis is based on two different methods: a Bayesian fit of analytical relations and a Random Forest (RF) regressor. While our results depend on the stellar models used, the methodologies can be performed with other stellar models. In this talk, I will show the promising results found to predict ages using these methods with up to 5-6% median differences between the predictions and the stellar models. In particular, we show that adding the magnetic activity proxy, Sph, as input improves the age prediction. Our results are now being implemented in the PLATO stellar analysis system.

*Speaker

Session B4

Stellar inferences: Inference of fundamental parameters

Challenges in inferring fundamental spectroscopic stellar parameters	Sérgio Sousa (Review)
Effect of stellar magnetism on limb darkening	Nadiia Kostogryz
Building blocks of rocky planets: trends in chemical make-ups of M dwarfs in comparison with brighter FGK dwarfs	Haiyang Wang

Challenges in inferring fundamental spectroscopic stellar parameters

Sérgio Sousa*[1]

[1]Intituto de Astrofísica e Ciências do Espaço – Portugal

Abstract

Fundamental stellar parameters are key for the understanding of many different fields in Astrophysics. There are several techniques available that can be used to characterize fundamental stellar parameters. Spectroscopy is one of the best keys to unlock the fundamental properties of the stars, mostly inferred based on the study of their atmosphere layers. Here we start by a brief description of the procedure of a well established spectroscopic analysis method based on line by line analysis. This method has been used for several years to derive homogeneous spectroscopic stellar parameters, mostly focused in the study of planet-host stars but not only. We present how these parameters compare with others derived with different spectroscopic analysis methodologies and show where these methods are more and less reliable. One of the problems is to accurately constrain the stellar surface gravity and we show how we can use asteroseismology and astrometry to constrain and improve its determination and access its dependence with other spectroscopic parameters. Finally it is mentioned some methods to approach the challenge of characterizing the coller M dwarf stars.

*Speaker

Effect of stellar magnetism on limb darkening

Nadiia Kostogryz*[1] and Alexander Shapiro[2]

[1]Max-Planck-Institut für Sonnensystemforschung – 37077 Göttingen, Germany
[2]Max-Planck-Institut fur Sonnensystemforschung – Germany

Abstract

Transit light curves are affected by host star darkening towards the limb, impacting transit profile and depth. Thus, accurate determination of planetary radii and atmospheric composition requires solving the problem of limb darkening for stars with different parameters. However, there is a conundrum: multiple observations show significantly brighter stellar limbs as compared to all available stellar models.
We propose that neglecting surface stellar magnetic fields is the main issue in models of the limb darkening. Magnetic fields form within stars and emerge on their surface. Here, we focus on small-scale concentrations of surface magnetic field that create a rather uniform network on stellar surface. We simulated it using 3D radiative magnetohydrodynamics (MHD) code MURaM and radiative transfer code MPS-ATLAS. We found that including this network in our simulations allows reproducing stellar limb darkening deduced from the observations of Kepler and TESS transits, thus reconciling models and observations.
The dependence of limb darkening on stellar surface magnetic field offers a fascinating prospect for measuring magnetization of stars with transiting planets. This method is especially promising since it is sensitive to small-scale fields, which in the exemplary case of the Sun play a crucial role in the total magnetic flux, and, thus, are important for comprehending stellar dynamo and star-planet interaction. All in all, the limb darkening approach presents an intriguing possibility to measure stellar magnetic fields using the upcoming PLATO mission, which is projected to discover numerous transiting planets.

*Speaker

Building blocks of rocky planets: trends in chemical make-ups of M dwarfs in comparison with brighter FGK dwarfs

Haiyang Wang*[1] and Sascha Quanz[1]

[1]Institute for Particle Physics and Astrophysics [ETH Zürich] – Switzerland

Abstract

In the Solar vicinity, M dwarfs dominate the stellar population and over half of them potentially host rocky planets. Stellar elemental abundances are crucial for understanding the properties of these planets, but they are yet scarce for M dwarfs due to challenges related to pervasive molecular bands that severely distort the spectral continuum in the optical wavelength range.

Here we compile the elemental abundances of a sample of up to 43 M dwarfs, which are measured in the near-infrared wavelength range where the molecular lines are greatly reduced. We investigate them in the (X/H) vs. (Fe/H) space to identify statistical trends, which can be used to estimate the abundances of major rock-forming elements (e.g. O, Mg and Si), given available (Fe/H) information.

Based on bootstrap-based linear regressions on the yet-limited sample of M dwarfs we derive M-dwarf (X/H)-(Fe/H) trends, which we compare with such trends of a population of FGK dwarfs based on the GALAH survey. We find that the (X/H)-(Fe/H) trends are not always consistent for major rock-forming elements between the two samples of stars. To account for the effect of Galactic Chemical Evolution, we also compare the trends in the (X/Fe) vs. (Fe/H) space and find similar discrepancies between cooler M dwarfs and Sun-like stars. If these discrepancies are physical it may suggest that inferring M dwarf stellar abundances based on solar or solar-type stellar abundances – a usual practice in the studies of star-planet chemical connections – may place incorrect constraints (e.g. C/O, Mg/Si, and Fe/Mg) on characterising rocky worlds around M dwarfs. While an increasing set of precise measurements of M dwarf stellar abundances are recommended, our analysis offers an intermediate step in constraining the plausible chemical compositions of M-dwarf planet hosts (given available (Fe/H)). This enables a population-level analysis of the properties of M dwarfs planets, for which mass and radius measurements are also available. In addition to increasing our knowledge of the diversity of rocky worlds around M dwarfs, such studies will pave the way towards investigating rocky worlds around brighter, Sun-like stars – a territory of research empowered by the PLATO mission.

*Speaker

Session B5

Stellar inferences: Benchmark stars

Benchmark stars in the PLATO LOP fields	Pierre Maxted (Review)
Gaia Benchmark Stars	Caroline Soubiran (Invited)
Gyrochronology from clusters	Sydney Barnes (Invited)
Wide binaries as co-eval probes of the rotational evolution of low-mass stars	Diego Godoy-Rivera

Benchmark stars in the PLATO LOP fields

Pierre Maxted*[1]

[1]Keele University – United Kingdom

Abstract

Stars that have precise, accurate and independent measurements of their fundamental properties will be essential to quantify the precision and accuracy of stellar parameters in the PLATO data products. The benchmark stars work package WP125500 have identified several types of star that will be useful for benchmarking PLATO data products, e.g., eclipsing binaries, transiting hot Jupiter systems, nearby stars with directly measured angular diameters, etc. In this talk, I will review the different types of benchmark star and give some preliminary results for the number and properties of benchmark stars in the LOPN1 and LOPS2 fields.

