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Abstract book

Posters

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Definition of state of the art seismic indicators with EGGMiMoSA and the case of KIC11026764

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Abstract

The presence of mixed modes in the interior of evolved solar-like stars opens numerous avenues for their precise and detailed characterisation. Indeed, their discovery allowed us to disentangle core helium burning giants from hydrogen shell burning ones (Bedding et al. 2011). This is the consequence of the fact that these modes propagate in most of the stellar interior – as opposed to modes in main-sequence solar-like stars, that propagate only in the outermost layers. We defined an approach, EGGMiMoSA (Extracting Guesses about Giants via Mixed-Mode Spectrum Adjustment, Farnir et al. 2021), that relies on the asymptotic description of mixed modes (Shibahashi 1979, Mosser et al. 2012, Takata 2016) and allows us to efficiently adjust the complex oscillation spectra of evolved stars and retrieve stringent seismic indicators, relevant to their structure. The present contribution consists in an exploratory work aiming at defining seismic indicators relevant to the structure of subgiants and at assessing their probing power. We consider the Gemma star (KIC11026764) as a benchmark. Indeed, this star has been observed for 48 months with the Kepler satellite. Consequently, Li, Y. et al. 2020 were able to precisely retrieve 45 individual oscillation modes. Taking advantage of the precise data, we explore the stellar parameters space over a grid of models encompassing the ones expected for Gemma (e.g. Li, T. et al. 2020) and determine the probing ability of defined EGGMiMoSA indicators and the structural information they hold. These indicators allow us to efficiently constrain the age, mass and radius of subgiants. This is crucial to the fulfillment of the PLATO mission requirements as subgiant stars are part of the core science program. This is also particularly relevant to future exoplanetary missions such as ARIEL that will benefit from PLATO's seismology to meet their requirements on precise planetary parameters.

*Speaker

Stellar characterization using Hierarchical Bayesian models

Víctor Tamames Rodero*[1]

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Abstract

Thanks to the improvement of astronomical observations and the recent massive surveys, we now have a huge amount of accurate data that we can explore and use for building new tools. Based on this, we present state of the art machine learning (ML) models which are able to predict stellar parameters like mass, radius, or age with unprecedented robustness, being these our particular study targets. The main goal of this work is to remark the importance of switching from classical ML predictors to probabilistic ones and show their advantages for research.
With classical ML approaches, such as linear regressions, random forest, or Neural Networks, for example, it is possible to get close predictions to target values based on optimized metrics, but this doesn't mean they truly reflect the nature of the data or that they are accurate. Stochastic models, on the other hand, let us get distributions of the possible values our predictions could have, which in many cases could be more convenient and realistic. For doing so, we have used statistically hierarchical architectures with several layers which let us learn from the input data and use that information for feeding posterior levels of the model, maximizing what we know about our dataset. Thanks to these kinds of architectures it is possible to consider the observational errors (which could be regarded as a random distribution), in combination with the bayesian nature of output level we are able to characterize the inner parameters of the ML models, achieving a better propagation of the errors and uncertainty treatment.

In our case, the training set used for mass and radius prediction comes from highly accurate measurements obtained using asteroseismology and eclipsing binary systems, providing 729 stars for our training. For stellar dating, on the other hand, the dataset was built again thanks to asteroseismology and also from well known clusters, giving a total of 351 very precisely dated stars. In both cases, quality prevails over quantity, being this scarcity of data the propeller of developing new creative ways to explode as much information as we can and the main reason we used these kinds of architectures. Actually, obtaining the age of stars represents a huge challenge in stellar physics, just comparable with the importance of this parameter. The most extended way to date stars is comparing them with isochrone models, but it has its own limitations and uncertainties. In the literature we can find other techniques such as using Chemical Clocks, Gyrochronology, stellar activity, lithium depletion, etc. All of them also with their own limitations. Using all these together in combination, thanks to ML techniques, could represent a huge step in the right direction.
In this work, we tried to squeeze as much information from our datasets as possible through Bayesian models, which in our case are a neural network and a random forest, which were

*Speaker

able to match the results of previous literature. Both of them were stacked together under another Bayesian level, which helped us to characterize another source of uncertainty, creating the final and stronger predictor for the stellar mass, radius, and age, giving a mean value and a robust standard deviation of these quantities.

Modelling intensity and velocity perturbations caused by stellar oscillations

Damien Fournier*[1], Nadiia Kostogryz[1], and Laurent Gizon[1]

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Abstract

The interpretation of solar and stellar observations requires a good understanding of the observables such as velocity or disk-integrated intensity. However, the modeling is often drastically simplified. Here, we model the perturbations in intensity caused by stellar oscillations in an atmosphere using first-order perturbation theory. We take into account the main sources of opacity (absorption and scattering) and solve 1D radiative transfer. From the intensity computed at several positions in the spectral line we also derive (line-of-sight or radial) velocity.

In the solar case, we show that the perturbed intensity differs significantly from commonly-used simplified models. Finally, we model the power spectrum for velocity and disk-integrated intensity and compare the latter to a Sun-as-a-star power spectrum obtained from the VIRGO instrument. We present our results on the Sun but the methodology is general and will be applied to many solar-like stars in the future.

*Speaker

Detection and characterisation of oscillations above the acoustic cut-off frequency in 91 Kepler stars

Laura Millson*[1] and Anne-Marie Broomhall[1]

[1]University of Warwick – United Kingdom

Abstract

Whilst oscillations with frequencies less than the acoustic cut-off frequency are trapped within stellar interiors, higher frequency oscillations are not, and so become travelling waves. The interference between these high frequency waves produce an observable, sinusoidal structure in the power spectrum of the star, above the cut-off frequency. These high frequency oscillations are known as pseudo-modes, and are the focus of our study. We have written an algorithm to detect these pseudo-modes, following on from the work of Jimenez et al. (2015), who extends analysis of the pseudo-mode region beyond the Sun to six Kepler stars. In our algorithm, we take a power spectrum of the power spectrum (PSxPS) for a range of frequencies in which we would expect to observe the pseudo-modes, and search for a statistically significant peak. This method has been applied to 91 solar-type stars (ranging in mass from 0.8-1.5 M), using KASOC data from NASA's Kepler mission. In addition, we search for temporal frequency shifts in the pseudo-modes. It has been found in the Sun that pseudo-mode frequencies vary in anti-phase with the solar magnetic cycle, and so we expand this search to our stellar candidates. We utilise the methodology of Kiefer et al. (2017) by obtaining frequency shifts through the generation of a cross-correlation function (CCF) between the periodograms of a reference time segment, and successive time segments. For the Sun, the variation in pseudo-mode frequencies is larger than the corresponding change in p-mode frequency throughout the solar cycle. Pseudo-modes, therefore, may represent a powerful tool for studying stellar magnetic activity cycles.

