TASC10 / KASC17

Abstracts

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Contents

Plenary

Special contributions

Forty years of asteroseismology

Invited: J. Christensen-Dalsgaard[1]

(1) Department of Physics and Astronomy, Aarhus University, Denmark.

Forty years ago, to within a day of the start of the present workshop, Aarhus University opened Symposium 123 of the International Astronomical Union, 'Advances in helio- and asteroseismology'. At that time, helioseismology was a well-established field although the major helioseismic projects were still in the future, and oscillations were studied in a range of stars, including white dwarfs, while asteroseismology of solar-like stars was an eagerly-pursued dream. However, none of us dreaming at the time could have imagined the richness of the present asteroseismic investigations, from the deepest interiors of red-giant stars to the characterization of the evolution of the Galaxy and the ages of exoplanets. This has been the result of a tremendous evolution of the observational capabilities on the ground and in space, and the development, although still lacking behind, of our physical understanding of stellar interiors and oscillations. I shall provide a brief reminder of the status of asteroseismology forty years ago and a very few highlights of the evolution leading to its present stage.

ERC funding opportunities in exoplanetary, stellar, and galactic physics

Invited: V. Schmid[1]

C. Aerts[2]

(1) ERC Executive Agency, European Commission.
(2) Institute of Astronomy, KU Leuven, Belgium.

The European Research Council (ERC) funds PI-driven frontier research across all fields, based solely on scientific excellence.

In this session, I will present the ERC funding opportunities specifically focussing on the ERC evaluation panel "Universe Sciences", which encompasses all topics treated in this conference. I aim to give an overview of ERC funding within the field, discuss interconnections between the Universe Sciences panel and other ERC panels in related disciplines, and will highlight the novelties and recent changes to the submission and evaluation process. Special attention will be devoted to funding of early career researchers and scientists from underrepresented groups.

The session will also include presentations by Conny Aerts, member of the ERC Scientific Council, outlining the scientific strategy behind the funding opportunities, and by a successful ERC grantee. It is useful for anyone interested in or planning to apply for ERC funding. You are invited to bring your questions about future ERC applications!

Missions and mission synergies

1

A forward-looking perspective onmission synergies in asteroseismology

Invited: T. L. Campante[1]

(1) Instituto de Astrofísica e Ciências do Espaço, Portugal.

Over the past 25 years, the number of stars observed with precise space-based time-domain photometry has increased by roughly four orders of magnitude, driven largely by CoRoT, Kepler, and TESS. Remarkably, we are now on the verge of yet another order-of-magnitude leap, with missions such as Roman, PLATO, and Earth 2.0 coming into operation within the next couple of years. In this talk, I will offer a forward-looking perspective on mission synergies in asteroseismology. Rather than attempting a comprehensive review, I will highlight a few examples of overarching opportunities that I find particularly promising, with an emphasis on upcoming missions.

The Nancy Grace Roman Space Telescope: A review for the stellar science community

Invited: J. C. Zinn[1]

(1) Department of Physics and Astronomy, California State University, Long Beach.

The Nancy Grace Roman Space Telescope will conduct a suite of wide-field near-infrared imaging and spectroscopic surveys that are optimized for cosmology and exoplanet science, but which also offer transformative opportunities for stellar science. With a 0.3 deg^2 field of view, $0.1''$ angular resolution, deep near-infrared sensitivity, and cadences as short as 12 minutes, Roman will open new parameter space for stellar characterization, stellar populations studies, and time-domain science. In this mission review, I will provide an overview of Roman's survey program, mission timeline, and scientific capabilities from the perspective of the stellar science community, highlighting the unique opportunities for asteroseismology and stellar populations studies enabled by the Galactic Bulge Time-Domain Survey. I will also discuss the Roman science ecosystem, including anticipated data products, analysis software and community tools, and opportunities for participation through observing proposals and archival research programs.

The Earth 2.0 (ET) Mission and Scientific Goals

Invited: T. Li[1]

J. Ge[2], H. Zhang[2]

(1) Beijing Normal University, Beijing, China.
(2) Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, China.

This presentation introduces the upcoming Earth 2.0 (ET) space mission. The spacecraft is designed to conduct two primary surveys: a transit survey covering a 500-square-degree field of view (encompassing the original Kepler field) and a microlensing survey targeting the Galactic bulge. While the mission's primary objective is the detection of Earth-analog exoplanets, it will also advance a broad range of key science cases. These include asteroseismology across the Hertzsprung–Russell Diagram (HRD), Galactic archaeology via metal-poor stars, and the study of transient sources. Notably, the ET mission boasts a remarkable data downlink capability of up to 2500 GB/day. This high bandwidth enables the delivery of full-frame images every 15 minutes, alongside short-cadence observations for selected targets.

Asteroseismology in the Rubin-LSST Era

Invited (online): S. Das[1]

(1) Inter-University Centre for Astronomy and Astrophysics (IUCAA), India.

The Vera C. Rubin Observatory, named after astronomer Vera Rubin, promises to revolutionize our view of the dynamic night sky. Rubin's 10-year survey, the Legacy Survey of Space and Time (LSST), will provide a unique optical time-domain view of the southern sky through repeated multi-band observations using the largest digital camera ever built. Although Rubin is not a dedicated asteroseismology mission, its combination of depth, sky coverage and long temporal baseline will enable large-scale studies of stellar variability across diverse Galactic environments, opening a new era of variability studies across the Hertzsprung-Russell diagram.

In this talk, I will briefly introduce Rubin-LSST and discuss its relevance for the asteroseismology community. Rubin's strengths in probing faint and distant stellar populations will be highlighted, including applications to Galactic archaeology, stellar evolution, cluster studies and variability in the Magellanic Clouds and nearby dwarf galaxies. I will also discuss the challenges and opportunities of variability analyses using Rubin's sparse and irregular cadence data.

A major focus will be the complementarity between Rubin and current and future space missions. Synergies with TESS and PLATO will help extend variability studies to much larger stellar populations, while the Nancy Grace Roman Space Telescope will provide important complementary capabilities in crowded and dust-obscured regions. I will briefly discuss Rubin's role within the broader landscape of upcoming stellar astrophysics missions and surveys.

The PLATO Mission: A Cornerstone for Asteroseismology, Stellar Physics, and Exoplanet Research

Invited: R. A. García[1]

(1) Université Paris-Saclay, Université Paris Cité, CEA, CNRS, AIM, 91191, Gif-sur-Yvette, France.

The ESA PLAnetary Transits and Oscillations of stars (PLATO) mission will open a new era in the joint study of stars and their planetary systems. Designed to deliver long-duration, high-precision photometry for large samples of bright main-sequence and subgiant stars, PLATO will combine exoplanet transit detection with asteroseismic characterisation of host stars, providing the precise stellar radii, masses, and ages needed to place planets in a robust astrophysical context. Beyond exoplanet-host stars, PLATO will also observe more evolved stars, providing key constraints for calibrating the physical processes included in modern stellar models. Through its Guest Observer programme, PLATO observations will also be opened to a broad range of stellar targets, including pre-main-sequence and massive stars. PLATO thus represents a natural successor to the seismic legacy of CoRoT, Kepler, and K2, while providing a powerful complement to the all-sky survey being conducted by TESS. After a brief introduction to PLATO and an update on the mission status ahead of its launch, expected in early 2027, I will focus on the scientific prospects for asteroseismology, stellar surface and internal dynamics, and the powerful synergies between asteroseismology and exoplanet science. Finally, I will place PLATO in the broader landscape of time-domain asteroseismology. Synergies with past and current missions will provide legacy benchmarks, continuity for bright targets, and extended temporal baselines for targets observed in common. Roman and Earth 2.0 will probe complementary planetary populations and Galactic environments; Rubin/LSST will add ground-based time-domain context; and the HAYDN mission concept will extend high-precision asteroseismology to dense stellar fields. Together, these facilities will enable a more complete view of stellar evolution, planetary-system architectures, and the star–planet connection across the Galaxy, opening perspectives that only a few years ago belonged to the realm of dreams.

The Transiting Exoplanet Survey Satellite (TESS): updates, highlights, and future prospects

Invited: J. Audenaert[1]

(1) Massachusetts Institute of Technology, Camridge, MA, USA.

TESS has transformed astrophysics by providing an unprecedented stream of high-precision photometric observations, enabling discoveries across asteroseismology and exoplanet science. Continued improvements in data processing and analysis techniques are further enhancing light curve precision and expanding its reach to fainter targets.

In this talk, I will present the latest developments of the TESS mission, highlight recent scientific breakthroughs, and discuss the evolving role of TESS in an increasingly data-rich era, where machine learning and large-scale statistical methods are becoming essential tools for scientific discovery. I will conclude with an outlook on the synergies between TESS and new and upcoming facilities such as PLATO, Roman and LSST.

HAYDN: High-precision AsteroseismologY of DeNse stellar fields

Invited: M. S. Cunha[1] (on behalf of the HAYDN Science Consortium)

(1) Institute of Astrophysics and Space Sciences.

In this talk I will present HAYDN, a mission concept proposed in response to ESA's M8 call, which will provide high-precision, high-cadence, long-duration photometric time series in crowded stellar fields. HAYDN will drive breakthroughs in stellar astrophysics through asteroseismic inferences on stars with common initial conditions and formation histories, enable exoplanet science in dense stellar environments, clarify cluster formation and evolution, and improve our understanding of the assembly, chemodynamics, and evolution of the Milky Way's bulge and nearby dwarf galaxies. I will highlight the mission concept, its unique capabilities, and the broad scientific opportunities that HAYDN would open across stellar, Galactic, and exoplanet astrophysics.

Decoding Massive Stars with MAGIC

D. L. Buzasi[1]

(1) Department of Astronomy and Astrophysics, University of Chicago, USA.

Stars constitute the primary building blocks for astronomical systems ranging in scale from exoplanets to galaxies. Massive stars in particular play pivotal roles in the universe, shaping its dynamic evolution and chemical composition as well as serving as progenitors for the compact object mergers which are a current focus for multimessenger astrophysics. Facilities such as Kepler and TESS have revolutionized modern stellar astrophysics by enabling asteroseismology for thousands of stars across the HR diagram, while upcoming missions like Plato promise to extend the asteroseismic golden age into the future. However, the study of oscillations in upper main sequence stars poses some unique problems which current platforms – all of which are single-color – are poorly suited to address. Identifying the geometry of individual oscillation modes (mode identification) is the key to successfully interpreting the oscillation frequencies, but the different excitation mechanisms for oscillations in these stars compared to solar-like oscillators means that new tools for mode identification are required. In this talk, I will present a proposed NASA Pioneer-class mission, the Massive Star AsteroseismoloGy Instrument Cubesat (MAGIC), which has the potential to unlock the asteroseismology toolkit for these important astrophysical objects.

PLATO Complementary Science Variability Catalogue: Improved Version and Asteroseismic Exploitation of Hybrid Pulsators

M. Kliapets[1,2,3]

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Unraveling the interiors of stars requires observing optimal targets with suitable instruments. Certain interesting physical phenomena, such as internal rotation, can only be inferred from long-baseline high-cadence photometric measurements. To prepare the asteroseismology community for the upcoming launch of the PLAnetary Transits and Oscillations of stars (PLATO) – which will provide long-baseline observations at fine cadences – we prepared a publicly-available PLATO Variability Catalogue using Transiting Exoplanet Survey Satellite (TESS) data. Our Catalogue focused on LOPS2, the first long-term pointing field of PLATO, to be observed for at least two years.

In this talk, we present scientific exploitation of the Catalogue using TESS, *Gaia*, and 2MASS data. We will first provide a high-level overview of variability and fundamental properties of millions of stars in the Catalogue. We subsequently zoom-in on main-sequence hybrid pulsator candidates. The latter are perfect stellar astrophysics laboratories thanks to gravity (g) and pressure (p) modes allowing to probe almost the entire stellar interior. More concretely, we measure near-core rotation rates from g modes, as well as envelope rotation frequencies from identified rotational splittings of p modes for an unprecedently large sample. Our results substantially increase the available pool of intermediate- and high-mass hybrid pulsators with measured radial differential rotation. Our hybrid pulsators with internal rotation serve as an excellent calibration sample for angular momentum and element transport processes.

Finally, we will share our plans to improve the Catalogue, particularly in the context of data processing, the training set, and accessibility. We will discuss our plans for the future integration of PLATO data once they are available, as well as our strategy to scale the developed framework up into an all-sky variability catalogue.

The PLATO Science Calibration and Validation Targets and their potential for asteroseismology

K. Zwintz[1]

(1) Institute for Astro- and Particle Physics, Universität Innsbruck, Austria.

The PLATO mission (PLAnetary Transits and Oscillations of stars) has been selected as part of ESA's Cosmic Vision 2015–2025 program for the M3 mission launch currently foreseen in early 2027. The main science goal of PLATO is to detect and characterise extrasolar planets, including terrestrial planets in the habitable zone of their solar-type host stars.

The PLATO core science needs proper scientific calibration which will be achieved by the monitoring of thousands of pre-selected stars. This subset of the PLATO Input Catalogue (PIC) is known as the Science Calibration and Validation Input Catalogue (scvPIC) and includes 38,585 individual targets belonging to six subsamples: binaries (scv1), legacy and benchmark stars (scv2), photometrically stable stars (scv3), red giants (scv4), γ Doradus stars (scv5), and known transiting brown dwarfs (scv6).

The scvPIC targets bridge PLATO's Core and Complementary Science and assist to achieve the mission goals of obtaining the radii, masses, and ages of solar-type stars to accuracies of 2%, 4%, and 10%, respectively. Additionally, PLATO L0/L1 data products of scvPIC targets that are not part of the core program will become public to the worldwide community with a timeline yet to be finalised.

In this talk, we will present the scvPIC, its potential for asteroseismic studies, and its importance for reaching improved input physics for stellar models.

The Habitable Worlds Observatory: Mission Goals and Precursor Science

Invited (online): A. Chontos[1]

(1) Department of Physics and Astronomy, Dartmouth College, Hanover, NH, USA.

The Habitable Worlds Observatory (HWO) is slated as the next flagship mission in the fleet of NASA's Great Observatories and is scheduled to launch in the early 2040s. Based on the top recommendation of the Astro 2020 Decadal Survey, HWO will be the first dedicated, large telescope designed to search for signs of life in the universe. With UV/O/IR sensitivity, HWO will also enable transformative science for nearly all fields in astronomy. In this talk, I will provide an overview of HWO's science objectives, summarize its current mission and design status, and highlight current and future synergies with stellar astrophysics. Especially for HWO's primary goal, achieving the contrast ratios needed to image true Earth analogs will require integration times of hundreds to thousands of hours on a single star and hence, emphasizing the importance of accurate and precise stellar properties. Therefore the success of a mission such as HWO hinges on precursor observations and science that the asteroseismology community is already well suited for.

2

A- and F-type stars

From Population Studies to Stellar Physics: Asteroseismology across A-F Stars

Invited: R.-M. Ouazzani[1]

(1) LIRA, Observatoire de Paris, France.

Space photometry has revolutionized the study of A-F stars, shifting the focus from individual pulsators to the characterization of entire stellar populations. Combining results from CoRoT, Kepler, TESS, Gaia, and large spectroscopic surveys now allows us to investigate the occurrence of pulsation, rotation, magnetism, and chemical peculiarities across the AaF domain.

In this review, I intend to present the current demographic picture of A-F stars and discuss how recent advances in asteroseismology have improved our understanding of stellar interiors. The observed population distributions provide new insights into the interplay between pulsation, rotation, magnetic fields, and chemical transport, placing strong constraints on the physical processes shaping intermediate-mass stars. I will conclude with the perspectives opened by PLATO and the next generation of stellar models, which will enable a comprehensive physical view of the A-F stellar population.

Sparse and Single-Mode Asteroseismic Inversions

J. M. Joel Ong[1]

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(1) University of Sydney.
(2) University of Southern Queensland.
(3) Yale University.

Asteroseismology can be used to determine stellar structure in a model-independent fashion through inversion techniques, in which quantities like the sound speed and density of a star are measured as a function of position inside it. Conventional techniques for this require a large number of mode frequencies already to have been observed, and such inversions therefore have only previously been possible for the Sun and Sun-like cool main-sequence dwarfs. We describe how this technique ought to be generalised to situations where only a limited number of modes are observationally available — which is more often the case in classical pulsators everywhere else on the HR diagram. We immediately apply this technique in single-mode inversions for δ Scu stars, where we demonstrate that existing observational data, in which only the l=0 n=1 mode differs substantially from current best models of their structure, imply sound-speed differences (relative to these models) that are highly localised to their cores, simultaneously with density differences distributed throughout the rest of the star.

Disentangling the role of nonlinear terms in δ Scuti oscillations

M. Rodriguez Sanchez[1]

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(3) Instituto de Astrofísica de Andalucía: Granada, Spain.

δ Scuti stars exhibit rich, complex power spectra in which numerous radial and nonradial modes are excited. Nonlinear contributions to the oscillations have generally not been taken into account, and most studies have remained within the linear regime due to the complexity involved.

However, some approximations to nonlinear codes have been developed, mainly focused on RR Lyrae stars and Cepheids. Complete nonlinear codes have been developed for white dwarfs (Brickhill 1991; Wu 2001), but their physics cannot be directly applied to these stars.

In this work, we investigate the role of nonlinear contributions by analysing the nonlinear oscillation equations derived from the fundamental hydrodynamic equations expanded to second order in perturbations in terms of the displacement vector. This approach follows the framework presented in Unno et al. (1989) and Aerts et al. (2010), considering no rotation, no magnetic fields, no viscosity, adiabaticity, and no turbulent convection.

The expansion introduces numerous cross terms that prevent us from getting a direct numerical solution. To address this problem, we quantify the relative importance of the nonlinear terms. This is done considering the simplest case of radial modes and a snapshot in time at which nonlinear terms have their maximum contribution. We compute the nonlinear terms using a grid of stellar models spanning the δ Scuti instability strip (1.5–$2.5 M_{\odot}$) and the eigenfunctions from the linear adiabatic oscillation equations for radial modes.

The results show that nonlinear contributions are more significant in the continuity and energy equations. In the outer convective regions, a point-by-point dominance analysis shows that nonlinear terms can become the largest contribution over a large fraction of the radial grid, reaching maximum dominance fractions between 63% and 83% across the models and modes considered. The first overtone systematically shows larger nonlinear contributions than the fundamental mode. These results suggest that second-order terms may play a role in the external pulsation dynamics of δ Scuti stars and may need to be considered in future nonlinear pulsation codes.

Integrated power reveals two pulsation regimes in 3300 bright TESS delta Scutis stars

P. Mani[1]

Timothy Bedding[1], Simon Murphy[2], Daniel Hey[3]

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(3) Institute for Astronomy, University of Hawai'i, Honolulu, USA.

Oscillation spectra of classical A–F type multiperiodic stars exhibit a wide range of excited frequencies and amplitudes, but the underlying principles governing their amplitude distribution remain unclear. We revisit this problem using a global, energy-based perspective. Using a complete sample of 3300 bright TESS delta Scuti stars, we compute the total integrated power in the Fourier amplitude spectrum to quantify the overall pulsation signal. From this, we derive a proxy for the total oscillation energy. We uncover a clear bimodality among higher-frequency delta Scuti stars in their integrated power. This suggests the presence of two distinct pulsation regimes. We propose that stars in the lower-power population may be driven by turbulent pressure, in contrast to the classical kappa-mechanism operating in the higher-power population. In addition, we identify an apparent ceiling to the total pulsation energy, indicating a constrained energy budget for these oscillations. This feature is not evident when stars are characterized solely by their dominant mode amplitude. We extend this framework to 600 gamma Doradus stars, demonstrating that integrated power provides a unifying way to characterize complex, multiperiodic pulsators.

The potential of SPATO: Survey of PLATO A-Type stars Oscillation frequencies.

C. C. Camino Mesa[1]

A. García Hernández[1], J. C. Suárez[1], Giovanni M. Mirouh[1], A. Florido-Tomé[1]

(1) Universidad de Granada.

Pulsating A-F type stars on the main sequence occupy the region where the classical instability strip intersects the main sequence, a regime in which different excitation mechanisms coexist and overlap in the HR diagram. This degeneracy hinders a clear observational classification and calls for large, homogeneous statistical studies.

To address this, we present SPATO, a new catalogue of oscillation frequencies for A-F type stars in the PLATO LOPS2 field, combining TESS light curves with Gaia DR3 and TIC stellar parameters. SPATO provides a unique dataset in which both stellar parameters and frequency content are consistently derived, including all significant pulsation frequencies down to a well-defined noise level.

Using this catalogue, we find a pulsator fraction of about 47% for δ Scuti stars, and revisit the classification of δ Scuti and γ Dor variables. The classical 5 c/d boundary does not translate into a clear separation in the HR diagram. Instead, the period-luminosity diagram reveals two dominant populations, with δ Scuti stars forming a well-defined sequence along the period-luminosity relation and γ Dor stars located below it. We propose the low-density region between them as a new purely observational discriminator.

Combining Gaia-based pulsation constants with TESS frequencies, we identify radial modes and show that the fundamental and first overtone define tight, nearly parallel relations. These correlate strongly with stellar radius and surface gravity, enabling ν_A to act as a proxy for R and $\log g$ with high precision. Higher overtones show larger dispersion, consistent with theoretical expectations and possible misidentification with non-radial modes.

SPATO demonstrates the power of frequency-based catalogues for population studies and provides a reference dataset to identify targets for detailed follow-up and to prepare future analyses with PLATO.

Asteroseismology of SX Phoenicis stars based on collision and binary merger models

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(2) Heidelberg Institute for Theoretical Studies, Germany.
(3) Department of Physics and Astronomy, Universität Heidelberg, Germany.

SX Phoenicis stars represent pulsating blue stragglers which underwent a non-standard formation process, such as stellar collisions or evolution in binary systems involving mass transfer or component mergers.