*Speaker

Gaia Benchmark Stars

Caroline Soubiran*[1]

[1]Laboratoire d'Astrophysique de Bordeaux – Université de Bordeaux, Institut National des Sciences de l'Univers, Centre National de la Recherche Scientifique – France

Abstract

The Gaia Benchmark stars (GBS) are reference stars which have been carefully selected for the calibration and the validation of atmospheric parameters massively determined from Gaia data and from spectroscopic surveys. They define the fundamental scale for Teff and logg which are determined independently of spectroscopy, through the fundamental relations based on angular diameters directly measured by interferometry, on bolometric fluxes (Fbol) measured by SED fitting, on parallaxes and masses, all being observable quantities with minor dependencies on theoretical assumptions. GBS are chosen to cover as well as possible the HR diagram in the FGK range, including dwarfs, subgiants, and giants of all metallicities, representative of the different stellar populations of the Milky Way probed by Gaia and other large surveys. After the initial version of 34 stars by Heiter+ 2015, we now present the third version which includes nearly 200 stars. The precision of fundamental (Teff, logg) significantly improved thanks to the exquisite quality of Gaia data reflecting on distances and Fbol. This set of well-characterised stars is also important to improve stellar models and in the context of PLATO for the WP125.

*Speaker

Gyrochronology from clusters

Sydney Barnes*[1]

[1]Leibniz Institute for Astrophysics (AIP) – An der Sternwarte 16, D-14482 Potsdam, Germany

Abstract

Several studies over the past few years have added substantially to the corpus of measured rotation periods in cool open cluster stars. These collectively allow an improved understanding of how rotation changes with age for a wide range of cool stars. This talk with summarize the main results of these studies and their implications for the derivation of ages via gyrochronology for main sequence stars in the PLATO mission.

*Speaker

Wide binaries as co-eval probes of the rotational evolution of low-mass stars

Diego Godoy-Rivera*[1], Savita Mathur[1], Rafael Garcia[2], and Angela Santos[3]

[1]Instituto de Astrofisica de Canarias – Spain
[2]CEA- Saclay – Commissariat à l'énergie atomique et aux énergies alternatives – France
[3]Instituto de Astrofísica e Ciências do Espaço – Portugal

Abstract

Rotation plays an important role in the life of stars, and offers a potential diagnostic to infer their ages via gyrochronology. Currently, however, gyrochronology faces critical challenges. Recent results from cluster studies and asteroseismology have shown that stars deviate from a simple Skumanich-type spin-down, and rather follow a more complex evolution with stalling in their rotation rates, gaps in the period vs. temperature diagram, and weakened magnetic braking in stars more evolved than the Sun. A detailed understanding of these phenomena, however, is currently limited by the lack of calibrators at old ages. In this talk, I will demonstrate how wide-separation binaries identified by Gaia can help address these issues. The components of a given binary are co-eval and taken together they can provide exquisite gyrochronology assessments. Particularly, I will discuss the outstanding opportunity that main sequence-white dwarf binaries present for expanding the existing rotational constraints in unprecedented age (and metallicity) regimes. Systems with a white dwarf component can be age-dated through stellar evolution modeling, and this may be complemented with rotation period measurements for their main-sequence companions by using photometric data from space-based missions such as TESS and the upcoming PLATO. In this way, these systems will produce the unprecedented and much-needed age-rotation constraints that are necessary for a thorough understanding of the complex angular momentum evolution of low-mass stars. With the advent of the PLATO mission, this work sets up the stage for decisive spin-down assessments and gyrochronology calibrations in the era of ever-expanding space-based photometry and astrometry.

*Speaker

Session C1
Synergies

Synergies with Exoplanet Science	Alessandro Sozzetti (Review)
The impact of red-giant asteroseismology on Galactic Archaeology	Friedrich Anders (Review)
Architecture of Kepler single exoplanet systems compared to star-planet evolution models	Rafael Garcia
Homogeneous Characterisation of Stars Hosting Small Exoplanets	Angharad Weeks

Synergies with Exoplanet Science

Alessandro Sozzetti*[1]

[1]INAF - Osservatorio Astrofisico di Torino – Italy

Abstract

Ultimately, we only know the properties of the planets we discover as well as we know the characteristics of the stars around which they orbit. The precise and accurate knowledge of fundamental stellar properties (mass, radius, age, chemical composition) and the in-depth understanding of stellar activity at all relevant time-scales (rotation, long-term cycles) are in fact key for a proper characterization of planetary properties (including the robust detection of planetary signals) and for population statistics studies, what we call exoplanet demographics. I will review the main aspects of the synergy between stellar and exoplanet science, highlighting both the most spectacular successes and the areas in which important progress has yet to be made, with a particular focus on the detection and characterization of true Earth analogs.

*Speaker

The impact of red-giant asteroseismology on Galactic Archaeology

Friedrich Anders*[1]

[1]Universitat de Barcelona – Spain

Abstract

I will review the advances of Galactic archaeology in the last 10 years, with a particular focus on studies that have become possible thanks to ensemble asteroseismology with CoRoT, Kepler, K2, and TESS - in combination with large ground-based spectroscopic surveys. Red-giant stars are particularly interesting for Galactic archaeology studies, since they are numerous, bright, and cover a wide range of stellar ages. Even in the PLATO era, red-giant ages derived from joint asteroseismic and spectroscopic constraints are only available for select samples in certain fields. Therefore, Galactic archaeologists typically use the much larger coverage of spectroscopic surveys like APOGEE, GALAH, LAMOST, or Gaia RVS to make inferences about the Galactic past. However, whenever age becomes a crucial parameter, asteroseismology is needed to obtain meaningful results.
Finally, I will try to convince the audience that the future for Galactic archaeology studies with PLATO (combined with the next Gaia data releases) is even brighter.