*Speaker

A Wrinkle in Timing: Core-Envelope Decouping and Gyrochronology

Marc Pinsonneault*[1]

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Abstract

The spin down of low mass stars is a potent diagnostic of their age. However, cluster stars exhibit "stalled spin down", a phase where the usual decay of rotation is slowed or halted. This phenomenon, first recognized as a brief phase for solar analogs, is longer and more pronounced for lower mass stars. A leading theoretical interpretation is core-envelope decoupling, where the apparent stalling is caused by a delay between the spindown of the envelope and the response of the core. In this poster I present evidence that Prasepe stars exhibiting stalled spindown have anomalous star spot filling factors and are highly magnetically active. This strongly supports core-envelope decoupling, and I show that starspot measurements are important calibration tools for spin down models. I provide evidence that this is a significant effect that should be accounted for in PLATO age estimates from gyrochronology, and highlight interesting possible implications for stellar dynamos.

*Speaker

High fluid-Rossby in the Kepler field: Promising candidates for anti-solar differential rotation

Quentin Noraz*[1] and Sylvain Breton*[2]

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Abstract

Anti-solar differential rotation (DR) profiles are characterized by a slow equator and fast rotating poles (reversed with respect to the Sun). They have been reported in numerous 3D numerical simulations over the last decades for slowly rotating solar-like models experiencing high Rossby numbers. However, unambiguous observation of anti-solar DR profiles is still pending for solar-type stars on the main-sequence, although it has been reported for later evolutionary stages.
During their main-sequence, stars spin-down, which increases their Rossby number and could induce a transition toward an anti-solar DR state. Such a rotational transition would have an impact on the large-scale dynamo process, activity and angular momentum evolution for old solar-type stars.

We show in this work the development of a new theoretical formula in order to estimate the effective fluid Rossby number Rof of solar-type stars. We express it as a function of observational quantities such as Teff and Prot, while considering several aspects, such as structure, evolutionary stage, and metallicity. We then quantify the fluid Rossby number of the most recent Kepler catalog of rotational periods by Santos et al. (2019, 2021).
After sanity checks, we obtain 22 targets experiencing high Rossby numbers and being promising candidates to host anti-solar differential rotation. The method can then be applied to future PLATO observations in order to extend this sample, whose future characterization would increase our understanding of magnetic and rotational evolution of solar-type stars. For that purpose, the formula we developed here will be implemented in the mission analysis pipeline.

*Speaker

Predicting Stellar Rotation Periods Using XGBoost

Nuno Gomes*[1,2], Fabio Del Sordo*[3,4,5], and Luís Torgo[1,2,6]

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Abstract

The estimation of rotation periods of stars is a key problem in stellar astrophysics. Given the large amount of data available from ground-based and space telescopes, there is nowadays a growing concern to find reliable methods that allow one to quickly and automatically estimate stellar rotation periods accurately and with precision.
The work we present is aimed at developing a computationally inexpensive approach to automatically predict thousands of stellar rotation periods.
We focused on building a robust supervised machine learning model to predict surface stellar rotation periods from structured data sets, built from the Kepler catalogue of K and M stars.
We analysed the set of independent variables extracted from Kepler light curves, investigating the relationships between them and the response.
With these variables in hand, we trained regression extreme gradient boosting models that contain different numbers of predictors, and assessed their prediction performance, resorting to several metrics.
We obtained models with quality comparable to the state of the art, and we were able to select a minimal set of variables with which we built extreme gradient boosting models without significant loss of performance.
We obtained a goodness of fit, as measured by the adjusted coefficient of determination, of about 97%, for a model built with data sets containing stars with rotation periods between 7 and 45 days.
Based on the results obtained with this study, we conclude that the best models built with the proposed methodology are competitive with the state of the art approaches, having the advantage of being computational cheap, easy to train, and relying on small sets of predictors.

*Speaker

Calculating the centrifugal deformation of stellar or planetary models with RUBIS

Pierre Houdayer[1] and Daniel Reese*[2]

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[2]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Observatoire de Paris – France

Abstract

RUBIS (Rotation code Using Barotropy conservation over Isopotential Surfaces) is a python-based code that calculates the centrifugal deformation of a star or planet for a given cylindrical rotation profile, starting from a spherically symmetric non-rotating model. It does so by preserving the relation between pressure and density, and can handle models with a discontinuity, for example a gaseous giant planet with a solid core. In this talk, I will outline how the RUBIS code functions both in the continuous and discontinuous cases, and describe a convergence acceleration scheme which enables convergence, even at 99.99 % of the critical rotation rate. This will then be followed by comparisons, in terms of structure, gravitational moments, and pulsation frequencies, with rotating polytropic and realistic models coming from independant codes such as ESTER (Evolution STEllaire en Rotation).

*Speaker

Mode classification in rapidly-rotating stars: towards a complete description of 2D oscillations

Giovanni Mirouh*[1]

[1]Universidad de Granada – Spain

Abstract

Oscillation modes in rapidly-rotating stars, such as δ Scuti or SPB stars, present a wide range of complex geometries each with their own properties. Modes in different geometry classes have been showed to follow patterns that relate to the stellar density, rotation rates, temperature... Two dimensional numerical calculations are necessary to describe the stellar structure and the mode geometries in presence of a rapid rotation. But these methods yield about 50.000 modes per model, that need to be separated into _˜8 geometry classes.
This classification is a major hurdle towards mode identification in rapid rotators. Expanding the capabilities of the convolutional neural network of Mirouh et al. 2019, we attempt the classification of entire synthetic oscillation spectra. In this presentation, I will present the geometries we see and discuss the spectral statistical properties this complete classification offers, the regularities it brings out, and the implications on rapid rotator seismic modelling.

*Speaker

Non-adiabatic pulsation computations in rotating ESTER models

Daniel Reese*[1], Marc-Antoine Dupret , Louis Manchon , Giovanni Mirouh , and Michel Rieutord

[1]Laboratoire d'études spatiales et d'instrumentation en astrophysique – Observatoire de Paris – France

Abstract

Taking into account non-adiabatic effects in stellar pulsation calculations is important for several reasons. It allows us to determine excitation or damping rates, and is important for obtaining the variations of effective temperature at the surface, which in turn play a key role in mode visibilities. Calculating these effects in rapidly rotating stellar models is a theoretical and numerical challenge due to the complexity of the questions and the stiffness of the numerical system. In the present poster, we will describe the latest progress in computing non-adiabatic modes in ESTER models using the TOP pulsation code and look at some preliminary applications.