We present an asteroseismic analysis of the five double-mode radial SX Phoenicis pulsators (V194, V220, V225, V237, and NV326) in the globular cluster ω Centauri, based on stellar collision models, computed using the Make Me A Massive Star code. Both the single-star evolution of the parent stars and the subsequent evolution of the merger product were computed with MESA code. The resulting collision products are then subject of seismic analysis containing of fitting two radial mode frequencies, effective temperature, and luminosity. We compare the inferred properties of the collision products with those derived from single-star evolutionary models, assessing whether stellar mergers provide a more plausible explanation for the observed characteristics of SX Phoenicis stars in dense cluster environments. For V237, located in the peripheral region of the cluster, where direct stellar collision is less likely, we additionally consider a binary coalescence scenario as an alternative formation channel.

Our results place new constraints on the masses, metallicities, and ages of blue stragglers in ω Cen and demonstrate the power of asteroseismology to discriminate between their formation scenarios.

The δ Scuti pulsator occurrence as a function of age, T_{eff}, rotation, and metallicity

I. Berry[1]

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Many A- and F- type stars do not display δ Scuti pulsations, despite being located within the instability strip. Here we use photometry from the TESS Mission to discover 487 δ Scuti pulsators in 20 open clusters within 500 pc and with ages between 20 and 900 Myr. We measure pulsator occurrence, which corrects the pulsator fraction for incompleteness, across all clusters. For the first time, we map δ Scuti pulsator occurrence as a function of age, demonstrating that clusters younger than 200 Myr systematically exhibit higher occurrence rates (88±3%) while the occurrence rates in clusters older than 200 Myr are lower (62±3%). In addition, we find that pulsators tend to rotate more rapidly in older clusters than those in younger open clusters, and that hotter pulsators may stop pulsating earlier than their cooler counterparts. We conclusively establish that pulsator occurrence decreases with age, and that rapid rotation is critical in maintaining δ Scuti pulsations over time. These results suggest that the depletion of helium from the ionization zone via gravitational settling is the underlying mechanism governing pulsator occurrence.

3 Clusters and stellar populations

Constraining the internal structure of Blue Straggler Stars with Asteroseismology

L. Briganti[1,2]

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Blue straggler stars (BSSs) are core-hydrogen-burning stars resulting from dynamical processes such as accretion by mass transfer, mergers or collisions. Due to their origin, they are considered key objects in understanding the dynamics of their host clusters, and therefore their astrometric, photometric, and spectroscopic properties have been extensively studied for many decades. Recently, there has been growing interest in the internal structure of BSSs and in searching for clues about their dynamical past, leading to an encounter between these stars and asteroseismology. In this talk, I will present the first systematic analysis of old, low-mass, BSSs' evolutionary models, both collisional and post-mass-transfer, in the γ Doradus instability region and show that their gravity-mode period-spacing patterns exhibit periodic modulations produced by chemical stratifications. These results highlight the potential of asteroseismology in constraining the origin of dynamical products and identifying them among field stars or within the main sequences of clusters (as is the case for blue lurkers). This will lead to the search for these signatures in data from existing space missions such as Kepler and TESS, as well as from future or candidate missions, such as PLATO or HAYDN. This synergy between asteroseismology and stellar clusters is fundamental to improving our knowledge of stellar physics.

Star Clusters and other Stellar Populations

Invited: K. Brogaard[1]

(1) Department of physics & astronomy, Aarhus University, Denmark.

Studying populations of stars through ensemble studies enable insights not possible for an individual single star. I focus mainly on results regarding the ages of stars and populations, both in an absolute and relative sense. Starting from a non-exhaustive summary of the current situation, I dive into specific details of current efforts while ending in future perspectives.

Among specific targets to be discussed are the globular cluster M4, the open cluster NGC6866, the Milky Way thick disc, along with the smallest population possible: Binary stars. Topics include the relation between asteroseismic scaling relations and detailed frequency modelling of solar-like oscillations, employing multiple simultaneous methods on ensembles, properties of potential globular cluster escapees, the age of the thick disc compared to globular clusters, and the probing of specific stellar physics in models.

Isochrone-cloud fitting and asteroseismology of the *Kepler* open cluster NGC 6866

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We aim to investigate how isochrones based on different input physics and computed for a variety of initial conditions affect age dating of the open cluster NGC 6866. By using the 4-year-long light curves of its members assembled by the *Kepler* mission, we further compare these results with asteroseismically derived ages. We developed an "isochrone-cloud" fitting method that simultaneously accounts for the range of free parameters occurring in the input physics. Synthetic colour–magnitude diagrams (CMDs) with various initial rotation rates were generated and compared with the observations to determine the best-fitting rotation distribution. Variable stars were then identified among the cluster members. For the 19 gravity-mode (g-mode) pulsators, we performed modelling using a dedicated grid of rotating stellar models. This modelling was constrained by stellar surface parameters, the measured asymptotic gravity-mode (g-mode) period spacing Π_0, and the near-core rotation rate. Two approaches were considered: modelling the pulsators individually and under the assumption that they share a common age. We found discrepant age estimates from PARSEC and MIST isochrones, which yielded 690^{+140}_{-30} Myr and 467^{+70}_{-50} Myr, respectively. The isochrone-cloud fitting indicates that NGC 6866 has an initial rotation distribution peaking at $\nu/\nu_{\rm crit} = 0.6$, which is a discrepancy with a factor of about two compared to the asteroseismic values. The asteroseismic modelling of the g-mode pulsators revealed agreement between seismic and isochronal masses, whereas the derived ages differ substantially due to the difference in internal mixing. When the g-mode pulsators were modelled under the assumption of one shared cluster age, we obtained a value of 759^{+54}_{-82} Myr, in agreement with the PARSEC-based isochronal age. We also observe an increased scatter in the rotation and internal mixing parameters under the shared age assumption, which is a possible representation of the nature of member stars. We conclude that using different input physics and various initial conditions impacts the age-dating results of open clusters. Our findings point to the need for more carefully calibrated evolutionary models. We also report the existance of a pulsating blue stragger star, which will be valuable for future direct merger seismology analysis.

Not all nitrogen-rich field stars originated from globular clusters

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The identification of Milky Way field stars with chemical abundance patterns characteristic of globular cluster (GC) multiple populations is generally interpreted as evidence that these field stars originated from globular clusters. We searched for such stars in the Kepler and K2 fields, classifying a primordial and enriched sample of low metallicity ([Fe/H] < -0.5) red giants, using APOGEE DR19 and GALAH DR4 abundances. Then, we combined in the masses and ages determined through asteroseismology, discovering that a significant portion of enriched field stars are apparently too young to have originated from GCs. Within our sample are also stars with masses and ages compatible with a GC origin, showing that they were likely ejected from GCs, or remnants of dissolved GCs. However, for the apparently young stars, we followed up by investigating alternative enrichment scenarios, such as mass-transfer in binary systems. We present the results of this work, focusing on light element and s-process element abundances, stellar kinematics, and the implications of assuming single-star evolution and mass loss estimates when deriving masses and ages of red giants and core-helium burning stars through asteroseismology. We conclude that enrichment through mass-transfer in binary systems is one plausible alternative to the previously assumed GC origin for these apparently young stars.

Tracing Metallicity-Dependent Mass Loss in Globular Clusters: Integrated Mass Loss of Evolved Red Giants in 47 Tucanae Using TESS

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Asteroseismology of red giant stars in Kepler K2 globular clusters has opened a new avenue for directly studying the masses of AGB, HB, and RGB stars, as well as for determining the integrated mass loss between consecutive evolutionary stages. While a clear mass-loss–metallicity trend has emerged, mass loss itself still lacks a solid theoretical framework that can be directly applied in stellar evolution modeling. Although mass loss appears to increase with increasing metallicity in globular clusters, other samples, such as field stars and open clusters, suggest a striking contrast in the metal-rich regime, indicating an opposing trend. There is an overlapping metallicity range around $-0.8 < [Fe/H] < -0.4$ where no integrated mass-loss measurements for globular clusters are currently available.

We investigate the metal-rich globular cluster 47 Tucanae, with $[Fe/H] = -0.72$, located in this contradictory regime, to assess whether it follows the same trend observed in K2 globular clusters. We derive the global seismic parameter ν_{max}, the frequency of maximum oscillation power, for 34 evolved red giant stars using TESS HLSP PATHOS light curves. In this talk, I present asteroseismic masses for 18 RGB and 15 early-AGB stars, and the integrated mass loss between these phases. Based on spectroscopic signatures from GALAH+ DR3 data, we find that first-generation stars dominate the mass distribution. I also introduce a newly derived metallicity–mass-loss relation for globular clusters, extending the sample to include both 47 Tucanae and the most metal-poor Kepler K2 cluster, NGC 5897. This provides the widest metallicity range to date, $-2.0 < [Fe/H] < -0.72$, over which the updated relation remains consistent with the previously established K2 trend.

Near-core evolution revealed by gravity-mode pulsators in 15 clusters or associations

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Star clusters provide an efficient way to determine the ages and masses of their member stars through colour–magnitude diagrams. Asteroseismology, in particular gravity-mode pulsations, offers a unique probe of stellar internal structures that are inaccessible to conventional spectroscopic or photometric observations. Combining cluster constraints with asteroseismology therefore enables a powerful framework for studying stellar physics from the core to the surface and for improving the calibration of stellar evolution models.

Over the past few years, we have collected a sample of 15 clusters and associations and identified dozens of gravity-mode pulsators within them. Using light curves from TESS and Kepler, we resolve gravity-mode period-spacing patterns and measure near-core rotation rates as well as asymptotic period spacings, which are sensitive to core properties. We find that stellar cores exhibit slight spin-down during evolution. In addition, the observed asymptotic spacings show significant discrepancies with current stellar models. We have also discovered some pulsating pre-main-sequence stars and pulsating blue stragglers. Our results provide new constraints for improving stellar evolution models, in both 1D and 2D frameworks.

4 Magnetic fields

A magnetic view of stellar evolution: Understanding when and where magnetic fields matter

Invited: L. Bugnet[1]

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The detection of buried magnetic fields in evolved stars has recently been made possible through the measurement of their impact on the oscillations of stars. It is fundamental to detect more of these magnetized stars to understand the impact of magnetism on stellar evolution through angular momentum transport and chemical mixing. However, the task of magnetic field characterization inside stars at multiple key evolutionary stages remains challenging due to the various and complex magnetoasteroseismic signatures these fields create. In this review, I will discuss recent advances in theoretical magnetoasteroseismology, opening observational windows on internal magnetism along the evolution of stars.

The magnetic field inside the intermediate-mass main-sequence star KIC 9244992 and its relation to the red-giant case

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Detection and measurement of stellar internal magnetic fields using asteroseismology has only recently been achieved in red giants. Since then, the study of internal magnetic fields has become one of the hottest research topics in asteroseismology. In this presentation, we firstly report results from the main-sequence star KIC 9244992, the first clear example of this type of star. Both p and g modes were detected in this star, and a series of triplets in the rotation-induced frequency splitting of the g modes were particularly clearly observed. All of the triplets originate from dipole modes with different azimuthal orders, but detailed analysis revealed that their frequency distribution slightly deviates from equidistant spacing. This cannot be explained by rotation alone. We therefore constructed a model that takes into account magnetic fields and aspherical buoyancy glitches in addition to rotation, and found that it can successfully explain the observed asymmetry. It is noteworthy that the magnetic field effect must be considered not only in its radial component but also in its azimuthal component. This model imposes the following constraints on the magnetic field strength: The root-mean-square lower bound for the steep chemical gradient layer just outside the convective core is 3.5 ± 0.1 kG in the radial component and 92 ± 7 kG in the azimuthal component. This implies that the azimuthal component is much stronger than the radial component. Furthermore, this presentation will discuss how these magnetic field structures develop as the star evolves into a red giant, and in particular whether they can be detected from the observed oscillation frequencies of red giants.

Large ensemble study of variations in oscillation frequencies of 15,000 Kepler red giants.

A. Bagga[1]

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Solar and stellar oscillation frequencies and mode amplitudes have been observed to shift systematically with surface magnetic activity cycles, providing an important diagnostic for inferring magnetic-cycle-like behaviour in other stars. However, these oscillation frequency shifts have been measured primarily for main-sequence stars and a few subgiants. Extending these measurements to red giants could reveal more about the evolution of magnetic activity at later stages of stellar evolution and provide additional constraints for dynamo models.

In this study, we present a first-of-its-kind large ensemble of measurements of these frequency shifts by cross-correlating the power spectra of short time segments with a reference spectrum for 15,000 red giant stars observed by Kepler. We detect over 250 stars with significant frequency-shift amplitudes, defined as peak-to-peak amplitudes greater than three times their uncertainties.

Additionally, we compare the shift amplitudes of all 15,000 stars with various physical stellar parameters, including mass, radius, surface gravity, metallicity, and rotation periods, to investigate which parameters influence stellar variability. These variability measurements provide important constraints on the interpretation of oscillation frequencies and the inference of accurate stellar properties.

Magnetohydrodynamical simulations of interior magnetic fields for rotating massive stars: a new numerical foundation for asteroseismic inference

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All stars in the Universe host magnetic fields, and yet they are currently not well constrained in evolution models. Stars like the Sun can have complex magnetic field structures generated by a dynamo in their convective envelopes. Massive stars have radiative envelopes, but dynamo action in their convective cores is also expected to generate magnetic fields. However, only about 10% of massive stars have strong, large-scale, magnetic fields at their surfaces detectable by spectropolarimetry, and insight of their interior fields was lacking until recently. Asteroseismology is now providing direct probes of the magnetic fields in the deep interior of stars across the Hertzsprung-Russell diagram. For example, asteroseismic constraints on magnetic fields exist for red giants (e.g. Li et al. 2022), but also for main-sequence intermediate- and high-mass stars (e.g. Takata et al. 2025; Vandersnickt et al. 2025). In this talk, we present the analysis of a suite of spherical dynamo magneto-hydrodynamical (MHD) simulations for 2- and 7-solar-mass main-sequence stars for different rotation rates. We show that the dynamo in the convective cores of such stars generates a magnetic field geometry and a (differential) rotation profile that are fully consistent with those inferred from asteroseismology by Takata et al. (2025). This not only supports the fact that robust inference of magnetic fields is possible by asteroseismology, but also provides a strong numerical foundation for the topology of magnetic fields in the deep interiors of intermediate- and high-mass main-sequence stars. Most importantly, our simulations show that a strong toroidal component of the magnetic field is generated at the boundary of the convective core even in the presence of weak differential rotation. Finally, since our suite of simulations spans a range of masses and rotation rates, we demonstrate that a predominantly toroidal magnetic field geometry is common for all setups. Therefore, we conclude that such a geometry is essential to consider when performing asteroseismic inference of magnetic fields in intermediate- and high-mass stars.

"Hump and Spike" Stars: A New Laboratory for Rotation, Surface Magnetism, and Pulsations

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Kepler data revealed a group of stars with a distinctive pattern in their frequency spectra: a broad low-frequency hump together with a narrow peak. These are the so-called "hump and spike" stars. The hump is attributed to Rossby modes, while the peak is consistent with rotational modulation caused by stellar spots linked to surface magnetic fields. A previous search, limited to stars between 6,000 and 10,000 K, identified just over 200 examples and found links between the Rossby modes and the rotational modulation.

In this work, we extend the search across the entire *Kepler* dataset of more than 200,000 targets. We use a search algorithm based on shape correlation of the frequency spectra with the known sample, followed by visual inspection of the highest-ranked candidates, while accounting for the challenges of detecting signals in the low-frequency regime. Combined with stellar parameters from *Gaia*, we identify new candidates spanning a broader region of the Hertzsprung–Russell diagram, with temperatures from roughly 5,000 to 12,000 K. This explores a wider set of stellar properties, potentially including different rotation regimes and evolutionary states, and suggests that the phenomenon may be far more widespread than previously recognised.

We present the first results of this search, including the first candidates outside the A- and F-type intermediate-mass stars. This expanded sample can help us understand how surface magnetic fields and Rossby modes are linked, and how both depend on stellar structure and rotation. Some candidates also show coherent pulsations, including δ Scuti and γ Dor variability. In a few cases, clear g-mode period-spacing patterns are also detected alongside the Rossby mode and rotational modulation signatures. If intrinsic to the same star, these systems create rare opportunities to study interior and surface rotation, magnetic variability, and stellar structure together.

5

K- and M-dwarfs

Asteroseismology of K-dwarfs

Invited: Yaguang Li[1]

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K dwarfs occupy a compelling but demanding frontier for asteroseismology. Their oscillations are intrinsically lower in amplitude and shorter in period than those of solar-type stars, pushing current space- and ground-based facilities to their limits. Yet the rewards are substantial: precise stellar ages for stars that are prime targets in the search for habitable-zone planets, and a unique window into the transition between the well-studied solar regime and the more complex and less-understood late-type stars. In this talk, I will survey the history and recent detections of solar-like oscillations in K dwarfs, drawing on results from space photometry and radial-velocity campaigns. I will discuss what these observations are teaching us about stellar ages, internal structure, and where current stellar models fall short. I will close with a look at how upcoming missions and surveys will advance the field in the coming decade.

Measuring Solar Oscillations using High-Precision Temperature Variations from SONG Spectra

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The same temperature variations at the surface of stars that are measured using photometry also cause changes in flux in temperature-sensitive absorption lines. This principle was used in the early days of asteroseismology to detect solar-like oscillations through differential equivalent widths in the wings of hydrogen lines. The technique was largely set aside, however, when improvements in ground-based RV precision made it possible to achieve much higher S/N of oscillations in the power spectrum.

In this talk, I present a newly developed method for extracting precise temperature variations from high-resolution stellar spectra. The method uses a weighted integration of the full spectrum, with weights derived from the temperature response function of the star, computed from synthetic spectra. The result is a noise-optimised measurement of the temperature variation that at the same time subtracts the continuum background and corrects for the highly variable telluric lines.

I have applied the method to a five-day series of solar spectra observed at SONG-Tenerife, achieving a temperature precision of 0.14 K in each of the 40,000 observations, and the oscillation envelope is prominent in the power spectrum with an S/N roughly 1/5 of that from RV measurements from the same data. These observations were originally obtained purely for RV measurements, which means that with this method the same oscillations can be measured from the same data in two different ways, stemming from two different physical mechanisms. This will allow for new studies of the physics by comparing phase shifts and amplitude ratios between the two types of measurements.

An observed decoupling of stellar granulation timescales for dwarf stars

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Granulation is the surface manifestation of near-surface convection and forms the background signal upon which solar-like oscillations are observed. Yet, its observational properties on the main sequence remain comparatively underexplored relative to giants. This is a limitation, as accurate modelling of the granulation background is crucial for both asteroseismic inference and the mitigation of stellar variability in exoplanet detection. To bridge this gap, we present a characterisation of granulation in main-sequence and subgiant stars, establishing a continuous picture across evolutionary stages. We analysed 753 *Kepler* short-cadence targets using a Bayesian framework, testing multiple background prescriptions and quantifying model preference on a star-by-star basis, enabling robust assessment of systematic effects associated with background modelling. Notably, when turning to the parameters of the granulation signal itself, we found that while granulation amplitudes broadly follow established giant-based scalings, a deviation occurs for the timescale. For main-sequence stars cooler than the Sun, the granulation timescale becomes decoupled from the oscillation timescale. The observed decoupling is supported by 3D hydrodynamical simulations, where reduced convective velocities – arising from more efficient energy transport in denser envelopes and a lower luminosity – lead to longer granulation timescales. The immediate consequence in stellar power spectra is an increased separation between the granulation background and the oscillation envelope, affecting mode detectability on the lower main sequence. More broadly, we have shown that the typical scaling relations assumed for the granulation signal do not hold for dwarfs – an important detail when modelling detection probabilities in preparation for PLATO.

Asteroseismic Studies on Delta Eridani Using Simultaneous TESS and SONG Data

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Stellar oscillations leave measurable signatures in both intensity and radial velocity (RV), enabling asteroseismology to probe stellar interiors, from convection in the outer layers to the core structure of evolved stars. Standard single-technique approaches, based on photometry or spectroscopy alone, are powerful but incomplete: they primarily constrain the global oscillation spectrum while remaining comparatively insensitive to the transition region between the stellar interior and the atmosphere. In contrast, combining intensity and RV measurements provides a unique diagnostic of the physical response of the stellar surface layers. The phase difference between luminosity and velocity variations directly probes the degree of adiabaticity in the topmost layers, while the amplitude ratio provides complementary constraints on mode visibility, atmospheric response, and convection–oscillation coupling. However, precise joint photometric and spectroscopic measurements remain rare.

We present a joint-method asteroseismic study of δ Eridani, a bright K subgiant, using simultaneous space-based photometry from NASA TESS and high-cadence radial velocities from the SONG high-resolution spectrograph in Tenerife. This target offers an excellent opportunity to investigate solar-like oscillations in a slightly evolved star, where surface convection properties and oscillation mode structure differ from the solar case. We analyze the time series with complementary methods. From the power spectral density, we extract and identify individual oscillation modes and aliasing structures in both intensity and velocity data. We apply Fourier reconstruction and Gaussian processes to determine the phase shift between the intensity and velocity signals.

By combining these methods, we aim to determine the phase difference and amplitude ratio between the velocity and intensity fields of δ Eridani with improved reliability. These measurements provide a direct observational constraint on the non-adiabatic behavior of the outer stellar layers and can test models of near-surface convection, mode excitation, and stellar evolution in subgiants. More broadly, this work demonstrates the scientific value of coordinated photometric and spectroscopic asteroseismology. It highlights SONG as a powerful ground-based spectroscopic complement to space missions such as TESS, ESA PLATO, and China's Earth 2.0 mission, and provides a framework for future joint observations.

6 Binaries

Pulsating stars in binary systems

Invited: D. Hey[1]

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Binary stars are of fundamental importance to asteroseismology. Eclipses and orbital dynamics yield model-independent masses and radii that calibrate asteroseismology, while pulsations reveal the ages, internal rotation, and mixing that orbital geometry alone cannot constrain. In this talk I review how this relationship has matured into a precision science. Eclipsing binaries hosting δ Scuti, γ Doradus, slowly pulsating B, and red-giant components now serve as benchmark systems for testing the physics of stellar interiors. Pulsation timing, through phase and frequency modulation and the classical O–C diagram, has turned coherent oscillators into instruments sensitive to stellar, substellar, and even compact companions. In parallel, tidal interactions in close and eccentric systems produce a rich array of phenomena, from heartbeat stars and tidally excited oscillations to tidally tilted pulsators whose pulsation axes track the orbital geometry. The all-sky TESS photometric coverage has expanded these samples by orders of magnitude and uncovered an outstanding sample of interesting systems. I will highlight recent results, some modeling challenges they expose, and the prospects for binary asteroseismology as we move toward the next era of high precision photometry.