*Speaker

Architecture of Kepler single exoplanet systems compared to star-planet evolution models

Rafael Garcia*[1], Clemence Gourvès[1], Angela R.g. Santos[2], Antoine Strugarek[1], Diego Godoy-Rivera[3], Savita Mathur[3], Sylvain N. Breton[4], Vincent Delsanti[5], and Stéphane Mathis[1]

[1]Université Paris-Saclay – CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif sur Yvette France – France

[2]Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, – Portugal

[3]Instituto de Astrofisica de Canarias – Spain

[4]INAF- Osservatorio Astrofisico di Catania – Italy

[5]CentraleSupélec – CNRS, CentraleSupélec, UPMC, Univ Paris Su – France

Abstract

The architecture of observed exoplanet systems is tailored by planet formation in protoplanetary disks and by the star-planet interactions making planet orbit on secular timescales. Previous statistical studies using NASA's Kepler mission have revealed a dearth of close-in planets around fast rotating stars, but recent research suggests this may be related to observational bias when TESS observations are added. To shed light on the physical processes leading to the observed architecture of exoplanet systems, in this work we compare the confirmed single exoplanet planet systems observed by Kepler to a synthetic population computed with the star-planet evolution code ESPEM. This approach takes into account tidal and magnetic interactions between a star and a single planet from the disk-dissipation phase up to the end of the main sequence. The study is limited to confirmed single planet systems orbiting around a main-sequence single star (no binaries, no evolved stars, no multi-planets). We find the existence of a dearth of close-in planets orbiting around fast rotating stars depending on the stellar spectral type (F, G, and K) in both observations and simulations, and find that the dearth seems stronger for the F-type stars. The number of M planet host systems is not enough to assess any strong conclusions. Realistic formation hypothesis included in the model and the proper treatment of tidal and magnetic migration are enough to qualitatively explain the dearth of hot planets around fast rotating stars.

*Speaker

Homogeneous Characterisation of Stars Hosting Small Exoplanets

Anghard Weeks*[1]

[1]Mullard Space Science Laboratory – United Kingdom

Abstract

Precise host star characterisation is imperative to our understanding of the diversity and architecture of exoplanetary systems. However, most host stars undergo heterogeneous characterisation at the time of planet discovery or analysis. We present a homogeneous analysis of ˜100 stars hosting small planets with Rp < 4R⊕. The planets border or sit in the radius valley - a dearth of planets with radii between ˜1.5 and 2 R⊕ - and also have planet mass measurements available. Characterisation is done with the Bayesian Stellar Algorithm (BASTA), using photometric, spectroscopic and astrometric data inputs from Gaia DR3 and 2MASS. These results are validated in comparison to stellar parameters from the Nasa Exoplanet Archive, and homogeneous spectroscopic subsets of exoplanet host stars such as the Kepler California Survey, and SweetCat. We use these new stellar parameters to recalculate planet masses, radii and densities, and compare these to values reported in the literature. A difference in the depth of the radius valley is reported, alongside analysis of the differences in 2-D distributions of planets in radius - period and radius - stellar mass space. The implications for the planetary mass - radius diagram are also explored, showing shifts of the positions of these planets in such parameter space. We conclude by recommending a similar homogeneous approach for all host star characterisation.

*Speaker

On the study of habitability conditions by merging asteroseismic and space climate techniques

Maria Pia Di Mauro*[1], Raffaele Reda*[2], Luca Giovannelli[2], and Francesco Berrilli[2]

[1]Istituto di Astrofisica e Planetologia Spaziali (INAF-IAPS) – Via del Fosso del Cavaliere 100 00133 Roma, Italy

[2]University of Study of Rome Tor Vergata – Italy

Abstract

We propose a new 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 Kepler/K2 or 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 and its orbiting planet, but also to study the stellar magnetic activity and the star-planet interaction in analogy to the Sun-Earth system allowing to determine the extension of the exoplanetary magnetosphere and the values of stellar wind dynamic pressure. This information, coupled with the precise age estimation by asteroseismology, will allow determining how long an atmosphere could resist to the action of stellar wind enabling to directly quantify the portion of the atmosphere which could potentially be eroded.

*Speaker

Session C2
Complementary science

Bridging PLATO's Core and Complementary Stellar Science	Konstanze Zwintz (Review)
Non-perturbative static 3D modelling of close binaries and its impact on the observations of low-mass and RGB binaries	Loïc Fellay
Rotation and activity of red giants in binary versus single stars	Charlotte Géhan
Gravito-inertial modes at the surface of fast rotating stars	Michel Rieutord

Bridging PLATO's Core and Complementary Stellar Science

Konstanze Zwintz*[1]

[1]Institute for Astro- and Particle Physics, University of Innsbruck – Austria

Abstract

We will demonstrate how PLATO's Complementary Stellar Science bridges to the Stellar Core Science programme and vice versa. We will illustrate the synergies between different scientific topics addressed in the Complementary Science Team and the stellar key objectives of the PLATO mission. A demonstration will be given with a first set of realistic simulations conducted with PLATOSim.

*Speaker

Non-perturbative static 3D modelling of close binaries and its impact on the observations of low-mass and RGB binaries

Loïc Fellay*[1] and Marc-Antoine Dupret[1]

[1]Département dástrophysique, Géophysique et Océanographie – Belgium

Abstract

In close binary systems, tidal interactions and rotational effects can strongly influence stellar evolution and observations. Current models of binary stars are relying either on the so-called " Roche model " or the perturbative approach that in each case results on several assumptions concerning the gravitational, tidal and centrifugal potentials.
To study the consequences of these assumptions we developed a new non-perturbative method to compute precise structural deformation of binary system in three dimensions that is even valid in the most distorted cases.
In this talk we are going to show that in the most distorted cases both Roche and perturbative models are significantly underestimating the deformation of binaries. In particular for low-mass and RGB stars we respectively found a 80% and 35% deformation increase compared to the Roche model. For the observations of close eclipsing binaries, these corrections are important as both stellar contours and gravity darkening are noticeably modified. In addition, basic astrophysical laws are impacted by the redistribution of mass in the bodies resulting from the deformations. We saw a deviation from the 3rd Kepler's law of a few percent adding uncertainties on the determination of the orbital and stellar parameters from observations. Asteroseismic studies of such bodies would also be importantly impacted by the deformations discrepancies found as their whole structural depiction is modified.

*Speaker

Rotation and activity of red giants in binary versus single stars

Charlotte Géhan*[1] and Patrick Gaulme*[2]

[1]Max Planck Institute for Solar System Research – Germany
[2]Thüringer Landessternwarte Tautenburg – Germany

Abstract

According to dynamo theory, stars with convective envelopes efficiently generate surface magnetic fields, which manifest as magnetic activity in the form of starspots, faculae, flares, when their rotation period is shorter than their convective turnover time. Most red giants, having undergone significant spin down while expanding, have slow rotation and no spots. However, about 8% display spots, including a fraction that belong to close binary systems. From photometric time series and chromospheric emission measurements, Géhan et al. (2022, A&A 668) showed that red giants belonging to binary systems in a configuration of spin-orbit resonance display an enhanced magnetic activity compared to single stars with the same rotation rate. In other words, the large magnetic field of red giants in close binary systems is not only due to the faster rotation rate induced by tidal interactions, as it is generally admitted. Somehow, this work resuscitates an old speculation about a special binary-induced dynamo activity. We discuss how the PLATO mission will help understanding differences between dynamo mechanisms of single versus close binary stars.