*Speaker

Comparative Study of Low-Temperature Stellar Opacities for different solar mixtures

Pedro Diaz Reeve*[1] and Aldo Serenelli[1]

[1]Institute of Space Sciences – Spain

Abstract

In this poster, we conduct a comparative study of the impact of low-temperature opacities in stellar models using two widely used opacity calculations, Ferguson and AESOPUS considering three different initial chemical compositions: GS98, AGSS09, and MB22. First, we overview the intrinsic differences between the opacity calculations. Then, using GARSTEC, we analyze the differences in the evolutionary tracks of stellar models relevant to the PLATO core program, from the main sequence to the RGB.

*Speaker

Blinded by our Sun: Testing solar models likelihood when looking from afar.

Yago Herrera*[1,2], Aldo Serenelli[1,2], Jakob L. Rørsted[3], and Kuldeep Verma[4]

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[2]Institut dÉstudis Espacials de Catalunya – Spain
[3]Department of Physics and Astronomy, Aarhus University [Aarhus] – Denmark
[4]Department of Physics, Indian Institute of Technology (BHU) Varanasi – India

Abstract

We present preliminary results for our study of the "Sun as a star". In this study, we use the Bayesian Stellar Algorithm (BASTA) to fit and compare a variety of solar models grids to a subset of the observational data of our Sun, including helioseismic data, but degraded to the amount and precision of data normally acquired for other distant stars. The fit computes the likelihood distribution of models in a particular grid, in terms of their chi2, for the given observational data constrains.

The models grids were constructed using different combinations of opacity tables available (OPAL, OP, etc) and the latest solar compositions proposed (Asplund et al 2021, Magg et al 2022). This allows us to use the Sun as a benchmark for testing the aforementioned combinations of opacity tables and compositions.

*Speaker

Helioseismic determination of the Solar metal mass fraction

Gaël Buldgen*[1]

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Abstract

The solar chemical composition is a key element entering both solar en stellar models. Due to the role of the Sun as reference in the metallicity scale used to determine the metallicity of distant stars. Therefore, knowing the chemical composition of the Sun is not only relevant for solar modelling but also for the choice of physical elements entering the stellar model grids. Following the revision in the early 2000s of the solar heavy element content (Asplund et al. 2004), an ongoing debate has agitated the solar modelling community as keeping a high solar metallicity (as in the Grevesse & Sauval 1998 tables) would provide a much better agreement with classical helioseismic constraints (sound speed, base of the convective envelope position, ...). The recent picture regarding spectroscopic determinations of solar abundances provided by Asplund et al. 2021 has been recently challenged in a paper by Magg et al. 2022, revising the solar metallicity back to its value of 1998. Independently of the controversy in spectroscopy, helioseismic determinations of the solar metallicity have been attempted in various papers (Lin & Däppen, Antia & Basu, Lin,Antia & Basu, Vorontsov et al. 2013, Buldgen et al. 2017). The latest studies favoured a low metallicity value, but suffered from very low precision. In this poster, we present an improved determination of the solar metallicity from helioseismic inversions and show that for all modern equations of state, we find a precise solar metallicity value in agreement with the Asplund et al. (2021) abundances, rejecting the Magg et al. (2022) values.

*Speaker

Improving stellar modeling with new precise nuclear reaction rates determined from nuclear experiment

Thibaut Dumont*[1], Emma Monpribat[1], Marcel Heine[1], Aurelie Bonhomme[1], Jean Nippert[1], and Sandrine Courtin[1,2]

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[2]Institut d'Etudes Avancées de l'Université de Strasbourg - Institute for Advanced Study – université de Strasbourg – France

Abstract

In recent years, new experimental determinations of numerous nuclear reaction rates relevant for astrophysics have been achieved via direct and indirect experimental methods, highlighting specific trends like the unexpected fusion hindrance phenomenon (steep fall of the fusion cross section at very low energies) and multiple resonances. In particular, a precise determination of the nuclear reaction rates is a crucial ingredient in understanding stellar evolution. New nuclear reaction rates have been determined for the different cycles of H-burning, He-burning and C-burning phases by nuclear experiment, leading to significant changes in the nucleosynthesis, with especially consequences on s-process elements abundances. In order to improve stellar modelling, we now need to take into account these new results that can bring one of the key to understand stellar evolution and especially the chemically peculiar stars.

In particular, new direct measurements for the C12+C12 nuclear reaction have been obtained at very low energies by the STELLA collaboration in France (Fruet et al. 2020) and open the way to improvements in stellar evolution modelling. This reaction is indeed the main nuclear reaction during the advanced C-burning phase of massive stars ($>$ 8Msol) and can drive important changes in the lifetime of this phase and in the resulting abundances, impacting later stages of the evolution. Monpribat et al. 2022 showed these new rates impact the burning lifetime as well as the production of C-burning products and s-process elements. Using the stellar evolution codes GENEC and STAREVOL, we computed new models for a larger range of mass and metallicity, and including rotation-induced mixing. We confirm previous preliminary results and highlight increased impact due to rotation as well as the dependence on the stellar mass/metallicity for the production of s-elements and final stages of stars (Dumont et al. 2023, A&A in prep.)

*Speaker

An efficient way to compute dense and accurate grids of stellar models including the effect of radiative accelerations

Nuno Moedas*[1,2,3]

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[2]Centro de Astrofísica da Universidade do Porto – Portugal
[3]Departamento de Física e Astronomia [Porto] – Portugal

Abstract

The chemical transport mechanisms are key ingredients in stellar evolution. However, the computation of stellar models, used to characterize stars, often includes a simple atomic diffusion treatment, ignoring other additional processes, like the radiative accelerations. This is mainly due to their high computational costs. But this approximation should not be applied to F-type stars because of the large surface depletion of chemical elements that the use of the gravitational settling only would induce.
With the incoming data from PLATO, the incomplete physics in stellar models would prevent us from extending the requirements imposed by this mission for G-type stars to hotter types, specifically in terms of accuracy in age and mass. Hence, it is fundamental to include other competing transport processes for a better characterization of such stars.