Probing stellar mergers through asteroseismology and models of carbon-deficient red giants

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Binary and multiple-star systems account for about half of all solar-type stars, and thus contribute significantly to Galactic chemical enrichment. Studying binary products is key to understanding their complex outcomes. We show here that the enigmatic weak G-band stars, also known as carbon-deficient giants (CDGs), are most likely binary merger products and offer a unique opportunity to study stellar mergers.

CDGs are rare G- and K-type giants with an extreme deficiency of carbon that cannot be explained by single-star evolution alone. While the first dredge-up reduces ^{12}C by only 30%, the depletion in CDGs is far more extreme. Previous attempts to determine their masses and evolutionary states were inconclusive due to degeneracies between the stellar parameters of the SGB, RGB, RC, and EAGB phases in the HR diagram.

We use asteroseismology combined with spectroscopy, and astrometry to decipher the nature of CDGs. From 129 CDGs observed by Kepler, K2, and TESS, we detect solar-like oscillations in 43 stars. By measuring $\nu_{\rm max}$ and applying seismic scaling relations, we derive precise masses and find that 79% are low-mass ($M \leq 2.0\,{\rm M}_\odot$). Furthermore, the seismic HR diagram reveals that 98% of these stars are in the core helium-burning or EAGB phase.

Combined with orbital constraints, we identify mergers of helium white dwarfs with RGB stars, possibly in hierarchical triples, as the dominant formation channel. We show initial comparisons between predictions from merger and envelope-stripping models and asteroseismic observations. Future measurements of $\Delta\nu$, ε, $\delta\nu_{01}$, $\delta\nu_{02}$ and $\Delta\Pi_1$ will help resolve remaining degeneracies and constrain internal structure, shedding new light on a century-old puzzle in stellar evolution.

The impact of binary modelling approaches and data precision on massive pulsating eclipsing binaries

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Understanding the structure and evolution of massive stars is key for understanding a myriad of concepts in physics, including galactic evolution, stellar feedback and compact object formation. Most massive stars exist in multiple systems with eclipsing binaries being some of the most powerful laboratories for testing stellar physics, as they allow for the determination of model independent masses and radii. A significant fraction of massive eclipsing binaries also pulsate. Asteroseismology probes stellar structure and when combined with binarity provides ultra-precise constraints on interior physics such as rotation and mixing. However, there are a variety of approaches to binary modelling of massive pulsating eclipsing binaries, which can yield different results. Differences arise from the choice of geometry, use of different codes, and quality of photometric and spectroscopic data. In this presentation we show the impact of different binary modelling approaches and of data quality using the binary modelling code PHOEBE. We take two approaches for pulsating massive eclipsing binaries and compare how iterative pre-whitening of pulsation frequencies before and after the binary modelling impacts the results. We also compare the results using archival and new radial velocity data. This allows for a direct comparison and quantification of the impact of the different modelling approaches and data quality on the resultant masses and radii. Understanding the impact of different approaches is important as the dynamical masses and radii from binary modelling are often used as constraints on stellar structure and evolution models in binary asteroseismology. We conclude that understanding the strengths and limitations of each approach is vital to test the accuracy of stellar structure models.

Detection and modelling of orbital modulated pulsations in KIC 10080943

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The majority of intermediate- and high-mass stars are found in binary systems. For close systems, the mutual influence of the components can significantly alter their evolution. Asteroseismic analyses can provide important insights into the internal structure of such stars and how they are effected by each other. However, one of the challenges when modelling close binary systems is that the tidal potential affects the pulsation frequencies and amplitudes. This results in a wide range of pulsation phenomena, visible as amplitude modulations over the orbital phase. Understanding these binary effects on the pulsation properties are a prerequisite to performing full asteroseismic modelling of such systems.

We have reanalyzed the eccentric binary system KIC 10080943, of which both components are dSct-gDor hybrids. We found that the primary component is most likely a triaxial pulsator. Only a handful of triaxial pulsators have been detected, and none in non-synchronized or eccentric systems. The combination of both g-mode pulsations and p-mode pulsations in both components, and the tidal effects makes this system completely unique. We discuss modelling of the tidal modulation using the StORM oscillation code. We also report on the discovery of 86 p-mode pulsators in eclipsing binaries that show strong evidence of orbit-modulated amplitude variations.

Zuko and Azula: A Rare TESS Asteroseismic Binary System and Model Calibrator

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Binary star systems are powerful tools for studying stellar evolution. In particular, wide, coeval systems with disparate masses enable the comparison of two stars evolving independently at fixed age and composition. When solar-like oscillations are detected in both components, asteroseismology enables precise constraints on their fundamental properties, making such systems especially valuable tests of stellar modeling hypotheses. We present Zuko and Azula, one of the few known binary systems in which solar-like oscillations are detected in both stars. Using 8 sectors of TESS photometry, we measure $\nu_{\max}$ and $\Delta\nu$ for our system with statistical precisions of $\sigma_{\nu_{\max}} < 1\%$ and $\sigma_{\Delta\nu} < 3\%$. In tandem with spectroscopic effective temperatures from Wu et. al. 2011, our asteroseismic surface gravities define independent axes in the $\log(g)$-$T_{\rm eff}$ plane, allowing for a more discriminating test of stellar evolution models. Preliminary analysis suggests that the system is a red giant/red clump pair. Such systems can constrain mass loss on the red giant branch by direct comparison of coeval stars before and after helium ignition. They also provide a means to explore discrepancies between observed and modeled period spacings ($\Delta\Pi_1$), which are sensitive to treatment of the convective boundary in the modeling of red clump stars. Coupled with asteroseismology, these so-called asteroseismic binaries become powerful laboratories for exploring the physics of stellar evolution.

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Galactic archeology

Galactic Archaeology: From cartography to reconstructing the Milky Way's assembly history in detail

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Galactic Archaeology seeks to reconstruct the formation and evolutionary history of the Milky Way by decoding the fossil record preserved in stars. Over the past decade, the field has been transformed by an explosion of data from large-scale spectroscopic, astrometric, photometric, and asteroseismic surveys combined with rapid advances in computational power and numerical simulations. Together, these developments have enabled detailed insight into the assembly history and dynamical evolution of our Galaxy.

In this talk, I will summarise recent advances in mapping the structure and evolution of different parts of our Galaxy, highlighting discoveries that are reshaping our picture of Galactic evolution. I will also discuss the exciting opportunities emerging from upcoming missions and next-generation surveys, and explore how new data and analysis techniques are set to drive the next era of discovery.

How Reliable Are the Asteroseismic Ages of Red Giants? Individual Mode Frequency Modeling from the Solar Regime to the Galactic Halo

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Precise and accurate stellar ages are crucial for understanding the Galaxy's dynamical and chemical evolution, yet they remain among the most challenging stellar properties to constrain. Stellar evolution and asteroseismic modeling, combined with precise spectroscopic and asteroseismic observables, offer a powerful path to reduce age uncertainties. To date, however, most evolved solar-like oscillators have been modeled using only spectroscopic and global asteroseismic constraints (ν_{max} and $\Delta\nu$). Yet initial evidence from a few case studies suggests that ages from individual mode frequency modeling may differ from those based on global asteroseismic parameters alone. This raises the question of how reliable the latter are for different stellar populations, especially for stars departing from the solar chemical composition, such as those in the Galactic Halo. To address this question, we built a framework consisting of a grid of MESA stellar evolution models on the red giant branch, with individual mode frequencies calculated with GYRE. We coupled this grid with a custom optimization method that delivers the fundamental stellar parameters (age, mass, radius) with their uncertainties. Applying it, for the first time, to an ensemble of around 100 *Kepler* red giants with near-solar masses and metallicities, we achieve age uncertainties of $\sim$13 % across a wide range of Galactic ages, representing a factor of two improvement over global seismic modeling for the same targets. Notably, ages from individual mode frequency modeling are significantly larger than those from global seismic modeling, revealing a systematic offset between methods even in the solar-parameter regime. Building on these results, we have extended the modeling to Galactic Halo stars: metal-poor, alpha-enriched targets that are crucial for understanding the Milky Way's evolution. In this talk, I will present the results of our study using our individual mode frequency modeling applied to red giants in the solar regime and, in particular, to stars of the Galactic Halo, enlarging the sample of stars modeled with individual mode frequencies by an order of magnitude in each population. Our preliminary results underline both the importance and the timeliness of extending individual mode frequency modeling to larger samples, leveraging current *Kepler* and TESS data and taking full advantage of upcoming missions such as PLATO and *Roman*.

The Bulge Wasn't Built in a Day: A New Age Posterior Inference Method for Roman's Galactic Bulge Time-Domain Survey, Validated with TESS and Kepler

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In light of Roman's forthcoming Galactic Bulge Time Domain Survey (GBTDS), we introduce a new method for stellar age estimation and demonstrate its effectiveness on roughly 30,000 APOGEE × Kepler (APOKASC) targets, with an eye toward the large asteroseismic samples (>100,000) expected from Roman. Our method uses calibrated stellar models to construct age–metallicity degeneracies that can then be combined with statistical metallicity distributions (MDFs) to produce age posteriors on a star-by-star basis, allowing for stellar age inference even when metallicity is poorly constrained. We validate this approach using stars with asteroseismic ages from Kepler and TESS, allowing for the direct comparison of seismic age scales against ours and quantifying offsets and variation between methods in a regime where the true ages are well constrained. Applied to the Bulge, this method enables age estimates for large samples from Roman alone and connects them to existing Kepler/TESS calibrators, enabling future Roman-derived ages to be placed on the same scale as current asteroseismic results. With GBTDS data, our method will produce robust stellar ages in a notoriously difficult region and enable quantitative comparison of those ages with those derived asteroseismically and via other methods, ultimately uncovering the formation history of the Galactic Bulge and Galaxy as a whole.

High Precision Galactic Chemo-Chronology from Asteroseismology and Spectroscopy with TESS and HARPS

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We present a high precision chemo-chronological study of Galactic stellar populations using asteroseismology as the primary chronometer. Combining HARPS spectroscopy with TESS asteroseismic constraints, we derive precise stellar ages for a sample of red giant branch stars, with tightly constrained stellar modelling yielding internally consistent age estimates.

We link these ages to homogeneous chemical abundances of Ti, Y, Nd, and Eu, spanning the iron-peak, first s-process peak, mixed s/r, and pure r-process regimes, to establish well-defined age abundance relations across distinct nucleosynthetic channels. This elemental set probes the differing enrichment timescales of core-collapse supernovae, AGB stars, and r-process sites such as neutron star mergers, with Nd providing a diagnostic of the interplay between s- and r-process contributions.

Probing the Milky Way's Accretion History via Asteroseismic Helium Abundances and Ages

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The structural and chemical evolution of the Milky Way is driven by a complex history of satellite mergers and gas accretion. While helium is a crucial tracer of these events, its direct spectroscopic measurement in the cool, long-lived stars typically used for Galactic archaeology is limited by their high excitation temperatures. In this contribution, we present a novel framework that overcomes this limitation by leveraging the asteroseismic signature of the stellar helium-ionization region. By coupling asteroseismic constraints from *Kepler/K2* with spectroscopic data and utilizing stellar models within a Bayesian framework that incorporates microscopic diffusion and turbulent mixing, we simultaneously determine initial helium and metal mass fractions, along with precise stellar ages. Tracking these extracted initial abundances as a function of lookback time reveals significant, abrupt deviations from standard Galactic chemical enrichment. We will discuss how this anomaly provides compelling evidence for a major accretion event of metal-poor gas onto the Milky Way. Furthermore, we will demonstrate that isolating undisturbed stellar populations within this framework enables robust extraction of fundamental cosmological parameters, including the primordial helium abundance and the Galactic helium-to-metal enrichment ratio. As the community prepares for the upcoming PLATO mission, this methodology opens a powerful new window for exploiting asteroseismic data to map the chemical history of our Galaxy.

8 O- and B-type stars

The Status, Complications (or Opportunities?) and Bright Future of O- and B-type Pulsators

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O- and B-type stars, with masses roughly above 3 solar masses, are cosmic powerhouses that chemically enrich and ionise our Universe. The compact objects left behind after their final collapse give rise to detectable gravitational-wave signatures and high-energy transients such as supernovae. The asteroseismic analysis of pulsating massive stars, often classified as slowly pulsating B-type and beta Cephei stars, using their gravity and pressure modes (or both) has taught us a great deal about their interiors. In this overview talk, I will summarise what we have already learned from the relatively limited number of seismically analysed O- and B-type pulsators, while also highlighting the gaps in our theory of massive stellar structure and evolution. Then, I will explore what we can learn from the enigmatic stochastic low-frequency variability detected in higher-mass main-sequence and blue supergiant stars. Next, I will address the elephant in the room and discuss the complications and opportunities that the ubiquitous binarity among O- and B-type stars entails. Finally, thanks to the increase in characterised O- and B-type pulsators from ongoing missions and the premise of high-quality long-baseline time series from PLATO, we can look (and plan!) ahead.

HARVEST: a multimodal optimization code applied to unbiased mode identification and stellar modelling in asteroseismology

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Bounded multimodal optimization problems (MMOPs) arise when multiple global or near-global optima exist in a bounded parameter space. In asteroseismology, such degeneracies are frequently encountered. Stellar modelling based on pulsation frequencies often admits families of models with different masses, ages, and internal structures that reproduce observations equally well. Another example is the identification of g-mode pulsations, which is done manually, remaining partly subjective and relying on sometimes arbitrary choices. In particular, assigning spherical degrees relies on detecting regular period spacings, leading to multiple plausible mode configurations for a given frequency set. Missing an optimum, that is, missing a fitting stellar model or mode identification, can significantly bias the inferred stellar properties.

In this talk, we present HARVEST, a multimodal optimization algorithm designed to systematically find global and near optima of bounded MMOPs. The method combines global exploration and local refinement, while iteratively defining taboo zones to ensure greater search of the parameter space. Its performance is validated on the CEC2013 benchmark test functions, demonstrating a strong ability to detect multiple and often narrow optima with a low computational budget across complex, rugged, and high-dimensional landscapes.

We apply HARVEST to the long-standing problem of g-mode identification using Kepler observations of subdwarf B stars. Based on objective criteria such as overlapping properties in reduced periods and period spacings across spherical degrees, we automatically recover multiple distinct mode configurations for a given frequency set. These solutions include both regularly spaced spectra and configurations exhibiting mode trapping, and differ primarily in the number of unattributed modes.

Our results highlight the intrinsic degeneracy of asteroseismic inference and demonstrate that it can be explored in a systematic, reproducible, and automated way. HARVEST opens the path toward unbiased mode identification and more reliable stellar modelling from high-quality Kepler and TESS data.

Beyond the photosphere: How an extended atmosphere changes the non-radial oscillations of massive stars

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The interior of massive stars ($M \geq 8\,\mathrm{M}_{\odot}$) is accessible through pressure mode oscillations in β Cephei pulsators. Many questions remain about their internal rotation, structure, and mixing processes, all of which are crucial phenomena for the evolution of these supernova-progenitors. With the plethora of data from missions such as CoRoT, Kepler, TESS, and the upcoming PLATO, the accuracy of these studies is increasingly limited by theoretical shortcomings. One of these concerns is the absence of an extended atmosphere beyond the photosphere in the computations of oscillation modes. Massive stars host strong outflows that expel mass and angular momentum from their surface. As the atmospheric and wind regime is dominated by processes that act on different time and spatial scales than the interior, stellar outflows are often considered an area of astrophysics that is not included in asteroseismology.

State-of-the-art stellar evolution models are typically truncated at the photosphere, ignoring the extended atmosphere and wind regime. This same restriction in the treatment of the star's boundary is then carried over to the computations of modes. In this talk, we use the sonic point as the more natural boundary for massive main-sequence pulsators. In such an approach, the wind speed overtakes the local sound speed and the oscillations are effectively cut off at the sonic point. By calculating stellar models with self-consistent atmosphere and wind simulations, we show that neglecting this upper regime in stars with an outflow leads to frequency deviations of several percent. The relative mode frequency differences are largest for low-order pressure modes, which is a highly relevant mode regime for β Cephei stars with masses between 8 and 30 $\mathrm{M}_{\odot}$ having an extended atmosphere. We discuss the implications for asteroseismic inferences based on such modes and argue that current systematic errors introduced by neglecting the regime of the wind between the photosphere and sonic point should be included in future applications of massive stars based on high-precision space photometry.

Unlocking the potential of asteroseismology to study massive stars in young clusters

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Our understanding of massive stars has improved greatly in recent years thanks to numerous observational campaigns and different theoretical and evolutionary models, highlighting how both binarity and pulsations are almost ubiquitous. Still, a large number of questions remain unanswered: how can we identify binary interaction products? How do pulsations affect the core envelope mixing and the transport of angular momentum inside the star? Why do some massive stars rotate so fast, and what causes the possible formation of their equatorial disk? Asteroseismology offers unique insights into the internal structure of stars, which other techniques (such as spectroscopy) alone cannot provide. Moreover, clusters give us another important advantage by having a chemically homogeneous and coeval sample, which is extremely important when trying to characterise an ensemble of massive stars. In this talk, I will show how combining these two techniques can help answer some of the open questions regarding massive star evolution. I will present the characterisation of 80 B-type stars in four Galactic young open clusters of different ages (15-30 Myr), and I will discuss the power of forward asteroseismic modelling for massive stars in clusters. In particular, I will show what we can be learned from the modelling of a single star with only three consecutive TESS sectors and its spectroscopic characterisation. I will discuss how comparable methods to determine the ages of stars, asteroseismic modelling and isochrone fitting, are consistent with each other. Performing asteroseismic studies of stars in clusters is crucial in being able to identify possible binary interaction products and being able to constrain their internal structure, but it is particularly difficult because of the dense environments they inhabit. The proposed ESA mission HAYDN will be purpose-built to study dense environments by having a much smaller pixel size compared to missions like TESS and Kepler, and will be key to unlocking asteroseismology of massive stars in young clusters.

9 Rotation

Stellar Rotation of Main-sequence Stars

Invited: Yuxi(Lucy) Lu[1]

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Stellar rotation is one of the few stellar properties that evolves significantly during the main-sequence lifetime, particularly among low-mass K and M dwarfs. Through magnetic braking, stars gradually lose angular momentum, establishing a strong connection between rotation and age that forms the foundation of gyrochronology. As a result, stellar rotation has become a powerful tool for determining ages of cool stars, with broad applications ranging from stellar physics to exoplanet science and Galactic archaeology.

In this talk, I will provide an overview of the current understanding of stellar rotation, including recent observational advances in rotational evolution, magnetic braking, and stellar dynamo theory. I will also discuss emerging challenges to classical gyrochronology and their implications for stellar age estimation and magnetic activity evolution.

Finally, I will highlight future missions that will aid the development of rotation and stellar spin-down. I will then explore how gyrochronology can be applied to Galactic archaeology to uncover the chemo-dynamic evolution of the Milky Way.

Absence of spin-up companions in half of wide hot subdwarf binaries

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Binary stars play critical roles across a wide range of astrophysical contexts, including the formation of exotic stellar objects and planetary systems, the progenitors of supernovae, and the sources of gravitational waves. They are widely believed—both from theoretical models and, more recently, from observational evidence—to be a primary channel for the formation of hot subdwarfs (sdO/B stars). Here we report an unexpected result that only about half of companions in a golden sample of wide hot subdwarf binaries exhibit measurable rotational signals attributable to magnetic modulation, based on a comprehensive survey of nearly 5000 TESS and Kepler sdO/B targets. Their rotation periods are predominantly shorter than 5 days, a distribution strikingly different from that of single field MS stars, whose rotation periods peak around 20 days. This markedly faster rotation suggests that the old MS companions in wide sdO/B binaries must have undergone a spin-up process through past mass accretion, as their rotation rates are comparable to those of much younger MS stars in open clusters. However, the absence of any detectable rotational signal in the remaining near half of companions, even among relatively bright targets, poses a challenge to the commonly held view that sdO/B formation universally requires binary interaction.

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Gravito-inertial waves in stars: Excitation and impact on the transport of angular momentum solar-type stars.

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A key open question in the field of modern stellar physics is the distribution and evolution of angular momentum throughout a star's lifetime (e.g. Meibom et al. 2009, 2011, F. Gallet & J. Bouvier 2013). Observational constraints from helio- and asteroseismology (e.g. García et al. 2007) reveal discrepancies that cannot be fully explained by classical processes such as meridional circulation and shear-induced turbulence, underscoring the need for additional transport mechanisms (Charbonnel et al. 2013). Internal gravity waves (IGWs), together with magnetic fields, have emerged as promising candidates. In particular, gravito-inertial waves (GIWs) are thought to play a pivotal role in regulating angular momentum and chemical transport in stellar interiors (e.g. Schatzman 1993; Zahn et al.1997, Charbonnel & Talon 2005, Rogers & McElwaine 2017, Mathis et al. 2017). However, several aspects of their excitation, dissipation, and the influence of rotation remain poorly understood. In this work, we develop a new theoretical framework for GIWs, that consistently accounts for rotational effects in both their excitation and damping. We implement a rotation-dependent interface excitation prescription, together with a Coriolis-modified damping formalism that includes the impact of rotation on wave propagation. This framework is incorporated into the stellar evolution code STAREVOL, allowing us to compute evolutionary models of low-mass and solar-type stars to quantify both the excitation and dissipation of GIWs. These results provide new insights into the role of GIWs in shaping the internal rotation profiles and chemical mixing. They pave the way for direct comparisons with spectroscopic and asteroseismic observations, and for improved predictions in the context of upcoming missions such as PLATO, ultimately advancing our understanding of internal stellar dynamics and evolution.