*Speaker

Gravito-inertial modes at the surface of fast rotating stars

Michel Rieutord*[1]

[1]Institut de recherche en Astrhysique et Planetologie (IRAP) – CNRS,, Université de Toulouse – 14 avenue Edouard Belin; 31400 Toulouse, France

Abstract

The recent discovery of gravito-inertial modes on the surface of Altair (alpha Aql) by Rieutord et al. (2023) (A&A 669, A99), using high-resolution spectroscopy, intriguingly presents the opportunity to investigate the surface layers of rapidly rotating stars. We shall first show that such waves are also detected on Rasalhague (alpha Oph), another fast rotator older and of higher mass than Altair.
This detection opens a new window on fast rotating star, in particular on the sub-surface layers where the kappa mechanism is presumably at work. Using two-dimensional ESTER models (Espinosa Lara & Rieutord 2013) combined with two-dimensional computations of eigenmodes with the TOP code (Reese et al. 2021), we show how these waves probe the thin convective layers and the sub-surface differential rotation (driven by the baroclinic torque) of rapidly rotating A-Type stars and can lead to new constraints on the physics of these stars and surface boundary conditions that should be applied.

*Speaker

Gravito-inertial modes at the surface of fast rotating stars

Michel Rieutord*[1]

[1]Institut de recherche en Astrhysique et Planetologie (IRAP) – CNRS,, Université de Toulouse – 14 avenue Edouard Belin; 31400 Toulouse, France

Abstract

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*Speaker

Session D1

Advances in stellar physics: Chemical composition and opacities

The chemical make-up of the solar photosphere	Carlos Allende Prieto (Review)
Recent determination of solar abundances	Maria Bergemann (Invited)
Laboratory Opacity Measurements for Stellar Interiors	Guillaume Loisel (Review)
Opacities: recent theoretical developements	Franck Delahaye (Invited)

The chemical make-up of the solar photosphere

Carlos Allende Prieto*[1]

[1]Instituto de Astrofisica de Canarias (IAC) – Via Lactea s/n 38205 La Laguna Tenerife, Spain

Abstract

The updated analyses of the solar chemical composition in the early 2000's brought a significant reduction (up to 40 %) in the abundances of carbon, nitrogen and oxygen compared to earlier estimates. These changes ended the excellent agreement between seismic measurements and the predictions from classical models of the structure of the interior of the Sun, and have triggered an ongoing debate on whether the discrepancies are related to issues with the interior models, their basic input data (e.g. radiative opacities), or the spectroscopic analysis that brought the abundance changes. This talk will critically examine the results in the recent literature on the subject, and probably make some recommendations.

*Speaker

Recent determination of solar abundances

Maria Bergemann*[1]

[1]Max-Planck-Institut für Astronomie – Germany

Abstract

I will present our recent results on the analysis of the chemical composition of the Sun using 3D NLTE models. I will also provide a comparison with other recent estimates, and discuss the implications for the standard solar models.

*Speaker

Laboratory Opacity Measurements for Stellar Interiors

Guillaume Loisel*[1]

[1]Sandia National Laboratories [Albuquerque] (SNL) – PO Box 5800 Albuquerque, NM 87185, United States

Abstract

Nearly a century ago, Eddington (1) recognized that the attenuation of radiation by stellar matter controls the internal temperature profiles within stars like the Sun. Opacities for high energy density (HED) matter are challenging to calculate because accurate and complete descriptions of the energy level structure, equation of state, and plasma effects such as continuum lowering and line broadening are needed for partially ionized atoms. This requires approximations, in part because hundreds of millions, or billions in some cases, of bound-bound and bound-free electronic transitions contribute to the opacity. Opacity calculations, however, have never been benchmarked against laboratory measurements at stellar interior conditions. Laboratory opacity measurements were limited in the past by the challenges of creating and diagnosing sufficiently large and uniform samples at stellar interior conditions. In research conducted over more than 15 years, we developed an experimental platform on the Z facility and measured (2,3) wavelength-resolved opacity at electron temperatures Te = 155-200 eV and densities ne = 0.7 − 5.0 x 1022cm-3 - conditions very similar to the radiation/convection boundary zone within the Sun. Models agree with data at the lower temperature and densities, but notable model-data discrepancies arise at higher temperatures and densities. The comparisons raise questions about how well we understand the behavior of atoms embedded in high energy density plasma. These measurements may also help resolve decade-old discrepancies between solar model predictions and helioseismic observations. This talk will provide an overview of the measurements, investigations of possible errors, and ongoing experiments aimed at testing hypotheses to resolve the model-data discrepancy.

Sandia National Laboratories is a multimission laboratory managed and operated by NTESS LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. DOE's NNSA under contract DENA0003525.

1 A.S. Eddington, The Internal Constitution of the Stars (Cambridge Univ. Press, Cambridge, 1926).

2 J.E. Bailey *et al., Nature* **517**, 56 (2015).
3 T. Nagayama *et al.,* Physical Review Letters **122**, 235001 (2019).

*Speaker

Opacities: recent theoretical developements

Franck Delahaye*[1]

[1]LERMA – École normale supérieure - Paris, Institut National des Sciences de l'Univers, Observatoire de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique, CY Cergy Paris Université – France

Abstract

A detail comparison between the 2 main methods to calculate opacities hare being reviewed. While trying to understand the differences between the measured Fe opacities at the Sandia National Laboratory and all theoretical calculation, a new set of monochromatic opacities for some Fe ions, important contributor to the Rosseland opacities for the Physical conditions characterizing the base of the Solar convection zone, has been calculated in the framework of the Opacity Project. This new set is being tested on solar models and the effect on radiative accelerations will presented. These new results pave the way in defining the best way for new calculations for the Opacity Project to prepare a new release of monochromatic opacities, Rosseland and Plank means as well as radiative accelerations.