In this talk, we present an efficient way to overcome this issue in stellar models. First, we show how to avoid the over-variations of surface abundances by introducing a turbulent mixing coefficient that can reproduce the effects of extra chemical transport processes, including radiative accelerations, parametrized on the surface iron abundance. Secondly, we will show the results of the implementation of a more efficient way to compute radiative accelerations by using the Single-Valued Parameter (SVP) approximation in MESA. As a test, we present the impact of our prescriptions on the characterization of Kepler stars.
With our work we manage to retrieve the surface chemical abundances of many elements, mimicking also the effect of radial acceleration in its complete implementation. This development allows a fast computation of a large number of stellar models including these processes, permitting us to produce more accurately the stellar fundamental properties (especially the ages) for F-type and hotter stars. The methods we present here can be adapted to any stellar evolution code selected to compute the grids used in the PLATO pipeline.

*Speaker

Constraining angular momentum transport processes of main-sequence F-type stars with asteroseismology

Jérôme Bétrisey*[1], Patrick Eggenberger[1], Gaël Buldgen[1], Othman Benomar[2], and Michael Bazot[3]

[1]University of Geneva – Switzerland
[2]National Astronomical Observatory of Japan – Japan
[3]Heidelberg Institute for Theoretical Studies – Germany

Abstract

With the advent of space-based missions such as CoRoT, *Kepler*, and TESS, asteroseismology has become a powerful tool to study the internal rotation of stars. The rotation depends on the efficiency of the angular momentum (AM) transport inside the star, and its study allows to constrain the internal AM transport processes, as well as improve our understanding of their physical nature. In this context, we compared the rotation rates predicted by asteroseismology and by starspots measurements for four main-sequence F-type stars from the *Kepler LEGACY* sample, considering different AM transport prescriptions, and investigated if some of these prescriptions could be ruled out.

Due to the slow rotation of these stars, we decoupled the modelling of the structure and of the rotational profile, respectively obtained by an asteroseismic characterization and by using rotating models including a detailed and coherent treatment of the AM transport. We then compared the mean asteroseismic rotation rate with the surface rotation rate from starspots measurements for each of the AM transport prescriptions. In the hotter part of the HR diagram (*M_star* > _˜ 1.2*M_sun* at solar metallicity), combining asteroseismic constraints from splittings of pressure modes and surface rotation rates does not allow to conclude on the need for an efficient AM transport in addition to the sole transport by meridional circulation and shear instability. Both prescriptions are indeed consistent with the quasi-solid rotation measured by Benomar et al. (2015) and Nielsen et al. (2017). In the colder part of the HR diagram, the situation is different due to the efficient braking of the stellar surface by magnetised winds. We find a clear disagreement between the rotational properties of models including only hydrodynamic processes and asteroseismic constraints, while models with magnetic fields correctly reproduce the observations, similarly to the solar case.

This shows the existence of a mass regime corresponding to main-sequence F-type stars for which it is difficult to constrain the AM transport processes, unlike for hotter, Gamma Dor stars or colder, less massive solar analogs.

*Speaker

Effect of angular momentum transport through mixed modes as a function of stellar evolution

Beatriz Bordadágua*[1], Felix Ahlborn[1], and Saskia Hekker[1]

[1]Heidelberg Institute for Theoretical Studies – Germany

Abstract

Current models of red giant stars predict higher core rotation rates than derived observationally. This indicates the need for an efficient mechanism of angular momentum (AM) transport. Mixed modes are proposed as a mechanism of AM transport through the interaction between the mean flow and the oscillations. This mechanism has been shown to potentially explain the seismic core rotation values.

We aim to uncover the potential of mixed modes as an efficient mechanism of AM transport as a function of evolution along the RGB and for different stellar masses. To this end, we compute stellar evolution tracks and implement the mixed modes mechanism for AM transport to obtain more realistic rotation profiles.

We present the evolution of the rotation profiles using AM transport through mixed modes and compare the results with observations.

*Speaker

RHD simulation of convection in bright F-type stars

Andrea Caldiroli*[1], Damian Fabbian , Friedrich Kupka , Mike Montgomery , and Herbert Muthsam

[1]University of Vienna [Vienna] – Austria

Abstract

To this date, the role of turbulence in the excitation and damping of global oscillations in A- and Am-type stars has not been investigated adequately with 3D RHD simulations. We report here the first results from a project which aims at creating a grid of simulation of the convective layers for stars in the range of hot F- to A-type. In particular, we present the results from a 3D RHD simulation of an F-type star with Teff = 6600 K and log(g) = 4 obtained through the ANTARES code. The simulation extends to a box of 23 $\times$ 46 $\times$ 46 Mm with a resolution of 65 $\times$ 190 $\times$ 190 km and covers a time span of $\sim$ 3 days. Here we show the results obtained for the mean structure profile and we present a first analysis of the seismic properties predicted by our model by computing the temporal power spectra of the average vertical velocity and radiative flux.

*Speaker

Simulations of early F-type to late A-type main-sequence and sub-giant stars

D. Fabbian*[1], Friedrich Kupka[2], Andrea Caldiroli[3], Michael Montgomery[4], and Herbert Muthsam[3]

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Abstract

We present preliminary results of supercomputer simulations of stellar atmospheres warmer than the Sun (with effective temperatures of up to 9000 K) obtained with the ANTARES numerical code. The data will be used as benchmark to improve multi-dimensional radiation-hydrodynamic modeling for this type of stellar objects and as the basis for computations of synthetic spectra and other observable signatures of the characteristic physical properties of relevant stars.

*Speaker

Ground-based contribution of average-sized telescopes to characterisation of PLATO targets

Šarūnas Mikolaitis*[1], Gražina Tautvaišienė[1], Arnas Drazdauskas[1], Renata Minkevičiūtė[1], Edita Stonkutė[1], Erika Pakštienė[1], Carlos Viscasillas Vázquez[1], Rimvydas Janulis[1], Markus Ambrosch[1], and Vilius Bagdonas[1]

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Abstract

A spectroscopic characterization is available for less than 30% of the bright stars in the Solar neighborhood. This missing information about the Galactic environment in this region of space is very important for asteroseismic and planetary studies and space missions (e.g., ESA PLATO or NASA TESS) that are designed to perform an in-depth analysis of large fields of the sky-sphere and searching for exoplanets around bright stars.
Accurate atmospheric parameters and chemical composition of stars play a vital role in characterizing physical parameters of exoplanetary systems and understanding their formation. A full asteroseismic characterization of a star is also possible if its main atmospheric parameters are known.