Magnetic activity enhancement during spin-down stalling: insights from wide binaries

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Stellar magnetic activity is generated by the interplay of rotation and convection. As they age, solar-like stars spin down and become less active. This was thought to be a monotonic behavior, but the *Kepler* mission revealed a phase of stalled spin down, during which the rotation period remains nearly constant, while magnetic activity is enhanced. The transition associated to this stalling manifests as an underdensity in the rotation-temperature distribution, commonly referred to as the intermediate rotation gap. In this work, we investigate the signature of spin-down stalling in the magnetic activity of wide binaries. Wide binary components undergo independent evolution, as their large separations ($\gtrsim 10^3$ au) ensure negligible interactions, preserving the magnetic and rotational evolution of single stars. Comparing coeval stars on either side of the transition allows us to study changes in magnetic activity, independently of age and composition. We analyze a sample of 372 wide binaries, identified in the literature via *Gaia* astrometry and observed by NASA *Kepler* and K2 missions, for which we recover rotation periods and magnetic activity indexes ($S_{\rm ph}$). A calibration of the convective turnover time is performed on seismic stars based on their corrected *Gaia* colors. This allows us to calculate the Rossby number, defined as the ratio of the rotation period to the convective turnover time. We compare their rotation-activity-color distributions to those of the full *Kepler* field population. We show that the wide binary distribution in the activity-rotation diagram closely mirrors the full *Kepler* main-sequence field population, with the upper envelope reproducing the gap and an enhanced magnetic activity at the transition. To further probe this, we examine individual pairs straddling the gap and find evidence that post-transition stars can exhibit higher magnetic activity than the pre-transition star, supporting a change in magnetic activity regime. This study will help better understand stellar evolution, as well as the environment around stars and the impact on the habitability of their orbiting exoplanets.

Constraining Surface Differential Rotation in Solar-Like Stars

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Surface differential rotation is a key driver of magnetic activity in solar-like stars, yet its measurement from photometric data remains challenging. In this work, we apply the peak-height ratios (PHR) technique to constrain surface differential rotation. The method uses the ratio between the amplitudes of the second and first rotational harmonics in the periodogram of quasi-periodic flux modulations induced by active regions rotating across the stellar disc. This ratio depends on the latitude of the active regions and the stellar inclination, allowing each detected rotation period to be associated with a likely active-region latitude.

We analyse a sample of 56 solar-like stars observed with long-cadence *Kepler* data, all with well-constrained inclinations from asteroseismology and detected rotational modulation. The sample includes 11 benchmark stars with independent asteroseismic measurements of differential rotation, enabling a direct validation of the method. For each target, we first construct star-specific relations between PHR and active-region latitude. We then identify robust harmonic pairs across independent light-curve segments and compute the respective observed PHR. These measurements together with the derived PHR relations are used to infer the surface differential rotation profile, including the equatorial rotation period and latitudinal shear, using weighted fitting and bootstrap uncertainty estimation.

For the benchmark sample, the PHR-based shear values are consistent with asteroseismic results, supporting the reliability of the method despite the different depths probed by the two techniques. Across the full sample, we recover the expected trend of decreasing equatorial rotation period with increasing effective temperature. We also find that hotter, F-type stars tend to exhibit larger relative shear, with indications of a systematic increase above $\sim$6000 K.

Overall, our results demonstrate that the PHR technique provides a viable photometric diagnostic of surface differential rotation, enabling new constraints on stellar dynamos and magnetic activity across large stellar samples.

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Exoplanets and their host stars

Exoplanets over Galactic Timescales with Asteroseismology

Invited: A. Weeks[1]

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Understanding exoplanets begins with understanding their host stars. Stellar ages and metallicities in particular trace the birth environments of planetary systems and their subsequent evolution. However, for many planet-hosting stars these parameters have remained uncertain and inconsistent across the literature.

This talk will explore how stellar characterisation in the era of Gaia and asteroseismology has improved our understanding of planet formation and evolution. Recent results which reveal correlations between stellar age and the properties of planets will be reviewed. Asteroseismology of exoplanet hosts, making use of data from missions like Kepler and TESS, has revolutionised demographic star-planet studies. This talk will conclude by considering how JWST may continue to facilitate this collaborative tradition.

Doubling the Sample of Asteroseismic Masses, Radii, and Ages for Transiting Planet Systems Observed by TESS

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Despite the hundreds of thousands of asteroseismic detections from TESS, relatively few asteroseismic detections of planet host stars have been made. However, the availability of additional data from the extended missions of TESS has made the detection of solar-like asteroseismic signals easier. Here, we report asteroseismic solar-like oscillations detected in the TOI-2669 and TOI-4551 systems. We use these newly measured asteroseismic constraints to redetermine stellar radii, masses, and ages in these systems, doubling the number of planetary systems discovered by TESS with asteroseismic ages. This analysis suggests that previous mass estimates were overestimated by 15%, and and ages reported were underestimated by 30-50% for these these systems, implying that these, and by extension many of the TESS evolved planetary systems, are likely closer analogs to the future of our Solar System than previously believed. Differences seen between this population and that of main sequence FGK stars are thus likely driven by system evolution rather than stellar mass differences.

Discovery of Two Warm Jupiters in Likely Spin-Orbit Alignment with the Oscillating Red Giant Star KOI-6194

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We report the discovery and confirmation of two warm Jupiter exoplanets orbiting their Red-Giant (RG) host KOI-6194: KOI-6194b (transiting) and KOI-6194c (non-transiting), on $42.30^{+2.05\times10^{-5}}_{-2.32\times10^{-5}}$ d and $63.53^{+2.88\times10^{-3}}_{-6.07\times10^{-3}}$ d orbital periods at 0.25 AU and 0.33 AU respectively. Using Kepler photometry and asteroseismology, we determine stellar properties ($R_* \approx 5.632 \pm 0.081\ R_\odot$, $M_* \approx 1.23 \pm 0.046\ M_\odot$, $\log g \approx 3.03 \pm 0.47$ dex), and a stellar rotational inclination of $(89.56 \pm 0.01)^\circ$. Coupled with the planetary orbital inclination ($i_p \approx 90^\circ$), we claim that KOI-6194b is consistent with spin-orbit alignment, while KOI-6194c deviates with a minimum mutual inclination of $\sim 4.58^\circ$. The most likely explanation for this orbital architecture is disk migration. We calculate the instellation of KOI-6194b to be $218.19 \pm 6.28\ F_\oplus$, which lies above the empirical inflation threshold of $150 F_\oplus$ determined by Demory+2011. Yet, KOI-6194b's radius of $0.97 \pm 0.02\ R_J$ suggests a non-inflated status. KOI-6194b is most likely in the early stages of re-inflation. Precise radial velocity measurements from Keck/HIREs are used to validate KOI-6194b and KOI-6194c, and to rule out the false positive first detected by Kepler. While these RVs also indicate a third companion, this is likely another false positive due to a correlated signal with KOI-6194's spectral activity. By confirming these exoplanets we provide a baseline for future work regarding exoplanet formation and inflation theories.

Pulsation-Driven Disk Response in the Benchmark ZZ Ceti G29-38: Mode-Selective Heating Seen with JWST

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White dwarfs, the remnants of most stars, show atmospheric metal pollution from disrupted planetary systems, providing a window into exoplanetary composition and dynamics. Frequently accompanied by dusty debris disks, these systems offer a laboratory for real-time studies of the disruption and accretion of exoplanetary material. The white dwarf G29-38 is in many ways the archetypal evolved planetary system, but also an extremely well-studied ZZ Ceti, including extensive modelling of TESS observations. Its large-amplitude non-radial g-mode pulsations and bright infrared excess from a compact debris disk make it a unique laboratory for studying how stellar pulsations are imprinted on circumstellar material. I will present an intensive, JWST-based, multi-wavelength monitoring campaign of G29-38 that, for the first time, jointly constrains its pulsation-driven irradiation and debris-disk structure. Time-resolved NIRSpec and MIRI spectroscopy reveal mode-resolved, minute-scale mid-infrared variability that tracks the white dwarf's pulsation spectrum, demonstrating that the disk responds preferentially to a subset of modes. This mode-dependent thermal response provides an independent handle on mode geometry and surface flux redistribution, effectively using the disk as an external "detector" of pulsation visibility. The high-cadence JWST spectroscopy constrains the thermal response time of the disk, while the detailed mineralogy and detection of cooler dust refine its radial extent. These observations deliver the most complete time-domain view to date of a pulsating white dwarf, its debris disk, and its accretion environment, establishing G29-38 as a cornerstone system for exploiting asteroseismology to probe the fate of planetary systems.

A possible mass-shifted brown-dwarf desert around giant stars

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In about 5.2 Gyr, the Sun will expand to 100 times its current radius and shine with 1000 times its present luminosity. When this happens, the innermost planets will be scorched or engulfed, while the outer planets will find themselves orbiting a red giant star. Detecting exoplanets around such luminous red giants is therefore important for understanding the fate of our Solar System. However, such detections are exceptionally rare: among thousands of known exoplanets, almost none are found around luminous red giants. The difficulty arises from the planets' intrinsic dimness and small size compared to their host stars, characteristics that prevent detection by both transit and radial-velocity detection methods.

Here, we study the mass distribution of companions to luminous giant stars and identify a double-peaked distribution with a pronounced valley at $\sim 0.14 M_{\odot}$. We interpret this valley as a mass-shifted analogue to the brown-dwarf desert, where almost no companions with mass between planets and stars are usually found orbiting Sun-like stars. This result implies that the 121 companions forming the low-mass peak may have originated as exoplanets and subsequently accreted $0.07^{+0.03}_{-0.02} M_{\odot}$ of material from their parent star. This mass growth can make the companions detectable due to dusty wakes and larger orbital radial-velocity amplitudes. Although the physical mechanism responsible for this mass gain remains uncertain, our observational results suggest that star–planet interactions can modify companion masses, offering new quantitative constraints on mass transfer processes between stars and their companions—a widespread, complex, and critical phenomenon in stellar astrophysics.

11 Solar-like oscillations

Solar-like Oscillators: recent advances in analytical methods

Invited: M. B. Nielsen[1]

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At some point in their lives most stars will transition to a stage where they can exhibit solar-like oscillations. They are therefore one of the most common types of variable stars, making them excellent tools for studying a variety of stellar physics and the environments around them. In this talk I will summarize some of the most recent, exciting results in works surrounding solar-like oscillators. Many of these results are made possible by the large quantities of data from past and current missions such as CoRoT, Kepler, and TESS; as well as recent advances in analysis techniques and machine learning. Future missions like PLATO, Roman and HAYDEN will study unexplored regions and populations of the Milky Way, providing an enormous amount of new data. However this presents its own set of challenges: how do we adapt existing methods to cope with this new data from potentially multiple sources, and how can we analyze these volumes of data without obscuring potentially interesting outliers that can reveal new physics?

Detecting Solar-Like Oscillations in the Highest Mass TESS Giants

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Red-giant asteroseismology yields precise stellar parameters, making it a powerful tool for studying stellar structure and evolution, as demonstrated by the *Kepler* mission. However, due to *Kepler's* limited field of view, it primarily sampled the more populous low-mass red giants found outside of the Galactic plane, leading to limited detections of intermediate-mass red giants ($3\,M_\odot \lesssim M_* \lesssim 8\,M_\odot$). Here we use the all-sky TESS data to isolate intermediate-mass stars from large catalogs with a pre-selection based on photometric and spectroscopic data. We optimize TESS light curves using a boutique light curve detrending method with custom apertures. Compared to the MIT Quick Look Pipeline, this yields a 12% average increase in the signal-to-noise ratio within the oscillation envelope, even in the heavily crowded Galactic plane. We find a total of 100 solar-like oscillators in a pre-selected sample of 227 APOGEE DR19 red giants. We find 44 stars in this sample to be intermediate-mass, with 10 stars having masses greater than $5\,M_\odot$, among the highest-mass solar-like oscillators detected to date. From our detections, we measure that the APOGEE DR19 spectroscopic $\log g$ is systematically larger by, on average, 0.23 dex compared to the seismic $\log g$. This offset is possibly due to the lack of intermediate-mass giants observed by *Kepler*, which was used to calibrate the spectroscopic $\log g$ in the APOGEE pipeline. Extending the same pre-selection criteria to TESS targets with Gaia XP spectroscopic parameters identifies up to 37,000 candidate intermediate-mass solar-like oscillators for follow-up and population studies. Because quiescent helium ignition, angular momentum transport, and internal mixing processes (e.g., convective boundary mixing and rotational mixing) differ substantially at intermediate mass, this sample enables new asteroseismic constraints on intermediate-mass stellar structure and evolution. These targets help bridge the gap between well-studied low-mass giants and the progenitors of massive stars that ultimately end as supernovae.

Asteroseismic Diagnostics for Evolved Stars with Kepler and TESS: Tracing Helium Ignition and the Transition from Subgiants to Red Giants

Y. Wang[1]

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Asteroseismology of large samples of red giants has been done very successfully using $\nu_{\rm max}$ and $\Delta\nu$. However, other global oscillation properties have been comparatively neglected. In a recent Kepler study of $\sim 16,000$ red giants, we used an automated collapsed- échelle analysis to measure $\Delta\nu$, ε, $\delta\nu_{01}$, and $\delta\nu_{02}$. The catalogue reveals red-clump and secondary-clump sequences in unprecedented detail, tracing the mass-dependent seismic imprint of helium ignition. Meanwhile ε and $\delta\nu_{01}$ show systematic offsets from stellar-evolution models, pointing to limitations in near-surface and outer-envelope modelling and possible mode-dependent surface terms. We have extended this framework to a TESS sample of bright subgiants and early red giants, targeting an evolutionary regime that was difficult to sample at scale with Kepler long-cadence observations: these stars have $\nu_{\rm max}$ above the long-cadence Nyquist frequency and Kepler short-cadence target slots were scarce. For ~ 700 stars, we measure p-mode diagnostics and, where mixed modes are detected, combine them with $\Delta\Pi_1$, q, and $\varepsilon_{p,1}$. These measurements allow us to trace the transition from a few avoided crossings to dense red-giant mixed-mode patterns, refining evolutionary-state and age constraints across the subgiant-to-red-giant boundary. By cross-matching these stars with spectroscopic surveys, we are able to link our seismic measurements to surface-abundance changes associated with first dredge-up and place these bright stars in age-abundance space for local Galactic archaeology.

The origins of power spectral complexity in red-giant oscillations

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Solar-like oscillations in red giants have characteristic patterns in their power density spectra (PDS) that enable the precise determination of stellar masses, radii, and evolutionary stages. However, a non-negligible fraction of red giants show complex PDS that challenge reliable asteroseismic parameter determination. Internal processes such as magnetic fields and structural discontinuities, dynamical effects including rapid rotation and mode degeneracy, as well as contamination from binary companions, can produce a wide diversity of complexities in the PDS morphology. Yet, no study has systematically investigated these origins across the *Kepler* red giants. We classify red giants with complex PDS using a two-dimensional diagnostic. This combines Shannon entropy, which quantifies the complexity of the power distribution in the PDS, with permutation entropy, which captures the sequential ordinal structure of the PDS. We find that several hundred *Kepler* red giants show noticeably complex PDS. Among them, we identify seismically unresolved asteroseismic binary candidates whose overlapping oscillations bias the inferred masses and radii by factors of up to 3 and 2 relative to those of the individual stars. Core properties such as period spacings and coupling factors also become unreliable, with the coupling factor overestimated by up to a factor of four. These biases can explain inconsistencies across independent analyses of red giants, such as red clump stars with anomalously low masses. Our results provide a framework for identifying and accounting for PDS complexity in asteroseismic analysis.

Splinter sessions

Splinter 1.a: Red giant interiors

Seismic probing of the mixing properties in Core Helium Burning Stars.

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Recent space missions such as CoRoT, Kepler, and TESS have established asteroseismology as a powerful tool to probe stellar interiors. Red giants are particularly valuable in this context, as their mixed modes provide constraints on both core and envelope structure (Bedding et al. 2011). In Core Helium Burning Stars, the evolution of the convective core leads to strong chemical gradients and the development of a semi-convective region. However, the treatment of chemical mixing in these regions remains uncertain, particularly concerning semi-convection (Castellani et al. 1971) with partial mixing and a more complex picture as drawn from hydrodynamical simulations (e.g. Wood et al. 2013, Fuentes 2025), with recent works by Blouin et al. (2024) claiming a fully mixed semi-convective region. Such uncertainties lead to discrepancies between models and observations, notably in period-spacings and radii (Chowhan et al. 2026). In this work, we investigate the seismic impact of various prescriptions in the semi-convective region using Core Helium Burning models computed with the Liège Stellar Evolution Code (CLES; Scuflaire et al. 2008) that include a consistent treatment of convective boundaries (Gabriel et al. 2014). We compare induced semi-convection with partial mixing to an extended overshooting formalism and identify new seismic indicators enabling to characterize the vicinity of the convective core's boundary and the semi-convective zone. Notably, the sharpness of the transition region at the edge of the mixed core is shown to strongly affect the Brunt-Väisälä frequency profile and thus the observed period-spacing pattern, allowing the mixing properties in these layers to be probed (Panier et al. in prep.).

Systematic detection of core magnetic fields in red giants

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It is now established that additional mechanisms of angular momentum transport are needed to account for the observed rotation profiles of stars, one of the most promising candidates being magnetic fields. Recently, asteroseismic detections of magnetic fields have been obtained in the cores in red giants, offering for the first time significant insight on the structure and geometry of these fields. Up until now, only 79 out of about 20,000 *Kepler* red giants were found to be magnetic. Previous studies focused on specific cases to detect core magnetic fields (e.g., triplet asymmetry, gravity offsets ...), thereby introducing strong observational biases. This has prevented us so far from estimating the prevalence of magnetic fields in reg giant cores.

We developed an automatic method to consistently search for and characterise magnetic fields for all red giant branch stars in the *Kepler* catalogue. One first challenging step is to automatically detect and identify significant mixed modes in the power spectral density. For this purpose, we use robust statistical criteria and we maximise the detection probability by exploiting the expected lifetime of mixed modes. The detected mode frequencies are then adjusted to an asymptotic expression for mixed modes taking rotation and magnetic field into account, using a Bayesian framework. This allows us to systematically measure rotation rates and magnetic field properties (intensity and geometry). In this talk we present the first results of this method applied to *Kepler* red giants. We discuss the relationships between magnetism, stellar mass, rotation and stellar evolution, and we investigate the link with angular momentum transport. This method is also a powerful tool to identify signatures of non-axisymetric core magnetic fields, which may generate more than three components per dipolar multiplet. This new method is readily applicable to TESS data, and to PLATO data in the near future.

Toward asteroseismic magnetometry for the full diversity of magnetic structures

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To date, magnetic fields have been asteroseismically measured in nearly one hundred red giant cores. However, most analyses assume weak magnetic fields and slow rotation so that perturbation theory can be applied. A recent formalism based on the "traditional approximation of rotation and magnetism" (TARM) method can predict asymptotic gravity-mode frequencies under strong magnetic fields and rapid rotation rates. It does so by modeling the modes as "magnetogravity polarizations" which propagate through the mode cavity, which is correspondingly treated as a waveguide. So far, this formalism has been limited to magnetic fields which are axisymmetric about the rotation axis.

We significantly generalize this waveguide formalism to apply to arbitrary magnetic field geometries, including cases where the magnetic and rotation axes are misaligned, as well as fields with no symmetry axis at all. The resulting gravity modes exhibit a rich diversity of wave behavior, including oblique pulsation, avoided crossings, and polarization conversion. We derive a new magnetic field threshold (distinct from the critical magnetic field for suppression) which delineates the domains of validity of perturbation theory and the waveguide method. These results open the door to broader searches for internal stellar magnetism.

Facing the Phase of asymptotic g-mode frequencies on the red-giant branch

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The pattern of mode frequencies observed in red-giant stars can be well approximated by asymptotic theory. In this limit, the oscillations are characterized by a handful of parameters, which can be obtained from observed oscillation spectra via frequency fitting. In order to interpret the observed parameters in terms of physics, it is essential to understand their sensitivity to the stellar structure.

We study one asymptotic parameter, the g–mode frequency phase, which probes the buoyancy cavity in the stellar core. In the literature, two contributions to this phase are discussed individually: non-asymptotic behavior at the outer cavity boundary, and buoyancy glitches. Using stellar models, we show that it is necessary to account for both these phase terms simultaneously. We further identify glitches in the evanescent region at larger radii as an additional contribution. We demonstrate how correctly interpreted ensemble observations of the g–mode frequency phase on the red-giant branch provide a test for convective-boundary treatment in stellar modeling.

Magnetic Signatures in Merger Products

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Due to the abundance of multiple star systems, mass transfer events and stellar mergers are expected to be fairly common. However, the impact of such events on the generation and survival of magnetic fields in stellar cores remains uncertain. To learn more about the origin of observed magnetic fields in the radiative interior of red giant stars, we investigate the impact of mass-gain events on the detectability of magnetic fields from asteroseismology. Using MESA models in a mass range of $1.1\,M_\odot$ to $2\,M_\odot$, with and without a mass-gain event, we assess how mass-gain events affect the efficiency of magnetic fields to produce frequency shifts of g-dominated mixed modes, and assess how a mass-gain history affects the critical field strength for dipole mode suppression. We find that for stellar masses below $1.5\,M_\odot$, magnetic effects on the frequency shift of oscillation modes are nearly identical between mass-gain and single star models with identical model values of either $\nu_{\rm max}$ or $\Delta\Pi_1$. However, when mass-gain models with initial masses below $1.5\,M_\odot$ reach total masses of above $1.5\,M_\odot$, we find that, at identical model values for $\Delta\Pi_1$, their model modes are more sensitive to the magnetic field by up to a factor of 25%. We also show that the critical magnetic field strength for dipole mode suppression is reduced by an order of magnitude for stars with total masses $M > 1.6\,M_\odot$ if a mass-gain event is assumed. Opening the way towards a better understanding of the origins of magnetic fields in stellar radiative interiors, we show that red giants exhibiting low dipole mode visibilities and total masses of $1.6\,M_\odot - 2.0\,M_\odot$ can be explained by considerably lower values for the critical magnetic field strength when assuming mass-gain or merger events. Furthermore, we can have access to significantly weaker internal magnetic fields from asteroseismology in merger products for stellar masses above $1.5\,M_\odot$.