*Speaker

Session D2

Advances in stellar physics: dynamical processes in stellar interiors

Turbulent transport in radiative zones : recent theoretical and numerical developments	François Lignières (Invited)
Spin down by dynamo action in simulated radiative stellar layers	Ludovic Petitdemange (Invited)
Numerical simulations of the Tayler-Spruit dynamo	Raphaël Raynaud
The action of waves in stellar interiors: transporting angular momentum and chemicals and providing key informations	Stéphane Mathis (Invited)
Gravity waves in the magnetised radiative core of low-mass stars: consequences for asteroseismology and transport of angular momentum	Louis Amard
Exploring surface abundance of lithium from Main-Sequence to Red giant phase with the constraint of angular momentum transport	Thibaut Dumont
Recent theoretical advances about core overshooting and convective penetration from a convective envelope	Friedrich Kupka (Review)
Impact of uncertainties in radiative/convective interfaces in Stellar Modelling (or stellar properties inferences)	Santi Cassisi (Invited)
Possible detection of penetrative convection in F-type stars with asteroseismology	Morgan Deal
How the modeling of mixing and nuclear energy production impacts the extent of convective cores	Anthony Noll
Entropy-calibrated stellar modeling: Improving the use of prescriptions	Louis Manchon
Stellar models with 3D atmospheres	Jakob L. Rørsted (Review)
Theory of surface effects	Jordan Philidet (Invited)
3D Time-dependent convection model for asteroseismology	Stéphane Lizin

Turbulent transport in radiative zones : recent theoretical and numerical developments

François Lignières*[1]

[1]Institut de recherche en astrophysique et planétologie (IRAP) – CNRS : UMR5277, Observatoire Midi-Pyrénées, Université Paul Sabatier (UPS) - Toulouse III, Centre National des Etudes Spatiales - CNES – France

Abstract

Many physical processes can potentially generate turbulence in stellar radiative zones, but limited observational constraints and uncertainties in the modelling of turbulent transport make it difficult to identify the most relevant processes. Renewed interest in this field has been sparked by the inability of existing hydrodynamical models to explain seismic measurements of rotation rates in the cores of red giants and intermediate mass stars. In this talk, I shall review recent theoretical and numerical work aimed at advancing our understanding of turbulent transport in radiative zones.

*Speaker

Spin down by dynamo action in simulated radiative stellar layers

Ludovic Petitdemange*[1]

[1]Laboratoire d'Etude du Rayonnement et de la Matière en Astrophysique et Atmosphères – Institut National des Sciences de l'Univers, Observatoire de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique, CY Cergy Paris Université – France

Abstract

The evolution of a star is influenced by its internal rotation dynamics through transport and mixing mechanisms, which are poorly understood. Magnetic fields can play a role in transporting angular momentum and chemical elements, but the origin of magnetism in radiative stellar layers is unclear. Using global numerical simulations, we identify a subcritical transition to turbulence due to the generation of a magnetic dynamo. Our results have many of the properties of the theoretically-proposed Tayler-Spruit dynamo mechanism, which strongly enhances transport of angular momentum in radiative zones. It generates deep toroidal fields that are screened by the stellar outer layers. This mechanism could produce strong magnetic fields inside radiative stars, without an observable field on their surface. Magnetic fields generated by dynamo action appear as a process to trigger turbulence in stellar interiors. Depending on the parameters or initial conditions, we report different dynamo branches that could explain stellar magnetism and the rotation profiles observed for stars with a thick radiative envelope.

*Speaker

Numerical simulations of the Tayler-Spruit dynamo

Raphaël Raynaud*[1], Paul Barrère[2], Jérôme Guilet[2], and Alexis Reboul-Salze[3]

[1]Université Paris Cité – Université Paris Cité, Université Paris-Saclay, CNRS, CEA, AIM – France
[2]CEA – Université Paris-Saclay, Université Paris Cité, CNRS, CEA, AIM – France
[3]Max Planck Institute for Gravitational Physics (Albert Einstein Institute) – Germany

Abstract

The so-called Tayler-Spruit dynamo has been proposed to provide an effective angular momentum transport in stellar radiative zones. This dynamo process could also play an important role to explain the formation of highly magnetized neutron stars called magnetars (Barrère et al. 2022). For many years however, our understanding of it relied on simplified analytical prescriptions. Recent numerical advances start to provide us with a 3D picture of this dynamo. In this context, I will present new results from 3D MHD numerical simulations in which a Tayler instability-driven dynamo is acting in a stably stratified region.

*Speaker

The action of waves in stellar interiors: transporting angular momentum and chemicals and providing key informations

Stephane Mathis*[1]

[1]Université Paris-Saclay, Université Paris Cité, CEA, CNRS, AIM, 91191, Gif-sur-Yvette, France – Laboratoire AIM, CEA – France

Abstract

Waves propagating in stars are of major importance. First, they provide thanks to asteroseismology the main window allowing us to probe their internal structure, chemical stratification, rotation, and magnetism. Next, they are able for low-frequency waves to transport efficiently angular momentum and chemicals that modifies the dynamics and the evolution of stars.

In this review, I will draw a complete picture of the state-of-the-art and of the most recent advances on our modeling and understanding of waves propagating in rotating stratified magnetized stellar interiors. First, I will discuss the consequences for asteroseismic observations. Then, I will show how the complex interplay between waves, rotation and magnetic fields is driving angular momentum transport and chemical mixing. Finally, I will discuss what are the perspectives to build a coherent vision of the multi-dimensional structure and dynamics of stars along their evolution.

*Speaker

sciencesconf.org:plato-stesci2023:467263

Gravity waves in the magnetised radiative core of low-mass stars: consequences for asteroseismology and transport of angular momentum

Louis Amard*[1] and Stéphane Mathis*[2]

[1]CEA Saclay – CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif sur Yvette France – France
[2]CEA Saclay – CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif sur Yvette France – France

Abstract

Magnetic fields and internal gravity waves have been identified as the main candidates to explain the efficient transport of angular momentum in stellar radiative regions expected from helio- and asteroseismic measurements in the Sun and all across the Hertzprung-Russel diagram. In this context, recent studies established that a magnetic field may modify the frequency spectrum and the amplitude of propagating gravity waves by possible trapping or resonances phenomena. Therefore, the co-existence of the two mechanism is unavoidable and PLATO could help to disentangle the situation. Nevertheless, their interplay has never been studied in terms of stellar evolution.

In this work, we choose to examine the impact on the propagation of gravity waves in solar-type stars of a magnetic field generated by the Tayler-Spruit dynamo action, which has recently been observed in numerical simulations, and is broadly studied as a potential solution to the angular momentum transport problem. We present self-consistent rotating stellar evolution models of solar-type stars with rotation-induced mixing and transport by magnetic instabilities. We then characterise the propagation of gravity waves in such magnetised medium and look at the case of standing gravity modes and progressive gravity waves, from the pre-main sequence up to the red-giant branch.