In this contribution, we discuss the effort of ground-based spectroscopic observations made by average-sized telescopes and compare them with ongoing and planned all-sky spectroscopic surveys. As an example, we will present the ongoing spectroscopic survey SPFOT that employs Vilnius University Echelle Spectrograph (VUES) mounted on the 1.65 m telescope of the Molėtai Astronomical Observatory in Lithuania. Using the high-resolution (up to R=68000) and long wavelength coverage (400 - 900 nm) VUES spectra we are able to provide the detailed spectroscopic characterization for bright stars. We have already observed about 2000 brightest stars in fields covering the PLATO LOPN and TESS continuous viewing zone. Most of LOPN P2 targets are already observed. Results for a part of the sample were already published in a number of contributions where we presented detailed atmospheric parameters and abundances of up to 34 chemical elements.

*Speaker

The first generation grid of stellar models for PLATO's stellar target characterisation

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Abstract

The main goal of the PLATO mission is to detect and characterise exoplanets orbiting around bright solar-like stars, preferably close to the habitable zone. The PSM is committing to providing, thanks to PLATO's observations, determinations of mass, radius and age (MRA) with respectively an accuracy of 15%, 2% and 10% for G0V stars with a magnitude of mV = 10. The WP121 will provide grids of stellar evolution models, used to estimate, through an interpolation, the MRA of of each PLATO target. Three generations of grids are foreseen. In this presentation, we present the 1st generation grid: the physics chosen, the parameter space tested; and the stellar evolution code chosen to compute it: Cesam2k20 (formerly known as CESTAM); and the path followed to validate these choices.

*Speaker

Suppressed dipole modes in red-giant stars

Quentin Coppée*[1,2], Saskia Hekker[1,2], Michael Bazot[1], and Jonas Müller[1,2]

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Abstract

The analysis of the *Kepler* light curves of red-giant stars revealed a few hundred stars with low-amplitude dipole modes. Various mechanisms that could damp the modes have been proposed including a magnetic field in the core, a peculiar internal structure, or binarity. However, none of these hypotheses have been confirmed.

To gain insight into the damping mechanism we investigate the peak properties (linewidths and amplitudes) of the radial oscillation modes. Since it remains unclear if and how these modes are affected, they can provide additional constraints on the damping mechanism. We compared the radial mode properties of suppressed dipole mode red giants with the properties of a control sample. We present the results of this comparison and its consequences for the proposed hypotheses.

*Speaker

Effect of Core Magnetic Fields on Red-giant Oscillation Modes

Shatanik Bhattacharya*[1], Subrata Panda[1], Srijan Bharati Das[2], and Shravan Hanasoge[1]

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Abstract

Stars during their formation and evolution tend to acquire magnetic fields that thread their interiors and stellar environments. Interpreting the associated oscillations enables us to infer properties of the stellar interior, including their internal magnetic fields. Hanasoge 2017 and Das et al. 2020 used ideas prevalent in terrestrial seismology to develop a rigorous theory to compute the splittings for self and cross-coupled normal modes due to general magnetic-field (**B**) configurations. We construct sensitivity kernels to the Lorentz stress tensor **BB** (Lorentz stress) due to pure self-coupling, invoking the isolated-multiplet approximation. Restricting the analysis to pure poloidal and pure toroidal magnetic fields within the radiative core, we have computed even splittings that would be observed in red giants. Our study shows that the even splittings of g-dominant mixed modes go as $\hat{\nu}\{-3\}$ and $\hat{\nu}\{-3/2\}$ for our chosen poloidal and toroidal field models respectively. We also found that the l=1 and g-dominant l=2 mixed modes' splittings for pure poloidal fields inside RGB cores may be well approximated using a modified version of the formulation of splittings in Hasan et al. 2005. Our code can be used to compute splittings for solar-like oscillators such as MS, SGB, and RGB stars with axisymmetric internal magnetic field models.

*Speaker

Asteroseismic signatures of internal magnetic fields in red giants

Jonas Müller*[1,2], Saskia Hekker[1,3], Michael Bazot[1], and Quentin Coppée[1,2]

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Abstract

Asteroseismology offers the opportunity to characterize the internal magnetic fields of red giants based on asymmetric splittings of non-radial oscillation modes. In addition, magnetic fields in the cores of red giants are proposed as a source of damping causing mode suppression. We aim to make predictions about observable signatures caused by internal magnetic fields. We show that the configuration of the magnetic field can have significant effects on the properties of the non-radial and radial modes, affecting both their frequency and inertia. In this contribution, we focus on the radial modes to estimate the strength of the horizontal components of the magnetic field.

*Speaker

Probing the evolutionary status of red giants with ratios

Pedro Fanha[1], Margarida Cunha*[1], Diego Bossini[1], Maria Ferreira[1], and Morgan Deal[2]

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Abstract

When stars evolve towards red giants, their structures experience significant changes that are not easily visible in classical observations, such as the stellar temperature and luminosity. On the other hand, period spacings, probing directly the stellar cores, provide an effective way to distinguish between red-giant branch (RGB) and core helium-burning stars. Nevertheless, their observation is not always possible, becoming particularly difficult in luminous RGB stars.
In this work we seek to find an alternative way to establish the evolutionary stage of stars crossing the read-giant phase. Based on stellar models, we argue that such an alternative is provided by a particular combination of the ratios of small to large frequency separations.

*Speaker

Accurate asteroseismic surface rotation rates for evolved red giants

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Abstract

The understanding of the internal stellar rotation and its evolution is crucial for constructing accurate stellar models. To that end, we use asteroseismology to probe the interior rotation of stars, with a focus on red giants. However, the accurate determination of near-surface rotation rates in evolved red giants was previously hindered by large systematic errors inherent to the inversion method (e.g., Ahlborn et al. 2020). To address this issue, we have developed a modification to a currently used rotational inversion method that effectively eliminates these errors (Ahlborn et al. 2022).

Utilizing our improved rotational inversion technique, we aim to determine accurate red-giant envelope rotation rates by employing a broader range of suitable reference stellar models (Ahlborn et al. in prep). We select suitable reference models by matching the large frequency separation and requiring a high degree of correlation of the mixed-mode character between the observations and the reference model. Our results indicate that, given an adequate set of reference models, rotation rates can be accurately recovered.

*Speaker

Delta Scuti stars with substellar companions

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Abstract

There is a small number of known delta Scuti stars with transiting exoplanets. The analysis of such systems is challenging because the pulsation distorts the transits and therefore, the proper subtraction of the pulsation pattern is essential in order to model the transit light curves correctly. In addition, in close systems, the tidal forces of the companion may influence the oscillations. We performed photometric analysis of two such systems, WASP-33 and HD 31221, using Transiting Exoplanet Survey Satellite (TESS) space telescope data. We modeled the transit light curves with the Transit and Light Curve Modeller (TLCM) code and determined the basic parameters of the systems. We also found evidence of tidally perturbed stellar oscillations related to the substellar companions. The continuous and longer time span of PLATO observations will allow better modeling and understanding of these kind of systems in terms of the transits and the pulsation.