Splinter 1.b: Massive and evolved pulsators

Oscillations and orbital evolution in Magellanic high mass X-ray binaries over seven years of TESS

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We present the results of an analysis of 276 high mass X-ray binaries in the Large and Small Magellanic Clouds, using custom light curves from TESS FFI data and spanning the first seven years of the mission. HMXBs consist of an O/B-type donor star and a compact accretor; understanding the physics of these systems is key to building out our picture of massive star binary evolution pathways and gravitational wave progenitor events. At present, the rate of HMXB mass transfer, and thus orbital decay, is poorly constrained. The aim of this study was to use TESS to follow up on 80 systems with orbital periods from decades of X-ray and optical monitoring of the Magellanic Clouds, and to search for optical counterparts in the remaining sample for future long-term monitoring. However, the more exciting result has been the prevalence of stochastic low-frequency (SLF) variability among the donor stars in these systems, for systems both with and without known orbital periods. The detection of SLF in HMXBs allows us to further characterize stellar interiors across all stages of massive star binary evolution. We do not detect SLF for HMXBs with literature periods under 11 days, suggesting a potential connection to tidal suppression of oscillation; however, we note that several reported 1 day periods in fact appear to be SLF, not signatures of binarity. We also report detections of ellipsoidal variability that largely do not align with literature periods. This underscores the importance of signal deblending in crowded fields, as well as thorough characterization of all types of variability in massive stars. Finally, for the well-known system SMC X-1, we retrieve a strong detection of an orbital period of 3.89 days, showing remarkable consistency with measurements over the past 40 years and allowing us to place an upper limit on its mass transfer rate. Detailed analysis of SMC X-1 across multiple years reveals variation in the period on the order of minutes, likely due to tidal effects, and illustrates a blueprint for detailed long-term monitoring of bright extragalactic objects with TESS.

New insight of stochastic low-frequency variability among a large and diverse sample of massive stars with TESS photometry and spectroscopy

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Massive stars are the progenitors of neutron stars and black holes and play a crucial role in shaping the chemical and radiative feedback of entire galaxies through their winds and explosive deaths as supernovae. Convective regions in massive stars excite internal gravity waves (IGWs), which facilitate efficient chemical mixing and angular momentum transport; both are important physical processes for a massive star's evolution. However, the presence, and hence impact, of convection is strongly dependent on a star's metallicity, and remains largely uncalibrated in 1D evolution models. It has recently been established that the vast majority of massive stars exhibit stochastic low-frequency (SLF) variability, which can be explained by the presence of IGWs that are stochastically excited at the turbulent interface of convective and radiative regions. This new type of asteroseismic signal has great potential for probing the interior physics of massive stars that lack coherent heat-driven pulsation modes. In this talk, we present the analysis of a large homogenous sample of massive Galactic stars with SLF variability using long-term TESS mission light curves combined with high-resolution spectroscopy. Furthermore, optimal light curves for an additional 100 massive stars in the SMC add the important dimension of metallicity to our study. Extracting light curves for such faint stars in heavily crowded regions requires dedicated software tools, such as point-spread function fitting to successfully mitigate the effects of contamination and telescope drift. This large sample of TESS light curves not only yield statistics of SLF variability across the HR diagram, and how this phenomenon depends on mass and age, but also sheds new light on the potential excitation mechanisms of IGWs in massive stars that are currently debated in the literature. Asteroseismology of this unique sample thus opens a new window for probing mixing, rotation and angular momentum transport in the interiors of massive stars at different metallicities and hence improve stellar evolution models.

Searching for the First Local Partially-Stripped Yellow Supergiants

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In traditional single star models, yellow supergiants (YSGs) represent a short, transitional, phase in a massive star's life as it evolves from the Main Sequence to the (helium burning) Red Supergiant phase–rapidly crossing the Hertzsprung Gap of the Hertzsprung-Russell Diagram. In this traditional picture, supernovae (SNe) are not expected in the Hertzsprung Gap. However, despite this, there is a growing subset of partially-stripped, hydrogen-poor SNe that have had their progenitors identified as YSGs from pre-explosion imaging. The favoured explanation for these observations is that a binary companion partially strips the SN progenitor of its envelope (leaving behind only a few tenths of a solar mass of hydrogen), after which it subsequently explodes as a YSG in the Hertzsprung Gap. However, to date, no analogs to these partially-stripped YSGs have been discovered in Local Group galaxies that can be studied in detail prior to their explosion. The inherent challenge is that, by definition, partially stripped YSGs have similar temperatures and luminosity (and therefore colours and magnitudes) as full-envelope YSGs. However, due to their higher luminosity-to-mass ratios, theoretical models predict that certain pulsations should be excited exclusively in partially stripped YSGs, resulting in unique lightcurve morphology. Thus, the variability of YSGs can provide a unique probe into understanding their stellar structure and the presence of a full or partially-stripped hydrogen envelope. In this talk, I will describe our ongoing program to characterize the variability of over 800 YSGs in the Magellanic Clouds with the goal of identifying candidate partially-stripped YSGs. In particular, I will give an overview of the photometric variability of the entire population, highlight the identification of around a dozen YSGs that have the predicted hallmarks of partially stripping, and describe on-going follow-up efforts to confirm the partially stripped nature of this sub-population.

Modeling strange mode Cepheids with MESA and RSP

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Strange-mode pulsations in classical Cepheids are characterized as shallow, low-amplitude, short-period surface oscillations that develop when higher-overtone modes become trapped in the outer layers and are effectively decoupled from the stellar interior. Their excitation is found to be highly sensitive to the underlying stellar structure and confined to a narrow region of the mass–metallicity parameter space.

We computed a grid of stellar evolution models with MESA, and carried out linear stability calculations using the MESA RSP module to map the conditions under which these modes may arise. This combined approach allowed the influence of convective overshoot, metallicity, and stellar mass on strange-mode excitation to be systematically explored. The resulting instability domains were placed on both the Hertzsprung–Russell diagram and the Gaia colour–magnitude diagram, where strange-mode pulsators occupy a distinct and isolated locus, clearly separated from classical Cepheids and other nearby variable classes.

Although the strange-mode phase is intrinsically brief, it can represent a non-negligible fraction of post-main-sequence evolution in regions where the ratio of strange-mode duration to instability-strip crossing time is enhanced. The predicted periods and amplitudes fall within the sensitivity range of current space-based photometry, indicating that strange-mode pulsators may already be detectable with TESS and, in the near future, with Gaia epoch photometry, despite challenges posed by blending and extinction.

Asteroseismology of white dwarfs in the era of PLATO

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White dwarfs, the final evolutionary stage of the vast majority of stars, are key tools for cosmochronology, studies of planetary system evolution, and tests of non-standard physics, including exotic cooling channels, weakly interacting particles, and crystallization processes. While spectroscopy and model atmospheres probe surface properties, global pulsations observed during several evolutionary phases provide a direct window into their deep in- teriors. In this talk, I will present the potential of the PLATO mission for studying pulsating white dwarfs, including hydrogen-deficient GW Vir and DBV stars, and hydrogen-rich DAVs. I will also discuss how long-duration, high-precision PLATO observations can probe internal structure, chemical stratification, and evolutionary history through asteroseismology, including sensitivity to very low-amplitude pulsations. I will also highlight synergies with Gaia, TESS, and ground-based spectroscopic follow-up, which together enable robust mode identification and detailed modeling. These efforts promise to transform our understanding of white dwarf physics, their evolutionary pathways, and the fate of stellar remnants.

Splinter 1.c: Input physics

Asteroseismology sheds light on the evolutionary link between Barium giants and dwarfs

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Barium (Ba) stars are a subclass of slow process (s–process) enhanced stars whose chemical peculiarities are often associated with mass transfer from an asymptotic giant branch (AGB) companion. Therefore, they are excellent sites for studying AGB nucleosynthesis, binary evolution, and mass transfer processes. However, an accurate estimate of their fundamental stellar parameters is still lacking, limiting our understanding of their formation and evolution. We aim to bridge this gap by performing the first extensive asteroseismic mass measurements for a sample of 31 Ba giants and 13 Ba dwarfs using TESS data. By measuring the global asteroseismic parameters ν_{max} and $\Delta\nu$ from their lightcurves, we apply scaling relations to determine seismic masses for these stars. For a sub-sample, we are able to measure period spacing, thereby ascertaining their evolutionary phase. We find a considerable overlap in the seismic mass distributions of Ba giants and dwarfs, both peaking at about the same mass ($\sim 1.3 M_{\odot}$). Combining these precise masses with chemical abundances, we identify an anticorrelation between the s–process abundance and the seismic mass of Ba stars, which we further explore with a grid of stellar models. Our results from asteroseismic analysis combined with their chemical abundances support an evolutionary scenario in which Ba giants evolve from Ba dwarfs, with mass accretion occurring while the progenitor Ba star is still on the main sequence. In this talk, I will present these key findings, together with their implications for AGB nucleosynthesis and post-accretion mixing processes in these stars.

Precision Constraints on Stellar Helium Abundances from Subgiant Stars

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The helium abundance in stars is a key parameter influencing stellar structure and evolution, yet it remains one of the most difficult quantities to constrain in stellar astrophysics. Unlike hydrogen and most metals, helium cannot be reliably measured through standard spectroscopic techniques in cool stars and must instead be inferred indirectly. In this study, we estimate stellar helium abundances by exploiting the sensitivity of stellar evolution models to helium content. We use grids of stellar evolution models spanning a range of masses, metallicities, and helium abundances, and infer helium from systematic offsets between observed and model-predicted luminosities. These offsets are interpreted through the response of stellar evolutionary tracks to variations in helium abundance relative to a reference helium-enrichment model. The APOKASC sample of subgiants provides a powerful opportunity to combine asteroseismology and spectroscopy to probe helium abundances across a broad range of stellar metallicities and ages. We integrate asteroseismic constraints with spectroscopic atmospheric parameters drawn from multiple large-scale surveys beyond SDSS/APOGEE, enabling a more comprehensive and tightly constrained model–data comparison. From this analysis, we infer helium mass fractions and constrain the helium-to-metal enrichment relation with a precision of $\sim 7\%$, consistent with previous empirical and theoretical estimates. This result provides an empirical anchor for stellar evolution models, demonstrating that while helium abundance has a substantial impact on derived stellar parameters such as ages and luminosities, its uncertainty is now sufficiently constrained to reinforce confidence in current model calibrations.

Red-Giant Asteroseismology of Low-Mass Population III Stars

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Low-mass Population III (Pop III) stars remain undetected despite being potential survivors of the first star-formation epoch, largely because they are difficult to distinguish from later stellar generations. Chemical tagging alone is often ineffective, as internal mixing and external pollution can obscure primordial signatures, thereby motivating diagnostics that probe stellar interiors. Asteroseismology offers then a powerful, yet largely unexplored, avenue to identify primordial stars through the structural imprint of metal-free evolution. Using evolutionary models below 1 $M_{\odot}$, we quantify how convection and associated mixing processes shape internal structure and evolutionary pathways, including self-enrichment episodes. Building on these models, we compute the first non-radial adiabatic pulsation analysis of low-mass Pop III stars. Focusing on a 0.85 $M_{\odot}$ red giant as a case study, we show that metal-free models occupy a distinct and observationally separable asteroseismic regime: at similar evolutionary stages, they exhibit systematically altered seismic signatures driven by lower opacities, higher internal sound speeds, steeper core-envelope stratification, and delayed mean-molecular-weight gradient development. We introduce a diagnostic based on the coupling between acoustic and buoyancy cavities and demonstrate that it robustly discriminates Pop III stars from metal-enriched counterparts, even in the presence of surface pollution. These results establish asteroseismology as a viable pathway for identifying surviving Pop III stars in the Milky Way, particularly in the era of large-scale photometric and spectroscopic surveys.

Evolutionary tracks and isochrones based on coupled 1D and 3D models underestimate temperatures for red giants

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A significant weakness in stellar structural and evolution modeling is the simplified treatment of convection, which leads to erroneous near-surface stratification and substantial uncertainties in predicted fundamental properties of low-mass stars. We developed a novel method that couples stellar structural models with 3D surface convection simulations during stellar evolution, across a wide range of metallicities. This 1D-3D coupling method makes evolutionary tracks effectively independent of the mixing-length parameter, meanwhile providing oscillation frequencies that agree more closely with asteroseismic observations. To expand this framework to ensemble studies of stars and age determinations of clusters, we present the GASTAG stellar evolutionary tracks and isochrones constructed using the 1D-3D coupling approach. Comparing effective temperatures from the APOGEE-Kepler catalog with GASTAG predictions, we find the theoretical temperatures are cooler by about 70 K near solar metallicity. Our isochrones are compared with observed color-magnitude diagram of clusters spanning from [Fe/H] = 0.3 to -1.9. In all cases, the synthesized and observed diagrams agree excellently in the main-sequence, turn-off, and subgiant region, while isochrones predict systematically cooler red giant branches. Taking these independent findings together reveals that the temperature mismatch is most likely due to deficiencies in stellar models. Because GASTAG is constructed using a method that greatly reduces uncertainties associated with surface boundary conditions and mixing-length parameters, the difference between modeling and observation can be more confidently attributed to other factors, such as α-element abundances or uncertainties in opacities. The tracks and isochrones are publicly available.

Contrastive deep learning for structure-preserving chemistry of TESS asteroseismic red giants from Gaia XP spectra

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The Galactic disc is bimodal in [α/M] versus [M/H], and whether the two sequences are connected by a smooth shock-heating transition or a discontinuous two-infall episode remains unresolved. Answering this question, and the related ones of disc flaring and radial migration, requires a red-giant disc sample with star-by-star ages, abundances, and kinematics. ArqueoGal, a *Gaia*-TESS Galactic archaeology project, is constructing such a sample, combining TESS asteroseismic ages, *Gaia* DR3+`galpy` astrometric and orbital parameters, and high-precision chemical abundances. Ages and chemistry are complementary tracers of disc formation, and we focus here on the chemistry. APOGEE delivers the precision and elements we need, but its sky coverage and magnitude limit leave most of the TESS asteroseismic cohort without high-resolution chemistry. *Gaia* DR3's GSP-Phot module sits at the opposite trade-off, delivering labels for $\sim$ 220 million stars to $G \sim 19$, but at $R \sim 30$ to 100 its [M/H] is qualitative only and α-elements are not produced. We present a deep neural network that takes *Gaia* DR3 BP/RP spectra and predicts five APOGEE-DR19 labels jointly: T_{eff}, $\log g$, [M/H], [α/M], and [Mg/H], with a per-star covariance matrix. Training proceeds in two stages on $\sim$ 230,000 stars from an APOGEE-DR19 $\times$ *Gaia* DR3 red-giant cross-match. In the first stage the network learns an embedding of BP/RP spectra in which APOGEE-similar stars are mapped close together in latent space; in the second it is fine-tuned to predict labels with statistically calibrated per-star uncertainties. Out-of-distribution detection in latent space automatically excludes targets requiring extrapolation, restricting the catalogue to the trained regime. On a $\sim$ 50,000-star test set we reach uncertainties of 100 K in T_{eff}, 0.18 dex in $\log g$, 0.13 dex in [M/H], 0.06 dex in [α/M], and 0.12 dex in [Mg/H], and the disc bimodality is preserved star by star into the metal-poor regime. The catalogue extends APOGEE-quality [Mg/H] and covariant chemistry beyond APOGEE's reach, providing the chemistry layer of ArqueoGal. Through the project it will be made publicly available, supporting chemo-dynamical and Galactic-archaeology studies of the disc.

Splinter 2.a: Scaling relations

Calibrating asteroseismology scaling relation by interferometric observation on Gaia binaries

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With CoRoT, Kepler, and TESS, asteroseismology has shown its potential to provide masses for large samples. PLATO, scheduled for launch in 2027, will offer accurate stellar masses for a larger sample. However, the asteroseismic scaling relations assume all stars have internal structures homologous to the Sun. Since this assumption is unrealistic, masses obtained via asteroseismology need to be verified, and the scaling relation needs to be calibrated with model-independent mass measurements. This calibration currently rests on a sample of only 17 "benchmark" binaries, for which seismic masses and dynamical masses are available. Furthermore, all existing benchmark stars are on the Red Giant Branch (RGB), which introduces a significant selection bias.

In this talk, we introduce an accurate method for measuring model-independent stellar masses by observing Gaia binaries using long-baseline interferometry on VLTI and CHARA arrays. By combining a single interferometric epoch of about 30 minutes with Gaia photocenter orbits, the full-3D orbits and precise dynamical masses of both components can be derived. In addition to the interferometric data, we also observed our targets spectroscopically to ensure homogeneous spectroscopic parameters. I discuss the method in detail and compare the seismic and dynamical masses for the first Gaia binaries observed. I will then discuss how we use our dynamical masses to test the scaling relations. Finally, we plan to use our calibrated scaling relations to maximize the outcome of future space missions like PLATO. Our method could provide benchmark stars with large diversity in period and inclination efficiently, and those at different evolutionary stages for the first time.

Red giant asteroseismology of Kepler background stars

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In 2023, Martínez-Palomera et al. extracted light curves for over 400,000 background stars that were incidentally captured in Kepler photometry. Red giants in this sample are intrinsically bright, and have large amplitude oscillations, and are therefore excellent asteroseismic candidates for probing the most distant regions of the Galaxy. In this talk, we present a sample of 2,500 oscillating red giants detected in Kepler background star photometry. The oscillations were detected using a deep-learning model, and characterised with the SYD pipeline. We carefully removed false detections due to blending between stars to ensure the purity of the sample. Based on distance, kinematics, and chemistry, we identify 291 strong halo candidates within the sample. Detailed frequency modelling of this population allows us to benchmark seismic scaling relations in the metal poor regime to further advance our understanding of the structure and evolution of the Galaxy's oldest stellar component.

Granulation and mesogranulation in red giants are not self-similar

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Granulation and mesogranulation represent different spatial and temporal scales of convection, yet are commonly assumed to follow the same stellar atmospheric scaling relations in red giants. We test this assumption using a sample of ~ 9300 *Kepler* red giants spanning the red giant branch and red clump, covering a wide range in surface gravity and effective temperature. We derive stellar parameters from a crossmatch with the APOGEE survey.

We model the background components in the power spectra and infer empirical scaling relations for the characteristic frequencies and amplitudes of both signals as functions of surface gravity, effective temperature, and metallicity within a Bayesian framework. We also use flexible, data-driven models to test for non-linearities beyond simple scaling relations, finding no significant deviations.

However, the scaling relations differ systematically across the full sample. In particular, mesogranulation shows a stronger dependence on effective temperature than granulation, and the best-fitting models differ in their functional form.

These results show that granulation and mesogranulation are not self-similar. This indicates that the two signals probe distinct convective regimes associated with different depths and spatial scales, and has important implications for the modeling and physical interpretation of stellar background signals in red giants.

Asteroseismology of the lowest metallicity star to date.

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Metal poor stars form the backbone for understanding the characteristics of the Galaxy, through the evolution and chemical composition of various stellar systems right from supernovae to planets. Even though they are few in numbers, detailed seismic analysis combined with stellar evolutionary models of metal poor stars have provided precise ages and hence overview of the formation history of our Galaxy. Here, we present the asteroseismology of BD +44 493 ([FeH] = -3.96+/-0.09 dex, [alpha/Fe] = 0.61 +/- 0.05 dex), the lowest-metallicity star for which seismology has been possible to date. The star is a carbon-enhanced, chemically peculiar object that exhibits solar-like oscillations in TESS light curves, with a frequency of maximum power at 214 muHz and a large frequency separation of 17.45 muHz. We derived precise individual frequencies using iterative sine fitting. Our determination of the asymptotic period spacing suggests that the star has not yet started core helium burning and shows high coupling factor between p and g modes. We model the star using MESA and we see that variations in the assumed reaction network, elemental diffusion and radiative levitation yield systematic uncertainties in the model age of order 5%. The best fit models produce an f-numax = 1.15 +/- 0.04, in agreement with the previous studies. This shows the importance of asteroseismology to constrain seismic properties, model compositions and ages to a level that haven't been explored before.

Next Generation Asteroseismology for Stellar Population Studies

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In this talk I critically examine two topics: the role of asteroseismology in upcoming stellar population studies, and the complementary roles of global and boutique asteroseismic studies. I make the case that new asteroseismic data is crucial, because important Galactic populations have not been well studied to date; machine learning tools applied to existing data sets are not sufficient. I use the Roman and TESS missions as complementary examples. I argue that global asteroseismic properties, such as scaling relations, will remain the central analysis tool for two reasons: they are an accurate approximation for low luminosity giants and red clump stars, and they will be available for far more stars than those amenable to boutique analysis. At the same time, the limitations of scaling relations in metal poor stars and luminous giants are clearly evident, and boutique analysis methods are essential for understanding these key populations. I close by highlighting the important of a proper calibration for both global and boutique studies, and the central role that photometry will play for stellar characterization in large upcoming data sets.

Splinter 2.b: Modelling beyond 1D

How Rotation Shapes Acoustic Mode Amplitudes in Low-Mass Stars: Evidence from Hydrodynamical Simulations

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In solar-like stars, acoustic modes provide the main way of probing their internal structure and dynamics. Although these modes are expected to be ubiquitous in stars with convective envelopes, Kepler observations have revealed that a significant fraction of solar-like stars show no detectable acoustic modes, particularly among rapidly rotating and magnetically active stars. Recent theoretical work has proposed that rotation tends to inhibit convective motions, thereby reducing the power available for stochastic excitation of low degree acoustic modes.

In this talk, I will present a series of fully compressible hydrodynamical simulations of a $1M_\odot$ stellar model spanning rotation rates from 0 to 8 $\Omega_\odot$. Our results show a clear and systematic decline of acoustic mode amplitudes with increasing rotation rate. In the most rapidly rotating models, mode damping rates are also enhanced. The combined reduction in excitation and increase in damping with increasing rotation rate provide a physical explanation for the observed decrease in mode detectability in rapidly rotating solar-like stars.

I will also present an extension of this analysis to rotating main-sequence solar-like stars with different masses (0.8, 1.1 and 1.25 $M_\odot$), thus providing a trend of the amplitude of acoustic modes with the size of the convective envelope and rotation. Our results demonstrate that rotation can significantly modify oscillation properties and must be accounted for when interpreting asteroseismic observations.