This allows us to demonstrate that both transport of angular momentum by the Tayler-Spruit instability and by internal gravity waves modified by magnetic field should be taken into account simultaneously, while the reduced amplitude of mixed modes observed in RGB stars should be due to a fossil magnetic field rather than to the Tayler-Spruit instability. Finally, we will present some perspectives of these results to build a robust picture of the transport of angular momentum in stellar interiors.

*Speaker

Exploring surface abundance of lithium from Main-Sequence to Red giant phase with the constraint of angular momentum transport

Thibaut Dumont*[1,2]

[1]Institut Pluridisciplinaire Hubert Curien – université de Strasbourg, Institut National de Physique Nucléaire et de Physique des Particules du CNRS, Centre National de la Recherche Scientifique – France
[2]University of Geneva, Department of Astronomy – Switzerland

Abstract

Robust modelling of low-mass stars is key to understand their structure and their evolution. So far, no clear consensus appears for which physics is required to reproduce the main observables: the evolution of chemicals (e.g. lithium, beryllium), the evolution of surface rotation with time, and the state of the internal rotation constrained by asteroseismology. In order to improve stellar modelling, we need to understand these observations that bring constraints during the different stellar evolutionary phases, and better characterise internal transport processes in stars.

Using the stellar evolution code STAREVOL, we compute the surface and internal rotation evolution rates, as well as the surface lithium (Li) abundance from models of rotating stars from main-sequence (MS) to red-giant phase. These models include atomic diffusion and additional transport for both chemicals and angular momentum (Dumont et al. 2021). We constrain the transport of angular momentum in our models with the asteroseismic observations and explore the impact on chemicals along evolution.

We confirm the need for a varying efficiency of angular momentum transport along evolution of evolved giant stars for which we have in particular strong constraints on core rotation rates from sub-giant to red-giant stars thanks to asteroseismology. We succeed to reproduce the observational constraints for Li at different masses during evolution but highlight a discrepancy reaching the giant phases of solar-type stars. We show that reproducing MS surface Li abundances for solar-type stars lead to an under abundance when reaching the giant phases of evolution, challenging the identification of transport processes at the transition between MS and giant stars (Dumont et al. 2023, submitted).

*Speaker

Recent theoretical advances about core overshooting and convective penetration from a convective envelope

Friedrich Kupka*[1,2,3]

[1]Fachhochschule Technikum Wien [Austria] – Austria
[2]Wolfgang Pauli Institute [Wien, Austria] – Austria
[3]Faculty of Mathematics, University of Vienna, Austria – Austria

Abstract

Convective mixing and the interaction between convectively and radiatively stratified layers in stars are physical processes which are particularly difficult to model. Their phenomenological modelling is too inaccurate and too sensitive to model parameters to be considered a satisfactory approach. Especially the latter depend on a variety of properties of the star to be modelled which implies this to be a descriptive rather than a predictive methodology.
Recent advances to proceed beyond such strongly limited models are achieved along two different avenues: numerical, hydrodynamical simulations and statistical models (non-local convection models, Reynolds stress models). Strengths and limitations of both methodologies will be outlined including some ambiguities and pitfalls.
For the numerical simulations particular attention will be given to aspects of simulation resolution, thermal relaxation, and self-consistency in the context of a full stellar model. For the statistical models the role of kinetic energy dissipation will be discussed as well as its consequences for the physical completeness of non-local convection models.
The limitations of either approach would benefit from stronger observational constraints. Some options how to improve on those will be suggested. PLATO might provide the key to such progress.

*Speaker

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The limitations of either approach would benefit from stronger observational constraints. Some options how to improve on those will be suggested. PLATO might provide the key to such progress.

*Speaker

Impact of uncertainties in radiative/convective interfaces in Stellar Modelling (or stellar properties inferences)

Santi Cassisi*[1]

[1]INAF-Astronomical Observatory of Abruzzo – Italy

Abstract

One of the major uncertainties in stellar modelling and, hence in the inference of the stellar properties via comparison between models and empirical measurements, is the treatment of the interfaces between radiative and convective zones. Despite the
tremendous improvement in our capability to compute stellar models in the various evolutionary phases and mass regime, we still lack of a sound and robust treatment of how to manage convection at the critical boundary between convective and radiative regions both in the interiors and in the outer convection zone.We briefly review the various approaches that have been suggested to treat the radiative/convective interfaces in stellar modelling and how they impact on the properties of the stellar models.

*Speaker

Possible detection of penetrative convection in F-type stars with asteroseismology

Morgan Deal*[1]

[1]LUPM – Laboratoire Univers et Paricules de Montpellier, CNRS UMR5299 – France

Abstract

Transport of chemical elements in main-sequence stars is still far from being understood and is responsible for large uncertainties in stellar models. The competition between all transport processes leads to variations of stellar abundances. This is only when taking all these processes into account that we will be able to explain observed surface abundances and to model correctly the internal structure of stars. The study of the signatures of seismic acoustic glitches in solar like oscillations has been proven to successfully unveil internal stellar characteristics such as the helium second ionisation zone and the location of the base of the surface convective zone. The latter is particularly important for the transport of chemicals as it strongly impacts the efficiency of atomic diffusion, especially for F-type stars. In this presentation, we show an analytical development making the link between the physical conditions in the penetrative convective (PC) region and the signature in the r010 frequency ratios. We applied this model to a Kepler Legacy F-type star and showed that if penetrative convection is responsible for the signature in the observed ratios r010, then PC extends much deeper than in the Sun. This opens new possibilities to constrain the transport of chemicals in these stars and to improve its current modelling in stellar evolution models.

*Speaker

How the modeling of mixing and nuclear energy production impacts the extent of convective cores

Anthony Noll*[1] and Sebastien Deheuvels[2]

[1]Heidelberg Institute for Theoretical Studies – Germany
[2]Institut de recherche en astrophysique et planétologie – Université Toulouse III - Paul Sabatier, Institut National des Sciences de l'Univers, Observatoire Midi-Pyrénées – France

Abstract

Convective cores are the hydrogen reservoirs of main-sequence stars that are more massive than around 1.2 solar masses. The characteristics of the cores consequently have a strong impact on the structure and evolution of the star. The high quality of the Kepler mission dataset allowed to better constrain the core extension and therefore to obtain more accurate ages. However, such results rely on stellar evolution codes, in which simple assumptions are often made on the physics in the core. Indeed, the convective mixing is commonly considered to be instantaneous and the most basic nuclear networks assume that both Lithium and Beryllium are at their equilibrium abundance. In this talk, we show how those two hypotheses lead to significant differences in the central composition of the elements for which the timescale to reach nuclear equilibrium is lower than the convective timescale. We present how this impacts the nuclear energy production and therefore the size of convective cores in low-mass stars. As those stars exhibit solar-like oscillations, we use data from the Kepler mission to study the impact of this effect on the seismic modelling. We find that the overshoot parameter of the best-fit model is significantly higher when using basic nuclear reaction networks. Thus, it is necessary to have consistent nuclear reactions and central mixing prescriptions when using observationally-calibrated overshoot parameters. This is key in the framework of the Plato mission, especially to ensure accurate age determinations within the main-sequence grid modeling pipeline.