*Speaker

Stellar oscillation - a tool to determine structure parameters of δ Scuti pulsators.

Subrata Panda*[1], Siddharth Dhanpal[1], Simon Murphy[2,3,4], Shravan Hanasoge[1,5], and Timothy R. Bedding[2,3]

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[5]NYUAD Center for Space Science – United Arab Emirates

Abstract

Asteroseismology, the study of stellar pulsation, is an indispensable tool for probing stellar structure, evolution and different stellar dynamics. With the precise time series photometries from space-borne instruments like MOST, CoRoT, Kepler, BRITE and TESS, dramatic improvements have been observed in the asteroseismology of different kinds of oscillating stars. These missions have significantly shed light on the oscillations of δ Scuti stars - a special class of oscillators, particularly interesting owing to their fast rotation rates and uninterpreted pulsation patterns. However, we still lack precise measurements of their mass, metallicity, and age because it's been challenging to identify different modes in their asteroseismic spectra. But recently, Bedding et al. (2020) discovered 60 δ Scutis with highly regular pulsation patterns from TESS and Kepler. We have developed machine learning and other techniques to infer the mass, metallicity, and ages of these stars. Our results indicate that most of these stars are younger than 30 Myr, having masses around 1.6 M and metallicities below Z = 0.010. By properly identifying the dipole modes, we found that machine learning techniques can improve age determination of δ Scutis. Our study shows that the radial modes succinctly contain the information of stellar luminosity and temperature. We also noticed that the effective surface temperature has a strong impact on the inferences of all the structure parameters. With the upcoming space data from TESS and PLATO, it is possible to obtain structure inferences on a much larger ensemble of δ Scutis, which can be promising to carry out galactic archaeology.

*Speaker

On the path to obtaining non-linear models for delta Scuti Star

Miriam Rodríguez Sánchez*[1], Mariel Lares-Martiz[2], Andrés Moya Bedon[1,3], and Javier Pascual-Granado[2]

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Abstract

Delta Scuti stars are known for their rich power spectrum, in which the immense number of modes that can be excited is reflected. This phenomenon, partly caused by non-linear components, makes it more challenging to obtain asteroseismic parameters and, therefore, to study their phenomenology. Nevertheless, in young delta Scuti stars, an absence of nonlinearities in their spectra is expected due to their evolutionary stage. This makes possible an easier way to identify their pulsation modes and other asteroseismic variables, as previously seen in Bedding et al. (2020).

In this work, we present two studies with two very contrasting approaches: the first is based on the analysis of frequency combinations through observations, and the second is more theoretical by focusing on the study of the oscillation equations. In the observational one, we study a set of light curves belonging to a young sample of delta Scuti stars observed by the satellite TESS and selected from young moving groups and open clusters. After analysing their power spectrum, no frequency combinations were found in these stars, supporting the previously mentioned assumption.

For the other one, a first approximation is presented with the ultimate aim of developing a complete non-linear pulsation code for delta Scuti stars. The process of numerically solving the non-linear differential equations of oscillations for High Amplitude Delta Scuti (HADS) stars is outlined. The equations are described in terms of the so-called Volterra expansion, which uses the generalised transfer functions. These functions, named Volterra coefficients, are required to calculate the values of some equation coefficients. Thanks to the latest ultra-precise photometric data, they can be estimated observationally through amplitude and phase relations between parents and children frequencies (see Lares-Martiz et al. 2020). After obtaining these coefficients, the equations can be numerically solved.

In summary, this is an approach to the long-sought-after complete solution of the non-linear pulsation equations that, in its early stage, can already be helpful for the development of models that more precisely describe the behaviour of HADS stars.

*Speaker

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Understanding nonlinearities with ML techniques

Javier Pascual-Granado*[1], Jose Ramón Rodón , Cristina Roche , Mariel Lares-Martiz , and Miriam Rodríguez

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Abstract

Ultra-precise photometric data gathered by recent space missions improve our knowledge of stars significantly but we are also facing challenges to find models that fit the observations with the state-of-the-art theory. In addition, the huge amount of data requires the application of innovative data analysis techniques to exploit the information.
Machine learning could help us both to deal with the large amount of data and to explore new ways of processing the lightcurves of pulsating stars. Of special interest for studies of intermediate mass pulsating stars is the decades-old unsolved non-linear phenomenon. The aim of this project is to use machine learning tools in order to characterize a sample of pulsating stars through clustering analysis to shed some light into the nature of this phenomenon.
Specifically, we focus on the classification of delta scuti stars as High Amplitude (HADS) and Low Amplitude (LADS) through the analysis of nonlinear parameters characterizing the lightcurves (e.g. harmonics and combinations). Subsequently, the same study is extended to hybrid stars, which have g and p-mode pulsation and gamma Dor stars that only pulsate in g modes. The input parameters are extracted from the lightcurves of a sample of stars observed by TESS space satellite. The application of ML techniques for understanding nonlinearities have a great potential use for the Complementary Science Program of PLATO.

*Speaker

Machine Learning to detect pulsations in M dwarfs radial velocity time series

Ciro Emmanuel-Martínez*[1], Cristina Rodríguez-López[2], Pedro J. Amado[3], and Jose Ramón Rodón[4]

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Abstract

PLATO mission will deliver hundredths of thousands of high precision light curves, and ground-based spectroscopic RV observations of thousands of interesting targets will follow. Machine Learning techniques must be applied to get insights from such a huge volume of data. We present an example of the application of Machine Learning techniques to search for pulsations in ground-based RV observations of M dwarfs. Thermodynamically and solar-like pulsations have been theoretically predicted for M dwarfs, but not yet detected observationally. PLATO mission will deliver high precision light curves for more than 5000 M dwarfs, that are also amenable of these ML techniques for pulsation searches.