SPAMMS: 3D spectroscopic patch models reveal the anisotropy of pulsation-induced macroturbulence and line-profile variability in massive stars

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Massive stars are progenitors of supernovae and black holes and play a key role in galactic chemical enrichment, because of synthesis and dispersal of heavy elements via strong stellar winds. Since most massive stars exhibit pulsations, asteroseismology is a powerful tools to probe their interior physics and constrain uncertain processes such as rotation, angular momentum transport, and mixing. While space photometry has transformed the field in recent years, it is far less sensitive to higher-angular degree modes because of geometric cancellation effects. High-resolution time-series spectroscopy can overcome this limitation by resolving line-profile variability associated with these higher-degree modes. Especially for massive stars, where period-spacing patterns are often difficult to detect, robust spectroscopic identification of pulsation mode geometries can provide the essential constraints needed for forward asteroseismic modelling, even when only a small number of excited modes are observed. However, spectroscopic analysis is currently limited by the use of 1D atmospheric models, which rely on assumptions such as spherical symmetry that break down for rotating stars. Since a substantial fraction of massive stars are fast rotators, this significantly limits the sample accessible for robust spectroscopic asteroseismology.

In this talk, we present a suite of proof-of-concept simulations using a 3D spectroscopic patch model to account for rotational distortion and complex surface velocity fields, including rotation, pulsations, and macroturbulence. We calculate synthetic spectroscopic time-series and demonstrate how the 3D model dramatically improves the interpretation of spectral line-profile variability, thus enabling more precise pulsation and atmospheric parameter determination. Furthermore, it allows the disentangling of complex velocity fields arising subsurface convection, rotation, and pulsations. We conclude that this 3D modelling approach is essential for reliably identifying pulsation-induced velocity fields and mode geometries, thereby enabling more precise and physically robust asteroseismic modelling.

Probing magnetic fields in stars: A 2D oscillation framework including rotation and magnetism

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Understanding the role of internal magnetic fields in stars remains a major challenge for the description of angular momentum transport and stellar evolution. In this work, we present a new implementation of the 2D oscillation code ACOR, which incorporates the effects of both stellar rotation and magnetic fields in a non-perturbative manner. The code has been rendered modular, allowing to specify the set of equations to solve and the underlying assumptions through a symbolic calculus approach. The full set of adiabatic, non-radial pulsation equations is solved using a spectral approach in the angular direction and a high-order finite differences in the radial direction.

As a first step, we focus on a simplified case in which the magnetic field is purely toroidal, axisymmetric, and aligned with the star's rotation axis. The numerical results are validated against first-order perturbative predictions in the weak-field regime and compared to the magnetic Traditional Approximation of Rotation and Magnetism (TARM) for stronger magnetic fields and faster rotation rates. In particular, our approach allows us to probe weakly stratified regions where TARM breaks down, opening a window to the magnetic coupling between gravito-inertial waves in radiative envelopes and inertial modes in convective cores of intermediate-mass main-sequence stars.

We further show that sharp magnetic gradients can produce mode-trapping signatures analogous to those induced by sharp structural discontinuities. This points to a promising new seismic diagnostic of strong, localized toroidal magnetic fields, such as those expected to be generated by radiative dynamo mechanisms.

Is a 1D perturbative method sufficient for asteroseismic measurements of rotation and internal magnetic fields in β Cephei pulsators?

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Asymmetries in the observed rotational splittings of a multiplet contain information about the star's rotation profile and internal magnetic field. Moreover, the frequency regularities of multiplets can be used for mode identification. However, to exploit this information, highly accurate theoretical predictions are needed. In the case of massive main sequence pulsators, β Cephei pulsators, the effect of rotation on the mode asymmetries cannot simply be neglected, hindering measurements of internal magnetic fields through signatures in the observed asymmetries.

In this talk, I will quantify the difference in the predicted mode asymmetries between a 1D perturbative method and a 2D method that includes a 2D stellar structure model, which takes rotation into account self-consistently without any simplifying assumptions. I will then place these differences between 1D and 2D methods in the context of asteroseismic measurements of internal magnetic fields. In other words, 'what would be the difference in the measured magnetic field strength when the rotation is treated in a 1D perturbative manner versus a 2D non-perturbative manner?'.

For the 1D perturbative method, the newly developed open-source pulsation code StORM is coupled to the 2D stellar structure code ESTER and is compared with the oscillation predictions from the 2D TOP pulsation code, where for the 1D case, a non-rotating ESTER model is used. We focus on models representative of rotating β Cephei pulsators spinning at up to 20 per cent of the critical Keplerian rotation rate, and specifically on low-radial-order gravity and pressure modes. Differences in the predicted mode asymmetries of a rotating star between 1D perturbative methods and 2D non- perturbative methods can greatly hinder accurate measurements of internal magnetic fields in main-sequence pulsators with low-order modes. Nevertheless, I will discuss under what circumstances accurate measurements could be achieved.

3D hydrodynamic simulations of massive main-sequence stars: internal gravity waves matter for SLF variability

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The origin of stochastic low-frequency (SLF) photometric variability observed in OB-type stars by CoRoT, Kepler, and TESS remains debated. SLF variability appears as a broadband, red-noise-like continuum in the light-curve power spectrum, ubiquitous across the OB domain of the main sequence but without a consensus physical origin. Core-generated internal gravity waves (IGWs) were long thought to be the driver, but Anders et al. (2023) in their Nature paper showed that radiative damping in the envelope prevents such waves from reaching the photosphere.

I will present results from the first 3D hydrodynamic `PPMstar` simulations of a 25 $M_\odot$ main-sequence star that simultaneously resolve core convection, the radiative envelope, and the thin near-surface iron-opacity convection zone (Pathak et al. 2026, ApJ, 1000, 89). The simulations show that IGWs excited at the envelope convection zone — not at the core — remain surface-visible and imprint a broadband SLF continuum on the luminosity power spectrum that matches CoRoT and TESS observations of HD 46150 in both slope and amplitude. Discrete eigenmode features are also identified in the simulated spectra, providing a new asteroseismic handle on massive-star envelope physics.

Beyond this published work, I will present new results on the geometric effect on the observability of individual eigenmodes. By integrating surface fluctuations with appropriate limb-darkening and spherical-harmonic response functions, we quantify how mode visibility depends on horizontal wavenumber ℓ. We find that only a restricted set of (ℓ, m) modes contribute significantly to disk-integrated photometry. This sharpens the connection between 3D-simulation predictions and what TESS and PLATO can actually see.

These results establish 3D hydrodynamic simulations as a quantitative tool for interpreting SLF variability and motivate a new generation of asteroseismic diagnostics for massive-star envelope convection, angular momentum transport, and near-surface mixing — directly relevant to the PLATO massive-star science case.

Splinter 2.c: Fast rotators

Population synthesis for delta Scuti stars: robust stellar parameters and the multi-ridged period–luminosity relation.

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Space-based photometry from Kepler and TESS, combined with Gaia parallaxes, has enabled detailed asteroseismic studies of A and F stars, while simultaneously exposing limitations in standard stellar models and inference techniques. In particular, rapid rotation and unresolved binarity – both common among these stars – complicate the interpretation of oscillation properties and inferred stellar parameters. I present a stellar population synthesis framework for asteroseismic inference that explicitly incorporates realistic distributions of rotation rates and binary companions, and accounts for their effects on observed stellar properties, including pulsation frequencies. The framework is released as a public tool for community use. Conditioning on temperature, luminosity and optionally other variables, it offers posterior predictions of stellar mass, age, angular rotation rate, density, mode frequencies, and related quantities with robust, physically motivated uncertainties. Applying this method, I show that widely used isochrone grids (including MIST and DSEP) systematically underestimate ages near the ZAMS and overestimate ages later in the main-sequence evolution when rotation and binarity are neglected. I then focus on the period–luminosity relation of δ Sct stars, where recent TESS and Gaia observations reveal a prominent second ridge whose origin has been debated. Using synthetic stellar populations, I demonstrate that binarity alone cannot explain this feature. Instead, mixture models in which different stars pulsate in different overtones successfully reproduce the observed multi-ridged relation. I further show that stellar rotation is a significant contributor to the intrinsic width of the period–luminosity ridges. Finally, I demonstrate that even with minimal conditioning, population synthesis can reproduce the observed large-frequency-separation ($\Delta\nu$) distributions of both field stars and clusters. I show that meaningful comparison between observed and theoretical instability strips will require population-based modelling that incorporates rotation, binarity, and observational selection effects.

Probing the extended main sequence turn-off of Stock 2 with asteroseismology

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The extended main sequence turn-off (eMSTO) is a feature first observed in the colour-magnitude diagrams of stellar clusters in the Magellanic clouds. With the precision of Gaia photometry, eMSTOs are now also frequently observed in Galactic open clusters. The prevailing explanation for the eMSTO is stellar rotation, wherein rapid rotators appear redder, thereby widening the turn-off region in the colour-magnitude diagram. Here, we present a study of the intermediate-age open cluster Stock 2 which shows a moderate eMSTO that was sometimes attributed to differential reddening. Careful de-reddening of individual sources shows that the turn-off region of Stock 2 exhibits a spread even in intrinsic colours. The turn-off region of Stock 2 falls within the classical instability strip, allowing us to probe it with asteroseismology. Among the cluster members, we find 30 pulsators across the entire early-type regime. The majority are hybrid pulsators that exhibit both pressure and gravity modes. This abundance of pulsators enables a model-independent probe of stellar rotation (probed by gravity modes) and pulsations across the upper main sequence and the turn-off region. We find that pressure-mode pulsators mostly populate the red side of the eMSTO and are faster rotators according to v sin i measurements. Both findings are in agreement with recent results suggesting that rapid rotators sustain pressure-mode pulsations longer during their main sequence evolution. This result also supports stellar rotation as the origin of the eMSTO in Stock 2. In addition to studying the upper main sequence pulsators, we estimate the cluster age by leveraging the large population of cool stars. From gyrochronology, we find an age of 450 Myr, which is in agreement with recent isochrone fitting results and will be used to optimally model the cluster members.

A multi-technique study of HR 7495 - a Rosetta stone for over 200 intermediate-mass rotational variables

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Magnetism is widely considered as an important ingredient in stellar evolution for intermediate-mass stars. Observationally, there are several 'flavors' of magnetism that are detected at the surface of intermediate-mass stars - dynamo-driven fields in late F stars, strong fossil fields in Ap stars, and very weak fields in Am/Fm stars. So far standing alone, Vega (A0), a rapidly-rotating non-Ap/Am star, has a weak magnetic field predominantly confined to its polar region.

Given its brightness and proximity, it is unlikely that the magnetic configuration of Vega is a statistical anomaly. We present here a detailed multi-technique analysis for HR 7495 - a fast rotating, intermediate-mass, non-Ap/Am 'hump+spike' star. Kepler and TESS photometry reveal rotational modulation that changes with time (i.e. from evolving starspots) and Rossby mode pulsations. We apply Doppler Imaging techniques to intensive time-series spectroscopy and map the surface brightness features of HR 7495, finding similar patterns as observed in Vega. The spectropolarimetric analysis reveals a weak magnetic field confined to the polar region, strikingly similar to Vega (and unlike the global fields of Ap and Am stars).

HR 7495 is thus a potential 'Rosetta stone', bridging the gap between the well-studied Vega system and the hundreds of hump+spike stars currently known from Kepler/TESS. Lessons learned from HR 7495 and Vega will have wide-reaching implications for interpreting the larger population of intermediate-mass rotational variables and the processes involved in generating surface-observed magnetic fields. Ongoing work includes obtaining additional magnetic measurements and intensive time-series spectroscopy of HR 7495 and similar systems, and better understanding the larger hump+spike population.

A neural-network emulator for rotating δ Scuti asteroseismology

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In the era of abundant space photometry, δ Scuti asteroseismology shows strong potential for determining the ages of young star clusters. Realising this potential, however, remains limited by two major challenges: the computational cost of evaluating dense pulsation model grids, and the difficulty of mode identification in rapidly rotating stars.

We present a publicly available neural-network emulator for rotating δ Scuti stellar models that addresses the computational bottleneck. Rather than running a stellar evolution and pulsation code at each point in parameter space during inference, the computational cost is front-loaded into constructing a model grid and training the neural network. Thereafter, the emulator predicts pulsation frequencies conditioned on stellar parameters – mass, metallicity, age, and rotation rate – in mere seconds, making it feasible to explore the full posterior distribution through Bayesian inference. We take advantage of a published grid of δ Scuti pulsation models to train, for the first time, a neural network that includes rotation and p, g, and f modes for degrees ℓ=0–3. More broadly, the emulator serves as a fast approximation to stellar evolution and pulsation calculations at fixed input physics, allowing for rapid first-pass tests of mode identifications, exploration of stellar parameter space, and future assessments of modelling systematics.

We couple the emulator to a Bayesian inference framework to model observed pulsation frequencies together with classical constraints. Unlike previous neural-network approaches based on non-rotating models, our method includes rotation and rotationally split multiplets, allowing the pulsation spectrum to constrain not only stellar age and structure, but also the equatorial rotation rate and inclination.

We validate the method using hare-and-hound tests on held-out models and then apply it to δ Scuti stars in the Pleiades observed by TESS. We obtain age estimates for individual stars and for the cluster as a whole. We also report inferred equatorial rotation rates and inclinations for each target. These results demonstrate that neural-network emulation of rotating pulsation grids is a practical route to precise asteroseismic age determinations for δ Scuti stars.

The symphony of binarity and pulsations in massive star populations

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Massive stars play a central role in the cosmic ecosystem through their intense radiation, powerful winds, and dramatic endpoints as supernovae or gamma-ray bursts, all of which strongly influence their surroundings. By producing heavy elements and enriching the interstellar medium, and as progenitors of black holes and neutron stars whose mergers generate gravitational waves, they provide key insight on the Universe and offer unique tests of fundamental physics. However, our ability to predict the outcomes of massive star evolution are currently limited by large uncertainties in stellar evolution models; for example, rotation and mixing, and how these are impacted by binarity and magnetic fields. Fortunately, thanks to modern space telescopes and advanced ground-based observatories, high-precision data sets are now available to constrain these different aspects of physics. Variability in massive stars arises from a combination of physical processes, including binarity, rotational modulation, pulsation, mass loss, and magnetic activity. Asteroseismology of pulsations has significantly advanced our understanding of stellar interiors for massive stars, as they exhibit pressure and gravity modes that constrain different internal layers. Here we present the analysis of a large and homogeneous sample of 850 O- and B-type stars using high-resolution HERMES spectroscopy and 2-minute cadence photometry from TESS, which provide complementary constraints on spectroscopic and photometric variability. Through this joint analysis, we disentangle the contributions of binarity, pulsation, rotation and magnetism. We find that vast majority of the sample exhibit pulsations, and we compare empirical and theoretical instability strips in the Hertzsprung–Russell diagram. We also discover many new eclipsing binaries, which are important laboratories for measuring model-independent masses and radii, and we identify 223 candidate-magnetic stars based on rotational modulation and their 5200-Angstrom flux depression. Our study represents one of the most extensive homogeneous surveys of variability among massive stars in the Northern hemisphere to date. This work establishes a statistical foundation for future asteroseismic modelling efforts and offers new insight into the physical processes governing stellar structure and evolution, particularly from the perspective of improving rotation, magnetism and binarity using pulsations.

Posters

Posters: Missions and mission synergies

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P-011: HAYDN Eyes on Classical Pulsation: Pulsating Blue Stragglers in Globular Clusters and Beyond

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The ESA M8 candidate mission HAYDN will open a new observational window for the study of classical stellar pulsation in dense stellar environments. Designed to deliver long-duration, high-precision photometry in crowded fields, HAYDN will provide unprecedented opportunities to investigate pulsating stars in stellar populations that remain largely inaccessible to current and planned space missions.

In this poster, we present the scientific potential of HAYDN for investigating pulsating Blue Straggler Stars (BSS). Likely formed through mass transfer or dynamical interactions in dense stellar environments, some of the observed BSS lie within the δ Scuti- and γ Doradus-like instability strip. Their seismic properties offer a unique opportunity to probe their internal structure and to constrain the physical processes responsible for their formation and subsequent evolution. HAYDN will provide unprecedented access to such objects in globular clusters and ω Centauri.

Beyond old stellar populations, HAYDN will observe the young cluster $\chi + h$ Persei, providing homogeneous samples of A–F stars, which offers a unique opportunity to investigate the pulsational behaviour of δ Scuti and γ Doradus stars under well-controlled conditions, enabling ensemble studies of rotation, mixing processes, and stellar evolution.

In addition, the large number of field stars expected within the HAYDN FoV will deliver extensive samples of pulsating stars across the classical instability strip, allowing to explore classical pulsation across a broad range of stellar populations, ages, metallicities, and evolutionary pathways.

P-024: Updates from the TESS Science Support Center

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The Transiting Exoplanet Survey Satellite (TESS) has currently observed over 97% of the sky—and is projected to reach 99% sky coverage by the fall of 2028—providing the astronomical community with high-cadence, optical time-series data featuring nearly continuous observations lasting from 27 days to a full year. Now in the 6th year of its extended mission, TESS continues to deliver time-series data for hundreds of thousands of targets, alongside Full Frame Images covering >2,000 square degrees of the sky each month. With some regions of the sky now benefiting from extended observational baselines beyond the standard 27 days, TESS's robust dataset drives advancements across a diverse range of astrophysical disciplines, including exoplanet detection, asteroseismology, stellar variability, extra-galactic transients, and active galactic nuclei.

The TESS Science Support Center (TSSC), based out of NASA Goddard, is dedicated to supporting the TESS scientific community. The TSSC does this through multiple channels, including providing information, tools, tutorials, workshops, and helpdesk support for TESS users, as well as running the annual proposal call for funded Guest Investigator (GI) projects and target observation requests. In this poster, we will highlight recent and ongoing initiatives led by the TSSC, including the development of new community tools, critical updates to the lightkurve Python package, and newly revised documentation designed to streamline TESS data analysis.

P-026: Pulsation and Modulation Properties of RR Lyrae Stars Observed with TESS During the First Year

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We present an analysis of a sample of RR Lyrae stars observed during the first Year, which comprised Sectors 1–13, by the Transiting Exoplanet Survey Satellite (TESS). High-precision light curves are extracted using differential image photometry and analysed to investigate pulsation modes and modulation properties. TESS photometric parameters are combined with parallaxes and colour information from Gaia DR2 and Gaia DR3 to establish a homogeneous classification scheme, enabling the identification of atypical RR Lyrae stars and their separation from other pulsating variables. We find that a significant fraction of the sample exhibits low-amplitude additional modes, whose distribution differs from that observed in bulge populations, suggesting a dependence on stellar physical parameters. The identification of these modes is, however, limited by uncertainties in their intrinsic frequencies. A comparison of amplitude ratios and Fourier parameters (R21, R31, φ21, and φ31) reveals two distinct groups of pulsators. Finally, we find a high percentage of modulated stars among the fundamental-mode pulsators, but also that at least 30% of them do not exhibit modulation, confirming that a significant fraction of stars lack the Blazhko effect.

P-028: Exoplanets and Asteroseismology with the NASA SHERA Mission

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SHERA (Searching for Habitable Exoplanets with Relative Astrometry) is a NASA Small Explorer mission concept that will use diffractive-pupil technology on a small, simple optical space telescope to achieve microarcsecond precision relative astrometry and high-precision photometry on Sun-like stars in nearby binary systems. With this precision, SHERA will: (i) search for rocky planets in the habitable zones of the closest Sun-like stars; (ii) investigate the impact of binary star formation on small, widely separated planets; and (iii) measure high-precision masses, oscillations, and granulation in nearby Sun-like stars. We will describe the mission concept with a particular focus on expected stellar astrophysics results, which include astrometric masses measured to better than 2% for 7 nearby binary systems, the highest-quality asteroseismic detections in alpha Cen A & B to date, and high SNR detections of granulation in K dwarfs.

P-033: HAYDNsim: an end-to-end photometric simulation pipeline for HAYDN, with applications for PLATO

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The CoRoT, Kepler, K2, and TESS missions have driven asteroseismology to characteristic precisions of a few percent in stellar radii, a few to ten percent in masses, and ten to twenty percent in ages, for samples now extending to hundreds of thousands of stars from main-sequence dwarfs to red giants. This progress has carried over to several open clusters, where targeted observations have yielded calibrated benchmark samples. Globular clusters, by contrast, are crowded environments whose central stellar densities exceed what the pixel scales and apertures of past and forthcoming photometers, optimised for bright and sparse fields, can spatially resolve, leaving these systems essentially inaccessible to asteroseismic study at scale. The proposed ESA HAYDN mission (High-precision AsteroseismologY of DeNse stellar fields) has been designed to close this gap. We present HAYDNsim, a modular Python pipeline for end-to-end forecasting of HAYDN's observational performance through realistic synthetic photometry. The pipeline ingests Gaia DR3 and archival HST ACS data, integrates structural and chemical parameters from established literature catalogues, generates TRILEGAL stellar populations under a calibrated mass-rescaling procedure, and assigns spatial coordinates via inverse-CDF sampling from King or, for core-collapsed clusters, observationally tabulated density profiles. The resulting catalogues serve as inputs to the consortium's HAYDN Noise Estimator (HNE) for per-star noise prediction. We demonstrate HAYDNsim on representative targets including open clusters (e.g. M67, h+χ Persei), globular clusters of varying structural regimes (e.g. 47 Tucanae, M54, NGC 6397, ω Centauri), and the Galactic bulge (Baade Window). Because HAYDNsim is mission-agnostic at the parameter level, it can be reconfigured to PLATO's instrumental specifications and applied to open cluster targets within its long-duration observing fields, producing automated per-star photometric noise and asteroseismic yield forecasts that can inform guest observation proposals.