*Speaker

Entropy-calibrated stellar modeling: Improving the use of prescriptions

Louis Manchon*[1,2], Morgan Deal[3,4], Marie-Jo Goupil[5], Aldo Serenelli[6,7,8], Yveline Lebreton[5,9], Jonas Klevas[10], Arunas Kučinskas[10], Hans-Gunter Ludwig[11], Josefina Montalban[12,13], and Laurent Gizon[2,14]

[1]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Observatoire de Paris – France
[2]Max Planck Institute for Solar System Research – Germany
[3]Laboratoire Univers et Particules de Montpellier – Centre National de la Recherche Scientifique – France
[4]Centro de Astrifisica da Universidad do Porto – Portugal
[5]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Institut National des Sciences de l'Univers, Observatoire de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique, Université Paris Cité – France
[6]Institute of Space Sciences [Barcelona] – Spain
[7]Institut dÉstudis Espacials de Catalunya – Spain
[8]Max-Planck-Institut für Astronomie – Germany
[9]Institut de Physique de Rennes – Université de Rennes, Centre National de la Recherche Scientifique – France
[10]Institute of Theoretical Physics and Astronomy, Vilnius University – Lithuania
[11]Zentrum für Astronomie der Universität Heidelberg – Germany
[12]Dipartimento di Fisica e Astronomia Augusto Righi, Università degli Studi di Bologna – Italy
[13]School of Physics and Astronomy, University of Birmingham – United Kingdom
[14]Institut für Astronomie, Georg-August-Universität Göttingen – Germany

Abstract

The modeling of convection is a longstanding problem in stellar physics. Up-to-now, all ad hoc models rely on a free parameter alpha which has no real physical justification and is therefore poorly constrained. However, a link exists between this free parameter and the entropy of the stellar adiabat. Prescriptions, derived from 3D stellar atmospheric models, are available that provide entropy as a function of the global stellar parameters. This enabled us to constrain α through the development of entropy-calibrated models. Several questions arise as these models are increasingly used. Which prescription should be used? Should they be used in their current form? How do uncertainties impact entropy-calibrated models? In this poster, we present how the entropy-calibration method is implemented into the stellar evolution code Cesam2k20, we give recommendations on the use of prescriptions and we show comparisons with the Sun and the alpha Cen system. In addition, we used data from the CIFIST grid of 3D atmosphere models to evaluate the accuracy of the prescriptions.

*Speaker

Entropy-calibrated stellar modeling: Improving the use of prescriptions

Louis Manchon*[1,2], Morgan Deal[3,4], Marie-Jo Goupil[5], Aldo Serenelli[6,7,8], Yveline Lebreton[5,9], Jonas Klevas[10], Arunas Kučinskas[10], Hans-Gunter Ludwig[11], Josefina Montalban[12,13], and Laurent Gizon[2,14]

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*Speaker

Stellar models with 3D atmospheres

Jakob L. Rørsted*[1]

[1]Aarhus University – Denmark

Abstract

Perhaps the primary tool for obtaining knowledge about stars is to perform calculations of stellar structure and how it changes in time using a stellar evolution code. These are one-dimensional (1D) numerical models, which have been developed and tested through decades; as a result they are highly optimised and very efficient. However, in several aspects they are also severely simplified and can be improved. From asteroseismology we know that perhaps the most prominent deficiencies are confined to the outer stellar layers.

A promising way of attacking the inadequacies in the stellar models is to use the results from realistic and highly detailed three-dimensional (3D) hydrodynamics simulations of stellar atmospheres. These simulations are able to accurately reproduce the convection in stars from only fundamental physical principles.

This talk will introduce the 3D convection simulations and the principles for utilizing them for stellar evolution calculations. Various approaches for applying them in stellar models are reviewed, including the so-called patched models and the use of the envelopes in the fly. These techniques constitutes a significant step forward in the field of stellar evolution theory, and can help us produce the stellar models of the future.

*Speaker

Theory of surface effects

Jordan Philidet*[1]

[1]Max Planck Institute for Solar System Research – Germany

Abstract

It is well known that in the Sun, and in solar-like oscillators at large, there is a discrepancy between the observed frequencies of global p-modes and those obtained from stellar models. This was dubbed the surface effects, because it is due to a poor modelling of turbulent convection, and of its complex interplay with acoustic oscillations, in the superficial layers of the star. Surface effects are the main obstacle preventing us from using the individual frequencies of stars for seismic analysis and diagnosis: instead, we must settle for combinations of frequencies that are insensitive to the surface. A prohibitve amount of the seismic information provided by PLATO data for these stars would be lost along the way, making the correction of the surface effect a crucial task.

During this talk, after giving an overview of the empirical formulae used to correct the theoretical frequencies a posteriori, I will review the much needed theoretical efforts that our community has developed to describe convection/oscillation interplay more realistically, and therefore to improve on the models themselves.