*Speaker

Low-amplitude, short-timescale photometric variabilty in a sample of M dwarf stars

Giovanni Bruno*[1], Isabella Pagano[1], Gaetano Scandariato[1], and Cheops Consortium

[1]INAF - Osservatorio Astrofisico di Catania – Italy

Abstract

We used ESA's CHaracterising ExOPlanet Satellite (CHEOPS) to monitor the short-term photometric variability of 133 late K and M dwarf stars, including some which were selected from exoplanet-search radial velocity follow-up catalogues. With CHEOPS's high-cadence observing mode, we obtained measurements every 3 seconds and a median uncertainty of 1 part per thousand per data point in our V < 12 sample. This allowed us to probe the parameter space of stellar flares down to energies and durations to-date unexplored in optical bands. Our study included the search for pre-flare flux drops, which have rarely been observed for particularly active stars. We carried out the same analysis on 20-second, publicly available TESS light curves for the same targets.
This work will help complement searches focused on more energetic flares. By depicting a more complete picture of cool stars high-energy events, it will contribute to the understanding of stellar activity and of its relationship with the environment exoplanets live in.

*Speaker

Stellar rotation and multifractality on F to M dwarfs main-sequence stars

Daniel Brito De Freitas*[1]

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Abstract

In the present study, high-precision time-series photometry for the active stars from different missions (e.g., CoRoT, Kepler, and TESS) is described in the language of multifractals. We explore the potential of using the rescaled range analysis (R/S) and multifractal detrended moving average analysis (MFDMA) methods to characterize the multiscale structure of the observed time series from a sample of 160 000 active stars. As a result, the Hurst exponent (H) derived from both methods shows a strong correlation with the period derived from rotational modulation. In addition, the variability indicators reveal how this correlation follows a high activity line. We also verify that the H-index is an able parameter for distinguishing the different signs of stellar rotation that can exist between the stars with and without differential rotation, as well as the planetary signature. In summary, the results indicate that the Hurst exponent is a promising index for estimating stellar variability. We hope that this statistical framework can contribute to the objectives of the PLATO mission, in particular, in the field of stellar activity and rotation.

*Speaker

Long-term Stability of Solutions in Benchmark Stars: UX Mensae

Ganesh Pawar*[1], Krzysztof Hełminiak[1], Ayush Moharana[1], and Tilaksingh Pawar[1]

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Abstract

Detached Eclipsing Binaries (DEBs) are the key sources of accurate and precise ($< 1\%$) stellar parameters. DEBs, whose analysis leads to stable and robust results can be used as benchmark stars. Benchmark stars are crucial for testing stellar models, calibration and data analysis algorithms used by space-based photometric missions like PLATO.

In our study, we focus on a benchmark candidate UX Men observed in the continuous viewing zone of the Transiting Exoplanet Survey Satellite (TESS). We obtained stellar parameters using two different detrending methods and two different modelling codes (JKTEBOP and ALLESFITTER) for lightcurve spanning over 23 sectors of TESS observations. We also coupled it with radial velocities to get precise masses ($< 0.5\%$) of both the stars in the system. Further, using disentangled spectra we obtain spectroscopic temperatures and use them as a calibration against photometric temperature estimates.

*Speaker

Search for low-mass star companions around short-period eclipsing binaries: the case of RX Gru

Frédéric Marcadon*[1], Ayush Moharana[2], Tilak Pawar[2], Ganesh Pawar[2], Krzysztof Helminiak[2], Maciej Konacki[2], and Andrej Prsa[1]

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[2]Copernicus Astronomical Center of the Polish Academy of Sciences – Poland

Abstract

The detection of exoplanets and low-mass stars around eclipsing binaries is the major goal of the Solaris network maintained by the Nicolaus Copernicus Astronomical Center (NCAC, Poland). Solaris consists of a network of four autonomous observatories located in the Republic of South Africa, Australia, and Argentina. The Solaris network aims to detect circumbinary objects on long-period orbits, otherwise inaccessible with current space telescopes, using the eclipse timing variation (ETV) method. This method is based on the detection of periodic variations of the mid-eclipse times through the light-traveltime effect (LTTE) caused by a circumbinary companion. In this talk, I will present the case of RX Gru, a solar-type eclipsing binary for which we detected a brown dwarf companion in a 24-yr orbit. This detection was made possible by our long-term monitoring of the system with Solaris and by using the SuperWASP and TESS photometry.

*Speaker

Stellar evolutionary tracks for medium mass stars - effects of microphysics, core and envelope overshooting and mass loss

Radoslaw Smolec*[1], Oliwia Ziółkowska[2], Rajeev Singh Rathour[2], and Vincent Hocde[2]

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Abstract

Reliable evolutionary tracks are a backbone of stellar astrophysics; they are an essential ingredient of asteroseismic inference. While some progress has been made towards advanced 3D modeling of stellar interiors, 1D evolutionary modeling will remain the only tool to efficiently model the large flow of data form new space telescopes and ground based surveys. Hence, it is critical to quantify the uncertainties inherent to 1D evolutionary modeling and to compute extensive grids of models that can later be used as a starting point for detailed stellar modeling.
We present an extensive grid of stellar evolutionary tracks for medium mass stars computed with Modules for Experiments in Stellar Astrophysics (MESA). A grid covers stellar masses from 2 to 9 solar masses and a range of metallicties, from Z=0.0014 ((Fe/H)=-1) to Z=0.02 ((Fe/H)=+0.2), altogether 11 metallicity values. Models are computed form the Zero Age Main Sequence till the end of core Helium burning. For selected masses and metallicities models were computed assuming different microphysical setups, ie., models assume different scaled solar mixtures, different atmospheric boundary conditions, different variants of the Mixing Length Theory and different sets of nuclear reaction rates. This allows us to determine the uncertainties in the evolutionary tracks and in the parameters of the models (eg. luminosity, effective temperature, age, surface composition) at selected points in the evolution, due to uncertainties in the microphysics. These uncertainties are usually very low, provided mixing-length parameter is properly calibrated. The largest differences are observed for the highest metallicities and when considering different nuclear reaction rates.

The effects of various macrophysical processes were investigated for the full model grid. The effects include convective core overshooting during the main sequence evolution, convective envelope overshooting and mass-loss. The latter two factors become important after the main sequence and influence the core helium burning phase, which is studied in detail. Mass-luminosity relations are computed and compared with observational constraints. The emergence of the blue loops, their properties, in particular dependence on the overshooting parameters and on the adopted nuclear reaction rates are studied. The loop properties (eg. minimum mass to enter the instability strip, temperature and luminosity extent) vary with mass and metallicity in a non-linear way and strongly depend on core and envelope overshooting parameters. While, in general, the larger the convective core overshooting, the

*Speaker

shorter the loop, and the larger the envelope overshooting, the longer the loop, the details depend on metallicity. The adopted nuclear reaction rates also affect the extent of the blue loops, in particular for higher metallicities.
A library of the computed evolutionary tracks will be made publicly available.