P-053: An Asteroseismology Archive

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It is possible to retrieve observational values for most quantities in stellar physics (e.g. colours, temperatures, metallicities) with a single query to either SIMBAD or the Gaia Archive. However, this remains difficult for *asteroseismic* observables, and increasingly so given the ongoing proliferation of data sources, expanding qualitative diversity in kinds of measurements (individual frequencies vs. summary quantities), and overlapping coverage of the same stars in different, and an increasing number of, catalogues. We aim to address this by providing a consolidated archive — hosted at asteroseismolo.gy/archive — which will accept continuous updates from the community, and remain accessible for our community to use. It is our belief that such an archive will become increasingly necessary in the coming era where potentially millions of stars will have asteroseismic measurements.

P-065: TauFOS: Faint Object Spectrograph for the 2-Meter Alfred Jensch Telescope in Tautenburg, Germany

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The Tautenburg Faint Object Spectrograph (TauFOS) is a low-resolution (R=2000) spectrograph optimized for the blue wavelength range (370–540 nm), which has been commissioned in April 2026 at the 2-Meter Alfred Jensch Telescope of the Thüringer Landessternwarte (TLS), Tautenburg, Germany. TauFOS is based on a custom, very efficient transmission grating used in first order, a set of custom lens objectives for collimator and camera and a blue-optimized 2k × 2k CCD detector. The instrument is fiber-fed with three channels for object, sky and simultaneous wavelength calibration. A dedicated frontend has been developed which includes a fast tip-tilt image stabilization system to minimize losses by guiding errors and seeing and to stabilize light injection into the fiber. Data from the commissioning campaign shows a performance en par with expectations. TauFOS will initially be used for a program targeting faint binary stars.

P-098: Recovering short-period signals in heavily contaminated TESS photometry

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The large pixel size of TESS cameras introduces substantial contamination and blending, potentially limiting the detectability of faint short-period variable stars. We investigate this issue using a sample of about 200 known blue large-amplitude pulsators (BLAPs) as test objects, owing to their distinct high-amplitudes and the short time scales of variability. Despite significant contamination effects, periodic signals remain detectable in a considerable fraction of sources, with successful detections obtained for approximately 30% of the sample. We show that variability can be recovered down to approximately $G \approx 19.5$ mag, demonstrating that TESS retains sensitivity to faint short-period variability beyond expectations based solely on crowding limitations. These results highlight the potential of TESS for the studies of faint rapidly varying stars, e.g. pulsating white dwarfs, hot subdwarfs, rapidly oscillating Ap stars, δ Scuti stars and many others.

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Posters: A- and F-type stars

P-005: SX Phoenicis Stars in M55: Double-Mode Radial Pulsators from a Reanalysis of CASE Photometry

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We present a reanalysis of photometric time-series data for SX Phoenicis stars in the globular cluster M55 obtained within the CASE Project. By performing a new frequency analysis of the light curves, we derived new pulsational solutions for the studied variables and investigated characteristic period ratios indicative of radial pulsation modes. For 7 stars, we identified period ratios consistent with radial modes, providing valuable constraints for asteroseismic interpretation. These mode identifications enabled seismic modelling using a Monte Carlo-based Bayesian approach.

P-008: High-precision K2/TESS Photometry and HERMES Spectroscopy of Four Bright Field Stars

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Space-based photometry from K2 and TESS, coupled with high-resolution spectroscopy, provides a unique opportunity to re-examine the variability and chemical nature of four bright stars (HD 73135, BD +19 2045, BD +19 2046, and TYC 1395-855-1), which were poorly characterised by the original ground-based campaign under the Nainital-Cape survey. We aim to establish the nature of the variability, chemical properties, and evolutionary status of these stars. We analysed ground-based Johnson BV photometry combined with K2 and TESS time-series data to establish the nature of their variability. Using high-resolution HERMES spectroscopy, we determined their spectral classifications and chemical abundances. In addition, we used the inferred spectroscopic constraints with grid-based evolutionary modelling to derive their corresponding masses, radii, and ages. The frequency analysis reveals a diversity of low-amplitude variability across the sample. HD 73135 shows a persistent modulation near 1.5 d that is most consistent with rotation, although an ellipsoidal-binary interpretation cannot yet be excluded, while BD +19 2045 exhibits multiple low-frequency signals and is identified as a new candidate γ Doradus g-mode pulsator. BD +19 2046 and TYC 1395-855-1 are non-variable or only marginally variable in K2 but display coherent low-frequency modulation in TESS of uncertain origin. Spectroscopically, HD 73135 is the only chemically peculiar star in the sample and shows a clear Am abundance pattern, whereas the other three stars are chemically normal. These results demonstrate the value of combining legacy survey data with contemporary photometric and spectroscopic analysis.

P-012: Near-core magnetic field strengths inferred from gravity modes in intermediate-mass stars

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Asteroseismology has shown that sufficiently strong internal magnetic fields can suppress gravity modes, preventing their propagation to the surface depending on their radial order. In this work, we place upper limits on the radial component of near-core magnetic fields in three pulsating stars using their observed gravity modes. We analyzed two main-sequence γ Doradus stars with many consecutive radial orders observed for modes of degree $\ell = 1, 2, 3$ and rotational splitting, as well as one evolved δ Scuti star hosting mixed modes. For each target, we find best-fitting stellar models via forward modeling with MESA and compute adiabatic oscillation frequencies with GYRE. From magneto-hydrodynamical calculations in the Dedalus code, we determine the critical magnetic field strength required to suppress gravity modes of radial order higher than those observed. A variety of magnetic field configurations are explored, including poloidal fields with dipolar and quadrupolar components, and mixed geometries including a toroidal field. The targets were selected to study the impact of the mode degree and rotational splitting on our calculations. We find that the critical field strength required for mode suppression increases gradually with increasing spherical harmonic degree, up to $\ell = 3$. Analysis of the individual components of the $\ell = 1$ and $\ell = 2$ rotational splittings further indicates that the inferred magnetic field strength is identical for prograde and retrograde modes. The resulting upper limits are consistent with magnetic field strengths measured in evolved red giants, supporting a scenario in which the observed fields originate from a core dynamo.

P-022: Tracing Blazhko-like Behaviour in High-Amplitude Delta Scuti Stars

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High-amplitude delta Scuti (HADS) stars are typically dominated by one or a few radial pulsation modes and exhibit large photometric amplitudes ($\Delta V > 0.1$ mag). In some cases, these stars display amplitude and phase variability. Proposed explanations include nonlinear mode interaction and beating between closely spaced frequencies, while similarities to the Blazhko effect observed in RR Lyrae stars have also been suggested. The Blazhko effect remains a long-standing unsolved problem in stellar pulsation theory, manifesting as amplitude and/or phase modulation in about half of RR Lyrae stars and exhibiting a rich variety of observational phenomena. Using the light-curve products of the TESS Quick Look Pipeline, we analyse a selected sample of HADS stars showing clear amplitude and phase variability. We present a phenomenological comparison of the modulation-like behaviour observed in HADS and Blazhko RR Lyrae stars, including Fourier side-peak structures and the relationship between amplitude and phase variations.

P-027: Wildly Oscillating Stars: a new mystery in A- and F-type pulsators

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Among the δ Sct and γ Dor population, we identify a group of stars, currently 39 objects, with dense agglomerations of frequencies in an intermediate-frequency range between the typical g- and p-mode regimes, which we refer to as wildly oscillating stars (WOS). A notable fraction are chemically peculiar Am stars, and most appear to be relatively slow rotators. The WOS occupy a very narrow strip in the Hertzsprung–Russell diagram, close to the overlap between the δ Sct and γ Dor instability regions, hinting that this is a highly selective phenomenon rather than a generic by-product of variability. One of their most striking properties is that the agglomerated peaks often form ridges or multiplets with repeating patterns in an echelle diagram. In several stars, the spacing that reveals these structures suggests a rotational timescale, and phase-folding the light curve with that same spacing reveals variability reminiscent of rotational modulation, raising the possibility that spots or other surface structures may be involved. At the same time, the ridge morphology and mode density are not reproduced by standard rotational modulation, asymptotic g-mode behaviour, low-order p modes, binarity, or typical rotational splitting. We explore whether the agglomerated peaks instead reflect a more complex interplay between rotation, pulsation, and nonlinear mode coupling, using echelle patterns, combination frequencies, and non-adiabatic stability calculations. The emerging picture suggests that rotation is likely part of the story and that pulsations are involved, yet the physical origin of the WOS remains unresolved. Ongoing work tests whether the Am phenomenon itself, through chemical gradients, magnetic fields, or both, may hold the key to their origin.

P-030: A complex network approach to TESS light curves of delta Sct stars

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"Asteroseismology" probes stellar interiors through the study of stellar pulsations. Standard linear tools in astroseismology of light curve analysis, derived from Fourier spectral analysis, often display uncertainties in identifying the real frequency peaks amid underlying noise, particularly for stars belonging to δ Sct class, characterised by highly irregular peak series in the frequency domain. With the aim of improving our understanding of δ Sct pulsations and their underlying physics, we employ a complex network approach to δ Sct light curves. Visibility algorithms are used to map time series into networks. To map a light curve into a horizontal visibility graph (HVG) using the horizontal visibility algorithm, each data point is considered as a node, and links are created between pairs of nodes if the corresponding data points can see each other following a horizontal line of sight. A database of 69 δ Sct star light curves observed by TESS has been mapped into undirected HVGs. The morphological characteristics of the resulting networks, such as degree distribution, shortest path length, and average clustering coefficient, were then examined to investigate the relationships between asteroseismic parameters and network metrics, as well as to better understand the pulsation dynamics. The average clustering coefficient shows two distinct linear correlations with the peak-to-peak amplitudes for HADS and LADS stars, naturally separating the two groups for the first time without an ad-hoc criterion. By applying the theoretical expression for the HVGs degree distribution of non-correlated random time series we can distinguish significant pulsations from the uncorrelated background noise which might become a practical tool in frequency analysis of stars.

P-032: Mode identification in young delta Scuti stars

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The identification of the p modes observed in delta Scuti stars remains elusive because p modes are strongly affected by the centrifugal deformation of these rapidily rotating stars and because their intrinsic amplitude is basically unknown. Only a few theoretical p-mode frequency spectra have been computed and identified without approximation on the effect of the rotation on the oscillations. They concern Zero-Age-Main-Sequence stellar structure models (Reese et al. 2009). From them, we construct a model of the p-mode frequencies restricted to degrees smaller or equal to 3 and radial orders between 4 and 8. We argue that this frequency model only depends on two main parameters, namely the large frequency separation of the $\ell = 0$ and $\ell = 1, m = 0$ mode series and the star rotation rate. We apply this model to a sample of TESS near-ZAMS stars for which this large frequency separation has been determined by Bedding et al. (2020) so that we attempt to fit the observed frequencies with a one-parameter model. We find a possible mode identification of low degree p modes and a rotation rate for 11 stars of the Bedding's 57 star sample. Such a success rate is not unexpected as our identification method requires that (i) high radial order modes are present in the spectra (ii) and among them, a significant proportion of low degree modes. This result opens new perpective for the asteroseismology of delta Scuti stars.

P-043: A Closer Look at a Wildly Oscillating Star

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Wildly oscillating stars (WOS) are a recently identified subgroup of A- and F-type stars showing dense agglomerations of peaks confined to a narrow frequency range between the typical g- and p-mode regimes that cannot be fully explained by classical pulsation theory. Here, we present a detailed observational analysis of one particularly interesting Kepler WOS showing clear rotational modulation together with a complex agglomerated oscillation spectrum, using space photometry from the Kepler and TESS missions together with ground-based spectroscopy from the Nordic Optical Telescope (NOT) and LAMOST. The combined photometric and spectroscopic analysis highlights the complexity of the WOS phenomenon in which rotation, pulsation, binarity and chemical peculiarity may all play a role in shaping the observed oscillation spectra.

P-046: Back to the $\Delta\nu$-ρ relation of δ Sct: automation to find $\Delta\nu$?

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During the last 3 decades, several methods to find patterns in the oscillation spectra of δ Sct stars have been proposed (Breger et al., 1993; Handler et al., 1997; García Hernández et al., 2009, 2013; Paparó et al., 2016; Bedding et al., 2020; Hasanzadeh et al., 2021). This pattern has been spotted as a $\Delta\nu$ thanks to its relation with the stellar mean density (García Hernández et al., 2015; 2017). However, these last observational results were obtained using only 11 eclipsing binary systems.

In this work, we have gone through the recent literature to search for eclipsing binaries with a δ Sct component and stellar parameters obtained from the binary analysis. Oscillations frequencies from satellite observations are also required. We gathered a total of 75 systems so far.

We aim to confirm the $\Delta\nu$-ρ relation but avoiding the possible subjective bias that these methods have. Here we test different methods in order to automate the finding of $\Delta\nu$. We also discuss the reliability of all of them to find the correct mean density.

P-049: Exploring The Definition And Properties Of High Amplitude Delta Scuti Stars

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Delta Scuti stars are a class of pulsating variable lying on the main sequence in the classical instability strip, with pulsation frequencies greater than about 5 cycles/day. Conventionally, High Amplitude Delta Scuti (HADS) stars are those with a peak to peak lightcurve amplitude of > 0.3 mag. This threshold for defining HADS is a matter of custom and practice in the literature, rather than being founded in observations of distinctive HADS properties, although it is sometimes argued that HADS have lower temperatures than other delta Scutis, and may be closer to the Terminal Age Main Sequence.

We used lightcurves from the TESS spacecraft to explore the distribution of the amplitudes of the main pulsation in stars in the delta Scuti region of the HR diagram. We found a discontinuity at the high amplitude end of the distribution lying at a frequency semi-amplitude of 18 ppt, corresponding to a peak to peak lightcurve amplitude of around 0.05 mag. This is substantially below the traditional HADS threshold. This statistical finding is a starting point for exploring the physical properties of HADS defined with the new threshold.

P-062: Asteroseismology of Am delta scuti stars HD 13038 and HD 13079

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In this paper, we present an asteroseismic analysis of two mild Am δ Sct (δ Sct) pulsators, HD 13038 and HD 13079, utilising both the space and ground-based photometry. From multi-sector TESS observations with different cadences, 37 pulsation frequencies for HD 13038 and 69 for HD 13079 were extracted with SNR > 5. Notably, light curves of HD 13079 are affected by ~ 15% of the flux from its neighbourhood star HD 13079B situated at an angular separation of 6.48 ± 2.70 arcsec. For HD 13038, the large frequency separation ($\Delta\nu$) is 6.08 $d{-}1$ leading two vertical ridges of radial modes consistent with the frequency ratios and pulsation constants (Q-value). However, the seismic age indicates the left-ridge frequencies are more acceptable as radial modes with orders $n = 5, 7$. We found that one radial ridge is visible for HD 13079 at $\Delta\nu = 5.15$ $d{-}1$ with orders $n = 1, 2, 3, 4, 6$. For both stars, excited radial overtones are higher than the predicted values for these Teff range. The stellar parameters were calculated using a mass-metallicity (M-Z) grid followed by seismic-χ2 minimisation technique constraining identified radial modes. The possible rotation frequencies for HD 13038 and HD 13079 are found at 0.94 $d{-}1$ and 0.86 $d{-}1$, provides inclination angle of ~ 90deg and ~ 42deg respectively. The present study is a crucial step in comprehending the processes that underlie the excitation of high-order radial modes in Am stars.

P-081: A Journey to the Interior of 10 Aql

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Chemical stratification plays a key role in the excitation of pulsations in roAp stars. In this work, we revisit the envelope structure of the benchmark roAp star 10 Aql by comparing two opacity prescriptions: the helium-stratified prescription used by Cunha et al. (2013), and a new treatment that includes depth-dependent abundances of multiple elements to calculate the Rosseland mean opacity. We show that these different chemical profiles introduce changed to the opacity in the H and He ionization regions, where pulsation driving and damping occur. Compared with the helium-only prescription, the inclusion of heavier elements changes the mode stability: the predicted growth rates are reduced in the observed frequency range, and the mode-energy-normalized work integrals show a weaker net driving contribution. This indicates that the additional metal opacity contributes to the damping of the pulsations while also bringing the excitation calculation results closer to the observed excited frequency range of 10 Aql. This comparison allows us to trace how the chemical structure of the envelope influences the excitation of the observed pulsations in 10 Aql. This work represents a stepping stone toward more accurate modelling of roAp stars, and toward a broader understanding of chemical transport in stellar interiors.

P-094: On the long term impact of gravitational settling on the helium of δ-Scuti stars and their theoretical instability strips

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δ-Scuti stars are variable A–F type stars, with typical masses between 1.4 and 2.2 solar masses. They exhibit unstable low-radial-order pressure and mixed modes. These oscillations are mainly driven by the κ–γ mechanism operating in the He II partial ionisation zone, while convective flux blocking may also contribute in the lower-mass part of the instability strip.

The efficiency of the κ–γ mechanism is highly sensitive to the amount of helium present in the excitation region. As a result, any process that modifies the helium abundance in the outer envelope can strongly affect mode excitation in δ–Scuti stars. In slowly rotating stars, gravitational settling may not be efficiently counteracted by turbulent mixing. Elements heavier than hydrogen can then sink below the surface layers, and helium is depleted from the He II ionisation zone. This weakens the κ–γ driving mechanism and can reduce the ability of the star to excite δ Scuti pulsations. This theoretical expectation is consistent with recent observational results suggesting that the observed δ-Scuti instability strip becomes narrower with stellar age (Berry et al., 2025).

In this poster, we present a grid of δ-Scuti stellar models including gravitational settling, in order to follow the evolution of the helium mass fraction in the excitation region as a function of stellar age. We then compute non-adiabatic oscillations with the MAD code (Dupret et al., 2001, 2002, 2005), using a time-dependent convection treatment, to determine the corresponding theoretical instability strips. These calculations allow us to quantify how the age-dependent depletion of helium near the surface modifies the excitation of δ Scuti pulsations. Finally, by comparing the predicted evolution of the instability strip with observations, this work provides a way to test both non-adiabatic pulsation physics and gravitational settling in A–F type stars.

P-102: Impact of radial differential rotation on resonance-induced period-spacing dips in gamma Doradus stars

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Context. In γ Doradus stars gravito-inertial modes in the radiative region can interact resonantly with inertial modes in the convective core, producing characteristic dip structures in period-spacing patterns. These dips contain information on the stellar core, in particular its rotation rate. While their properties have been studied under the assumption of solid-body rotation, γ Doradus stars are expected to exhibit radial differential rotation, which can significantly modify the dip morphology. Aims. We aim to characterise the impact of radial differential rotation on period-spacing dips and to develop seismic diagnostic tools capable of constraining the rotation rate and structure of γ Doradus stellar cores, with potential implications for age determinations and stellar evolution studies. Methods. We used the two-dimensional oscillation code TOP to compute oscillation modes in γ Doradus stellar models spanning a range of rotation rates, evolutionary stages, and levels of differential rotation between the convective core and the surrounding radiative region. We then characterised the resulting dips by measuring their location and width in the period-spacing patterns. Results. Differential rotation strongly modifies both the location and width of period-spacing dips. In particular, we find that dips associated with higher-degree inertial modes can be shifted into the observable range, providing a potential direct diagnostic of core differential rotation.

3 Posters: Clusters and stellar populations

P-004: The youngest stars in PLATO's LOPS2: Towards an Automated Classifier for YSOs

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As part of the complementary science preparation for the ESA mission PLATO (PLAnetary Transits and Oscillations of stars), an automated stellar variability-classification framework has been developed using TESS observations of the PLATO field LOPS2. While the current classifier successfully identifies many classical types of stellar variability, it is not designed to capture the complex and often irregular photometric behavior of Young Stellar Objects (YSOs).

Young stars exhibit a broad range of variability phenomena arising from both stellar and circumstellar processes. In addition to pulsations, periodic rotational modulation caused by starspots, and eclipses, YSOs commonly show pseudo-periodic and non-periodic variability linked to accretion processes and variable circumstellar extinction.

To address this limitation, we investigate the young stellar population in the PLATO long-pointing field LOPS2 using existing high-cadence photometric observations from TESS. We present a variability survey of stars in young star-forming regions, clusters, and associations located within the LOPS2 field, with the goal of characterizing the diversity of YSO variability behavior.

This work forms the basis for the development of a dedicated machine-learning-based classifier for young stellar variability. Trained on simulated light curves that will include periodic, semi-periodic, and stochastic YSO variability, the tool is intended to complement the general PLATO variability classification pipeline. Initial validation will use TESS observations before application to early PLATO data.

P-045: Near-Infrared and Optical Analysis of NGC 2539: an open cluster hosting lithium-enriched giant stars

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We present a thorough chemical analysis of 13 member stars of the intermediate-age (850 Myr) open cluster NGC 2539, using high-resolution optical (FEROS) and near-infrared (IGRINS H- and K-band) spectra. We derived atmospheric parameters and abundances for 23 elements (Li, C, N, O, F, Na, Mg, Al, Si, P, S, K, Ca, Sc, Ti, Cr, Fe, Ni, Y, Ce, Nd, Yb, and Pb), and report the oxygen isotopic ratios 16O/17O and 16O/18O for the first time in this cluster. The sample includes two lithium-enriched giants. Lithium-rich giants comprise a very rare class of chemically peculiar stars whose formation mechanism is largely debated in the literature, and the presence of these objects makes this cluster a valuable asset to help unveil the nature of these stars. The infrared spectroscopy allows us to provide unprecedented results for elemental abundances that are still poorly determined and analyzed in the literature, such as those of F, P, K and Yb, that we presented for the first time for the stars of NGC 2539. Particularly, the cosmic origin of fluorine is intriguing and remains a matter of debate in the literature, and the study of its abundance is subject to observational challenges. In this sense, our analysis can offer valuable constraints about its origin. We also conducted membership analysis and isochrone fitting using Gaia DR3 astrometry, providing the cluster's fundamental parameters. Our analyses combined provide valuable insights into Galactic chemical evolution models, evolutionary stages of Li-enriched giants and allow us to address various stellar aspects such as: the mixing processes in stellar interiors; stellar rotation, its binary nature and chemical peculiarities; and the Galactic chemical enrichment history. Our results also highlight the importance of open clusters as laboratories for chemically peculiar stars.