*Speaker

3D Time-dependent convection model for asteroseismology

Stéphane Lizin*[1] and Marc-Antoine Dupret[1]

[1]Département dástrophysique, Géophysique et Océanographie – Belgium

Abstract

Due to an ill-depicting model of the convective layers below the photosphere and a misrepresentation of the coupling between convection and oscillations, a well-known deviation appears between observed and theoretical frequencies which grows towards high frequencies; the so-called surface effects. Alongside the frequency, convection also impacts the damping rate of the modes and represents an important part of the driving mechanism behind the stellar oscillations of low-mass stars. With the increasing observational capabilities at our disposal nowadays with Kepler and TESS, this constitutes the main limitations to accurate seismic probing of solar-like and red giants stars. In this talk, we will present the formalism of an innovative approach that changes the current paradigm by going 3D. This new formalism consists in an original non-adiabatic 3D time-dependent convection model for asteroseismology that we are currently developing. To tackle the current issues, we aim at keeping the entire 3D structure of the astrophysical flow in these superficial layers to fully account for the nature of turbulence in our model via the use of advanced hydrodynamic simulation CO5BOLD. Making use of the perturbative approach alongside the introduction of spectral decomposition, we bring forward a new formalism describing standing waves in 3D which is set to solve the global non-adiabatic oscillation equations in a full 3D framework. We show the importance of working in a 3D space and how it allows us to stay as close as possible to reality. We present some preliminary results of the model: the impact of this 3D structure on modes frequencies and damping rates as well as the computation of 3D eigenfunctions. We discuss the impact of the main hydrodynamic simulation characteristics (resolution, time,...) on our results. Finally, we establish how our formalism is able to precisely locate regions of driving and damping of the modes in this 3D environment and detail the different physical contributions to the damping of the modes.

*Speaker

Session E
More about the PLATO mission

Properties of PLATO calibrated light curves	Cilia Damiani
End-to-end simulations as an indispensable tool for PLATO's core and complimentary science program	Nicholas Jannsen
A benchmark database for PLATO	Pierre Maxted
PLATO Science Calibration and Validation Input Catalog	Patrick Gaulme
Measuring stellar rotation and activity with PLATO	Sylvain N. Breton

Properties of PLATO calibrated light curves

Cilia Damiani*[1] and Reza Samadi

[1]Max Planck Institute for Solar System Research – Germany

Abstract

PLATO achieves high photometric precision while covering a large field of view thanks to its segmented optical design of 4 groups of 6 cameras. To obtain the best SNR possible for each target, the fluxes obtained by up to 24 cameras with different random and systematic noises, over multiple quarters, must be combined. This has led to the design of a sophisticated calibration and correction pipeline unique to PLATO. The resulting properties of the science ready light curves are substantially different from that of Kepler or TESS. In this talk, I will describe the most critical aspects of the correction pipeline and their impact for the scientific exploitation of the data, in particular for applications which are not the core-science program of PLATO.

*Speaker

End-to-end simulations as an indispentable tool for PLATO's core and complimentary science program

Nicholas Jannsen*[1]

[1]Institute of Astronomy [Leuven] – Belgium

Abstract

The uninterrupted and high-precision photometry provided by space-borne instruments such as PLATO require long preparatory phases. Versatile siulations that accomudate PLATO's innovative payload design are thus needed to continuously assist with the design, assessment, and validation of the instrument. Realisitic and reliable simulations are likewise essential in order to shape and test the processing pipeline which will, together with ground-based RV follow-up observations, deliver the necessary unforseen stellar and planetary parameters needed for system characterisation. Accordingly, we here present PlatoSim, a dedicated end-to-end PLATO camera simulator with the ability to simulate all of the expected observations of the PLATO space mission, including image time series, meta data, house-keeping data, and light curves. The strong predictive power of PlatoSim will be shown through its diverse applicability and contribution to numerous working groups within the PLATO Mission Consortium. Aside the core science program, 8% of the mission operation will be used on complimentary sciences. Thus, a suite of new simulation studies will be used to highlight the scientific potential of the PLATO complimentary science program – including stellar pulsators (e.g. gamma Doradus star, delta Scuti stars, Cepheids, and RR Lyrae), eclipsing binaries, transient events (e.g. super massive black hole binaries, gamma-ray bursts, and stellar activity), and synergies of these to the core science program. PLATO's ability to photometrically detect a suite of variable phenomenae will be placed in the context to how simulations with PlatoSim quantitatively can help the future observations to push beyond current theoretical barriers of stellar structure and evolution.

*Speaker

A benchmark database for PLATO

Pierre Maxted*[1] and Orlagh Creevey[2]

[1]Keele University – United Kingdom
[2]Observatoire de la Côte dÁzur – Université Côte d'Azur, COMUE Université Côte d'Azur (2015-2019) – France

Abstract

I will describe the selection of stars and collection of data for the benchmark database currently being compiled by the WP125500 "Benchmark stars" work package.

*Speaker

PLATO Science Calibration and Validation Input Catalog

Patrick Gaulme*[1], David Brown*[2], and Juan Cabrera

[1]Max Planck Institute for Solar System Research – Germany
[2]University of Warwick – United Kingdom

Abstract

The science calibration and validation catalog of the PLATO mission (scvPIC) is one of the four components of the PLATO input catalog (PIC). The general idea of the scvPIC is to support the success of the PLATO mission by ensuring that crucial targets will be observed by the mission independently of the prime sample or guest-observer programs. Its scientific objectives and technical requirements are still in progress. Typically, science calibration stars allow for the discovery and inclusion of new input physics in stellar models, whereas validation stars serve to get optimal values of free parameters for chosen input physics. Currently, the expected catalog includes: red giants and gamma Doradus oscillators, known exoplanets or detached eclipsing binaries, Ap/Bp stars, Kepler/TESS legacy stars, and stars with known radii from interferometry. The goal of this presentation is to discuss the content of the scvPIC before the requirements are finalized, and discuss open issues.

*Speaker

Measuring stellar rotation and activity with PLATO

Sylvain N. Breton*[1], Antonino F. Lanza[1], Sergio Messina[1], Frederic Baudin[2], Lisa Bugnet[3], Enrico Corsaro[1], Rafael A. Garcia[4], Savita Mathur[5], and Isabella Pagano[1]

[1]INAF - Osservatorio Astrofisico di Catania – Italy
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[5]Instituto de Astrofisica de Canarias – Spain

Abstract

Space-based photometry is an extremely powerful observing method in order to measure surface rotation of large samples of main-sequence solar-type stars. PLATO will provide, for bright stars, years-long continuous light curves of exquisite quality which should allow characterisation of surface rotation in tens of thousands of stars. In this talk, I will present the rotation and activity analysis module of the PLATO stellar analysis system (SAS), which combines Fourier analysis, autocorrelation of time series and machine learning methodologies to measure both stellar surface rotation and long-term modulations related to stellar magnetic activity. In particular, I will explain how the ROOSTER random forest methodology guarantees the completeness and the robustness of the automated analysis of rotation in the SAS. In order to underline this efficiency, I will present the results of the first tests performed on a Kepler reference data set and PLATO simulated light curves. Finally, I will point out how combining these measurements with asteroseismic inference will enable us to draw an unprecedented dynamical picture of the stars observed by PLATO. This will improve our understanding of the evolution of the angular momentum of late-type stars and of their planetary systems.

*Speaker