Observational probe into evolution and dynamics of Compact Hierarchical Triples

Ayush Moharana*[1], Krzysztof Hełminiak[1], Frédéric Marcadon[1,2], Tilaksingh Pawar[1], Ganesh Pawar[1], and Maciej Konacki[1]

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[2]Department of Astrophysics and Planetary Science [Villanova] – United States

Abstract

Compact Hierarchical Triples (CHTs) are systems in which the tertiary star orbits the inner binary in an orbit shorter than 1000 days. These systems were previously thought to be rare but with photometric observations from space telescopes (Kepler and TESS), we have found a few hundred new candidates. CHTs provide an interesting setup to study star formation (using orbital architecture and metallicity distribution) at small scales (less than 5 AU) and also evolution scenarios of dynamical mergers. CHTs with an eclipsing binary as the inner binary gives us an opportunity to extract information about all three stars. Further, the effects of the tertiary (e.g. eclipse depth variation) are visible in the photometric observations spanning the time frame of a present-day photometric mission. In our work, we use TESS lightcurves and time-series spectroscopic observations to extract stellar, orbital, and atmospheric parameters of the stars in our sample of low-mass CHTs. Using this set of parameters, coupled with evolutionary tracks and numerical integrators, we probe into the stellar and dynamical evolution of a few sample CHTs. We also discuss specific evolutionary scenarios where an old CHT (_˜3Gyr) evolves into a contact binary with the tertiary star affecting the timescale of this evolution. The launch of PLATO will extend the timeline of observations of the CHTs and will allow us to constrain the long-term dynamical effects of these triples better.

*Speaker

Stellar differential rotation from spot mapping via planetary transits

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Abstract

Just like the Sun, other stars also exhibit differential rotation. Currently, it is possible to estimate the rotation profile of a star that hosts at least one planet in an orbit that periodically eclipses the star. During one of these transits, a planet may occult a spot on the photosphere of the star, causing slight variations in its light curve. By detecting the same spot during a later transit, we can deduce the stellar rotation period at that latitude. In a multiplanetary system, each planet may occult different latitudes of the star. Therefore, spots can be observed in more than one latitude of the stellar disc. By observing these starspots in various latitudes, we can estimate the differential rotation profile of the star. In this study, we use the model described in Silva (2003) to characterize the starspots. We present the results of differential rotation for seven stars observed by the Kepler satellite, two of which have multiple orbiting planets. The results show that the differential rotation is highly correlated with the stellar mean rotation period and weakly linked to the stellar mass or effective temperature.

*Speaker

3D non-LTE modeling of the stellar centre-to-limb effect for characterizing planetary atmospheres

Gloria Canocchi*[1] and Karin Lind[1]

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Abstract

The center-to-limb variation (CLV) of the stellar lines across the stellar disk is an important effect for planetary transit spectroscopy. Indeed the variation of spectral line profiles when the planet transits different part of the stellar disk can affect the determination of elemental abundances in the exoplanetary atmospheres, as shown by Yan et al. (2017).
Accurately modelling the CLV of the stellar lines in planet-host stars is fundamental to correctly detect and measure abundances of atmospheric species and thus improve the exoplanet atmosphere characterization.
However, we know that the commonly used 1D plane-parallel LTE atmosphere models fail to reproduce spatially resolved observations of the solar disk. 3D hydrodynamic models and non-LTE line formation is required for an accurate modelling of the stellar CLV effect.
So far, the best studied atomic lines in transit spectroscopy are the Na D lines and the NIR K resonance lines. In this talk I will present new results regarding the modelling of these lines in the Sun using 3D non-LTE radiative transfer and discuss possible implications for transit spectroscopy of planets around F, G and K type stars, like those that will be observed by the forthcoming PLATO mission.

*Speaker

Astrophysical false positives in the PLATO LOP fields.

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[2]The University of Auckland – New Zealand

Abstract

While it is recognised that eclipsing background binary systems in the LOPS and LOPN fields will cause false positive signals, the scale of the problem is not well understood. In this presentation we summarize our paper published in November 2022 in Monthly Notices of the Royal Astronomical Society (MNRAS), in which we utilise the Binary Stellar Evolution and Population Synthesis (BiSEPS) code, to create a complete synthetic stellar and planetary population for the proposed southern LOP field (LOPS0), as well as for a representative portion of the northern LOP field (LOPN-sub), and analyse these areas for astrophysical false positives.
We also update progress on our work on summarising the properties of the binary systems generating the false positives to better understand what types of binaries are most likely to cause false positives, especially in the Earth-like radius range.

*Speaker

PLATO's capability in detecting stellar tidal deformation due to transiting companion.

Vikash Singh*[1], Gaetano Scandariato[1], Isabella Pagano[1], Giovanni Bruno[1], Marco Montalto[1], Claudio Arena[1], Daniela Sicilia[1], Flavia Calderone[1], and Nino Greco[1]

[1]INAF - Osservatorio Astrofisico di Catania – Italy

Abstract

With the advent of PLATO, we will have the opportunity to visit a significant number of cool stars and associated transiting planets. The shape and motion of the host star are substantially affected by its planetary companions, the effect being larger as the planet to star mass ratio increases. The light curve of a transiting system such as a hot Neptune around a cool star provides information on the tidal shape and orientation of the host star, in addition to its rotational velocity. In this context, we predict the performance of PLATO over such systems with a particular focus on the detection of ellipsoidal variations. Since the tidal deformation of stars depends on their internal structure, the detection of ellipsoidal variations will allow us to test and validate current models for the interiors of M and K dwarfs.

*Speaker

The influence of magnetism on the stochastic excitation of acoustic modes in solar-type stars

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Abstract

Amplitudes of p-modes in solar-like stars are intrinsically linked to the properties of turbulent convection, which acts as an excitation source. In this framework, stellar rotation and magnetic field strongly influence convection. Recent observational works using results of the *Kepler* mission, showed that p-modes signals are not detected in a large fraction of solar-type stars, where they are expected. One hypothesis is that the excitation source term is too low to sustain oscillations. In addition, observations of solar-type stars show that the amplitude of these waves are modulated along their magnetic activity cycles. To asses the impact of magnetic field, we extend the state-of-the-art of the formalism describing stochastic excitation. We show that the turbulent source terms are modified by the presence of rotation and magnetism. First, magnetism influences Reynolds stresses and the entropy source terms. Second, new magnetic source terms appear. Next, we illustrate how the acoustic waves amplitudes are modulated by the magnetic activity of stars. This work helps predict p-modes detectability in rotating magnetic solar-like stars, which is paramount to prepare the forthcoming space missions in asteroseismology, such as *PLATO* and *HAYDN*.

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