P-063: An open cluster in the TESS continuous viewing zone: Gyrochronology and Asteroseismology of NGC 1901

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An open cluster consists of stars sharing the same age, distance and initial metallicity. Characterising its members deepens our understanding of stellar formation and evolution. NGC 1901 is an 891-Myr-old open cluster confirmed using Gaia data and located in the TESS southern continuous viewing zone (CVZ). It is the third cluster discovered within this region, enabling a thorough investigation due to extensive available data. Our main goal is to measure the most precise age estimate of this cluster to date, using gyrochronology and asteroseismology. Age-dating an open cluster is challenging, as different methods often yield different values. Similar analysis of UBC-1, another CVZ cluster, by Fritzewski et al. (2024), suggests how promising the approach is, when addressing targets within the CVZ. Long-duration TESS observations allow accurate measurements of rotation periods, and this is the first time NGC 1901 is comprehensively characterised. As a preliminary task, we refine the NGC 1901 membership list using spatial and kinematic filtering of Gaia DR3 data, and compare it to that from Hunt & Reffert (2023) and Kos (2024). We explore stellar light curves from TESS cycles 1, 3 and 5 to search for brightness variability indicative of rotation. The next step involves deriving the cluster's age through gyrochronology, a technique based on how rotation periods evolve with time. G, K and M-type dwarfs experience strong magnetic braking, and therefore spin down as they age. When plotted as function of colour, rotation periods highlight age-dependent sequences. In this context, we compare NGC 1901's distribution to those of NGC 6811 and Praesepe, which are 1 Gyr (Curtis et al. 2019) and 670 Myr old (Rampalli et al. 2021), respectively. Moreover, we examine three red giants and A and F-type main sequence stars for variability: we use asteroseismology to identify potential g-mode and p-mode pulsators and found a few δ-Scuti and γ-Doradus stars. Future work will combine gyrochronology with an independent age estimate from the asteroseismology of pulsating stars to enhance the precision of NGC 1901's age.

P-078: On the inference of masses and ages of SX Phoenicis stars in globular clusters

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SX Phoenicis (SX Phe) stars are pulsating blue straggler stars commonly observed in Galactic globular clusters such as M55, 47 Tucanae and Omega Centauri. Their pulsational properties, together with the stellar parameters accessible through photometric and astrometric observations, make them promising laboratories for studying the formation and evolution of blue stragglers. However, despite numerous observational studies, several fundamental stellar parameters, including mass, age, and helium abundance, remain poorly constrained for many SX Phe stars. These quantities are nevertheless essential for discriminating between the proposed blue straggler formation channels, such as stellar collisions or binary mass transfer.

In this project, we investigate whether the currently available observational constraints are sufficient to infer the fundamental properties of SX Phe stars through Bayesian stellar modelling. We combine multiband photometric observations, together with effective temperatures and surface gravities, parallaxes, and metallicities. These observables are analysed using BASTA, a Bayesian framework based on the BaSTI stellar evolution grid, to derive preliminary constraints on the masses and ages of SX Phoenicis stars in globular clusters prior to detailed seismic modelling.

P-084: Inferring the efficiency of convective-envelope overshooting in red giant branch stars

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The understanding of mixing processes in stars is crucial to improving our knowledge of the chemical abundances in stellar photospheres and their variation with evolutionary phase. This is fundamental for many astrophysical issues on all scales, ranging from stellar evolution to the chemical composition, formation, and evolution of stellar clusters and galaxies.

Among these processes, convective-envelope overshooting is in dire need of a systematic calibration and comparison with predictions from multi-dimensional hydrodynamical simulations. The red giant branch bump (RGBb) is an ideal calibrator of overshooting processes, since its luminosity depends on the maximum depth reached by the convective envelope after the first dredge-up. Indeed, a more efficient overshooting produces a discontinuity in the hydrogen mass-fraction profile deeper in the stellar interior and consequently a less luminous RGBb.

In this work, we calibrated the overshooting efficiency by comparing the RGBb location predicted by stellar models with observations of stellar clusters with HST and *Gaia* photometry, as well as solar-like oscillating giants in the *Kepler* field. We explored the metallicity range between −2.02 dex and +0.35 dex and found overshooting efficiencies ranging from $0.009^{+0.015}_{-0.016}$ to $0.062^{+0.017}_{-0.015}$. In particular, we found that the overshooting efficiency decreases linearly with $[M/H]$, with a slope of (-0.010 ± 0.006) dex^{-1}. We suggest a possible explanation for this trend, linking it to the efficiency of turbulent entrainment at different metallicities.

P-095: Red-Giant Asteroseismology of Low-Mass Population III Stars

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Low-mass Population III (Pop III) stars remain undetected despite being potential survivors of the first star-formation epoch, largely because they are difficult to distinguish from later stellar generations. Chemical tagging alone is often ineffective, as internal mixing and external pollution can obscure primordial signatures, thereby motivating diagnostics that probe stellar interiors. Asteroseismology offers then a powerful, yet largely unexplored, avenue to identify primordial stars through the structural imprint of metal-free evolution. Using evolutionary models below 1 $M_{\odot}$, we quantify how convection and associated mixing processes shape internal structure and evolutionary pathways, including self-enrichment episodes. Building on these models, we compute the first non-radial adiabatic pulsation analysis of low-mass Pop III stars. Focusing on a 0.85 $M_{\odot}$ red giant as a case study, we show that metal-free models occupy a distinct and observationally separable asteroseismic regime: at similar evolutionary stages, they exhibit systematically altered seismic signatures driven by lower opacities, higher internal sound speeds, steeper core-envelope stratification, and delayed mean-molecular-weight gradient development. We introduce a diagnostic based on the coupling between acoustic and buoyancy cavities and demonstrate that it robustly discriminates Pop III stars from metal-enriched counterparts, even in the presence of surface pollution. These results establish asteroseismology as a viable pathway for identifying surviving Pop III stars in the Milky Way, particularly in the era of large-scale photometric and spectroscopic surveys.

4

Posters: Magnetic fields

P-007: Constraining the model-based uncertainties of internal magnetic field measurements of red giants

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Magnetic fields in the radiative interiors of red giants can now be measured using shifts in the stellar oscillation frequencies. However, converting an observed frequency shift into a radial magnetic field strength requires knowing the overall sensitivity of modes to the magnetic field. This sensitivity is described by the so-called core structure parameter. This parameter must be inferred from stellar models, which introduces a source of uncertainty beyond the observational uncertainty. This work seeks to quantify this model-based uncertainty and explore which stellar properties are key to a precise and accurate estimate. Using MESA models, we construct a grid of stellar models and a sample of synthetic stars. We then test how well our grid-based fitting method recovers the core structure parameters of our synthetic stars. We find that our fitting methods recover the underlying core structure parameter well, resulting in a model-based uncertainty of 10%. After applying this procedure to stars with existing magnetic field measurements, we find that in most cases the dominant source of uncertainty remains observational. For stars with exceptional data quality, however, more precise modeling can significantly reduce the uncertainty of the magnetic field measurements.

P-009: Constraining the evolution of magnetic fields on the RGB

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Recent asteroseismic observations of magnetic fields deep in the radiative interiors of red giants have made it possible, for the first time, to probe the strength of deeply buried magnetic fields in stars. Large-scale stable fields resulting from past dynamo action are often invoked to magnetize radiative interiors. However, the radial profile of the field geometry strongly impacts the effect of magnetism on stellar dynamics and controls our ability to detect the magnetic field with asteroseismology.

Hence, we investigate how the geometry of stable fields is modified by changes in stellar structure as stars evolve along the red giant branch. For this purpose, we evolve internal magnetic fields in intermediate-mass stars, accounting for both advection by the stellar structure and diffusion of the field on evolutionary timescales. These simulations, initiated with outputs from simulations of magnetic field relaxation, produce exciting new magnetic field geometries. We obtain fields strongest in a shell away from the center due to the effect of strong density gradients around the hydrogen-burning shell in red giants. We also discuss whether such field geometries are expected to shift or suppress dipolar mixed modes, which component of the magnetic field dominates the signature, and under which conditions the asteroseismic signature of such a magnetic field is detectable in data.

Our work provides a clearer window into the effects of stellar evolution on the geometry of large-scale stable magnetic fields. With this, we can place tighter constraints on magnetic geometries and, therefore, on their effects on the internal dynamics of stars.

P-019: A model of rotating and magnetised convection in stellar and planetary interiors

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Convection plays a pivotal role in stellar astrophysics, as it serves as a fundamental mechanism for transporting energy, and in turn influences the stars' structures and evolution. A monomodal approach of convection, the Mixing-Length Theory, is often used and implemented in 1D stellar evolution codes. However, it neglects the combined impacts of rotation and magnetic fields, which are nevertheless of keen importance in stars.

To address this limitation, we extend the Mixing-Length Theory for stellar and planetary convection, taking into account both rotation and magnetic fields. We show that both phenomena tend to inhibit convection, and we account for the magnitude of the root-mean-square (rms) velocity, characteristic length scale and degree of superadiabaticity depending on the rotation rate and magnetic field strength. In a second time, we apply those results to estimate how rotation and magnetic fields influence the convective penetration length between convective and stably stratified regions of stars.

P-023: Seismic probes of internal magnetism on the Red Clump stage

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The reduced amount of differential rotation between the core and the envelope measured in low-mass Core Helium burning stars on the Red Clump (RC) cannot be explained by hydrodynamical transport prescriptions, but rather needs additional transport processes such as internal magnetism.
We provide realistic estimates of the magnetic field strength along the radiative interior of RC stars by computing 1) the radial evolution of the magnetic energy triggered by structural reorganization of the radiative zone along the RGB, 2) estimating the magnetic field generation by the helium flash and 3) considering the magnetic field left by the deep convective envelope on the RGB.
We consider the signature that this resulting magnetic field would have on mixed pressure-gravity modes. We show that the observation of non-suppressed mixed modes in RC stars implies an efficient redistribution of the localized magnetic energy by the helium flash, as well as a moderate efficiency of the convective dynamo during the flash. We further consider the weak-field regime for which mixed modes would experience a frequency shift during the RC. We show that this regime would be attained during the RC for fields too weak to be detectable during the young-RGB stage, thereby opening an opportunity to probe magnetic fields in a new subgroup of evolved low-mass stars and intuit their former presence during the RGB. We also highlight the impact of strong structural glitches in the radiative zone of RC stars and how they can be used to place finer constraints on the field's radial extent.
Using these prescriptions, we prepare potential detections of magnetic fields on the RC stage with existing Kepler of future PLATO data, that would constrain the presence of internal magnetism in late stellar evolutionary stages, and guide modern transport calculations.

P-036: Linking Fractal Variability to Magnetic Cycles in Sun-like Stars

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Understanding stellar magnetic variability requires robust characterisation of stochastic signals across activity cycles. This is typically achieved through the spectroscopic S-index or photometric Sph. Photometric data is more available and easy to obtain but the visibility of magnetic features such as spots is required for the study of magnetic variability and this is not always possible. On the other side, through fractal analysis it is possible to separate the harmonic spectrum from the stochastic background, thus, providing a tool of high potential for the characterization of granulation.

Here we analyse ultra-precise photometric data from the Sun (SoHO/VIRGO) and ι Hor (TESS). After careful preprocessing of the lightcurves using ARMA-based interpolation, we estimate fractal power spectra using the IRASA method, which isolates scale-free variability from oscillatory components. Once filtered the oscillatory components, power spectra of the background are modelled through a flexible fitting framework incorporating power-law, Harvey-like, and hybrid descriptions. Model selection is driven by robust criteria. Our results show that the spectral background slopes vary systematically with magnetic phase. This provides new observational constraints on stellar magnetism through a photometric index even when spots are not visible.

This approach highlights fractal analysis as a powerful diagnostic linking photometric variability to underlying magnetic processes which can help for the better asteroseismic characterization of stars.

P-037: The Mount Wilson Survey Revisited

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Decades of monitoring the Sun's 11-year magnetic cycle have led to a workable theory of the stellar dynamo, yet even this well-studied case has been debated for over 70 years. The Mount Wilson Survey of Ca II H & K chromospheric activity provides an unrivaled view of stellar magnetism, comprising time-resolved observations of more than 250 FGK dwarfs and 300 giants spanning 1966–2003. We present the magnetic activity properties of the full archival data set for the first time, including evidence for magnetic cycles in evolved red giants as revealed by variability in the S-index. We characterize this variability using Gaussian processes and introduce the resulting cycle decoherence timescale as a new, quantitative dimension for describing the stellar dynamo. We demonstrate recovery of TESS photometric rotation periods for short-period rotators in the sample, and show that longer rotation periods can be recovered using the S-index. Finally, we present an empirical recalibration of the R′HK activity measure that enables accurate comparisons of magnetic activity between dwarf and giant stars.

P-039: Asteroseismic detection and modelling of an internal magnetic field inside an evolved main sequence B0.5V-star

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Internal magnetic fields are an elusive component in stellar structure and evolution. Few observational constraints on magnetic fields inside the radiative envelope of massive main sequence stars are available. Moreover, observations of magnetic fields of massive stars have long been limited to the surface with about 10% of them hosting a strong surface field. The lack of observational constraints stands in sharp contrast with the significant role theory predicts for these fields. For example, they can efficiently transport angular momentum throughout the radiative envelope leading to a more uniform internal rotation profile. Additionally, they inhibit core-boundary mixing, reducing the burning core's access to hydrogen. An internal magnetic field is thus one of the key factors determining a massive star's life.

We present our discovery and the modelling of the internal magnetic field inside the radiative zone of HD 192575, a $\sim$12 $M_\odot$ B0.5V star. The star is a β Cephei pulsator, nearing the end of its life. It shows both gravity (g) modes and pressure (p) modes with clear rotational splittings. The strong inclination of the magnetic field with the rotation axis (60°) leads to additional features in the star's g mode multiplet, where the perturbation of the magnetic field leads to the quadrupole mode showing nine frequency peaks instead of the expected five peaks from rotation only. We show that an internal magnetic field explains these features. The maximum magnetic field strength is estimated to be around 24 kG. We discuss the methods and challenges of this detection and consider the implications for the star's angular momentum transport and its further path towards the supernova explosion. The discovery makes HD 192575 a prime target for testing theoretical models of magnetism in radiative envelopes.

P-061: Beyond Harvey-like models: studying the shared residual structure of the stellar background

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Harvey-like background models are widely used to describe the structure of stellar power spectral densities, particularly granulation and other low-frequency background variability. However, imperfect background reconstruction may leave systematic residual structure shared across stars.

We present a symbolic regression framework to model shared residuals in stellar power spectral densities individually fitted with Harvey-like background models. For each star, we fit a Harvey-like baseline, compute the residuals, pool them across multiple stars, and learn a common low-complexity residual function using symbolic regression.

The goal is to identify a stable common structure left unexplained by the adopted Harvey-like baseline. We present application examples using both synthetic data and real stellar data from Kepler and TESS. The learned symbolic expression is evaluated on stars not used during the training to test whether the shared residual structure improves predictive reconstruction while remaining interpretable.

P-082: Convective Penetration in the presence of Rotation and Magnetic Fields

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Stellar interior modeling is essential for the understanding of stellar structure and evolution and to interpret asteroseismic data with forward modelling. However, because of the long computation time required for the needed extended grids of stellar models, not all the physical phenomena can be described accurately. In particular, the penetration of turbulent convective motions in adjacent stably stratified radiative layers is difficult to parametrize and is not fully understood as of today. A wrong parametrization of it may lead to incorrect chemical mixing and change in the thermodynamic properties of these regions. Up to now, the theoretical studies of this phenomenon do not take into account both rotation and magnetic field. Nevertheless, they both affect the properties of convection. We thus expect to see an impact on the penetration depth.

In this work, we use for the first time the new Rotating and Magnetic Mixing Length Theory (RM-MLT), which we have recently developed, in order to predict the penetration depth taking into account the impact of rotation and magnetic field. Secondly, we explore different dynamo scaling laws to link the intensity of the magnetic field to the rotation rate. Finally, consequences for different stellar masses and evolutionary stages are discussed.

P-083: Properties of extremely weak magnetic field in roAp star HD210684

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High-spectral resolution and high SNR spectra of roAp star HD210684 acquired with the spectropolarimeter ESPaDOnS at CFHT have been used together with the available TESS data to study its photometric variability and magnetic properties. Detailed analysis of photometric data provided by TESS has revealed rotational modulation with period P=5.02188±0.00005 d and splitting of high-overtone pulsations that corresponds to the same rotational period. The Least Square Deconvolution method was applied to the accumulated Stokes I & V spectra to measure its extremely weak mean longitudinal magnetic field ($B_z <$ 200G) that varies with the rotational phase. The amplitudes of high-overtone pulsations and the detected B_z variability were used to describe a configuration of the surface magnetic field in HD210684 assuming the models of inclined magnetic pulsator and of the inclined magnetic rotator. Our results indicate that the configuration of the surface magnetic field seems to be more complex than the dipolar one.

P-086: Magnetic fields in γ Doradus stars: new asteroseismic insights

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Magnetic fields have been measured in the core of red giant stars through their effects on gravity (g) mode frequencies. These discoveries have led to the search for seismic signatures of magnetic fields in other g-modes pulsators. Recently, Takata et al. (2026) reported evidence for a magnetic field dominated by its azimuthal component in a slowly rotating δ Scuti - γ Doradus hybrid star while Ihallaine et al. (submitted) found a magnetic field signature in a rapidly rotating γ Doradus star (KIC 2309579). Unlike the model that has been developed by Takata et al. for slow rotators, the current perturbative magnetic theory within the traditional approximation of rotation (TAR) only accounts for the radial component. We therefore developed a generalisation that allows both radial and azimuthal fields to be considered. Based on these calculations, we reanalysed KIC 2309579 and extended the study to newly detected magnetic γ Doradus stars, providing new constraints on magnetic fields in γ Doradus star interiors. This contributes to outlining an overall picture of the origin of magnetic fields in the cores of low-mass stars, from the main sequence to the red giant branch.

5

Posters: K- and M-dwarfs

P-006: New grids of M dwarf stars and the impact of their atmospheres

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M-type dwarfs are the most common stars of the Universe, spending tens of billions of years on the main sequence, and harbouring most of the known small planets in their close-in habitable zone. However, the fundamental parameters of such stars are ill-constrained, due to their complex chemical spectra and their magnetic activity, which both lead to radius and/or colour discrepancies.

In this work, I present new model grids obtained with MESA for a wide range of metallicities and convection efficiencies. These parameters are associated with the implementation of various atmosphere tables, namely MARCS, PHOENIX, NewEra, and ATLAS. The thorough investigation of the changes induced by the different atmosphere choices is the first of its kind, quantifying the impact on the stellar effective temperature, radius, and structure quantities. These changes in turn affect predicted oscillations, whose calculation is a necessary step towards the detection of the ever-elusive M dwarf pulsations.

The grids of models and isochrones I present will be publicly available on a dedicated website for download and interpolation, ISTMO, that I also introduce here.

P-041: The BASTA view on σ Draconis

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Asteroseismic modeling of K-dwarf stars has received increasing attention in recent years. One such target is σ Draconis, for which several additional oscillation frequencies have become available since the previous modeling was performed. Previous studies also included the interferometric radius as a modeling constraint. However, recent work suggests that this may bias the resulting stellar models, as discrepancies between modeled and interferometric radii are increasingly being observed for K-dwarfs. This discrepancy is similar to the radius inflation problem previously identified in M-dwarfs. In this work, updated stellar models were used together with all currently available TESS observations and the newly identified oscillation frequencies, while excluding the interferometric radius from the fit. The newly measured interferometric radius (Chowhan et al., in prep.) is $(0.765 \pm 0.005)\,R_\odot$, while the radius derived in this work is $0.758^{+0.015}_{-0.016}\,R_\odot$. These results suggest that σ Draconis follows the same general trend of smaller modeled radii than observed. For σ Draconis the difference between the two is not statistically significant with a difference of 0.4σ (or 0.9%), however given that σ Draconis is an early K-type star (K0), this is not surprising.

P-042: On the edge of crystallization

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Stellar plasmas live in parts of parameter space that avoids the critical point, which means there is no abrupt transition between gaseous and fluid. There is, however, a phase transition to solid at sufficiently high density, at the critical coupling parameter (ratio of Coulomb to kinetic energy) of $\Gamma = 173$. On the way to crystallization, all molecules pressure dissociate and all atoms and ions pressure ionize. We will explore this regime, as part of the development of the T-MHD equation of state (EOS). This is an extension of the Mihalas-Hummer-Däppen (MHD) EOS, to include much more physics and greatly expand the regime of validity, including up to the crystallization line. This is a regime that is encountered in white dwarfs, approached in red dwarfs, and affects the sound speed and our asteroseismic inferences about them.

Posters: Binaries

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P-029: Exploring the circumbinary desert with Gaia, TESS, and PLATO

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While the existence of a brown dwarf (BD) desert is well established, there is another desert, hereafter referred to as the circumbinary desert, that deserves to be further investigated. This circumbinary desert is characterized by a dearth of short-period stellar and substellar companions around eclipsing binaries (EBs).

On the one hand, EBs orbited by a close ($P_{out} \lesssim 1000$ d) stellar companion are rare among the entire population of hierarchical triple stellar systems. Such systems, referred to as compact hierarchical triples, or CHTs, are thought to form differently than wider triple systems, most likely through a sequential disk fragmentation mechanism. On the other hand, there is a clear deficit of circumbinary BDs with orbital periods less than 1000 d, which might indicate different formation mechanisms for close-orbiting BDs and isolated ones. Indeed, it is commonly accepted that BDs in close orbit around main-sequence single stars can be divided into two populations distinguishable by their physical and orbital properties. One of them consists of high-mass BDs formed like stars through the fragmentation of molecular clouds, while the other consists of low-mass BDs that are thought to be formed by disk instability in the same manner as planets.

In order to examine the population statistics of the circumbinary desert, it is necessary to increase the number of confirmed circumbinary systems. Recent studies have demonstrated the feasibility of detecting short-period circumbinary companions with masses as low as those of BDs in the Transiting Exoplanet Survey Satellite (TESS) full frame images using the eclipse timing variation (ETV) method. However, the detection of the lowest-mass, shortest-period circumbinary candidates will require a dedicated photometric survey based on high-precision and high-cadence data from the future ESA PLAnetary Transits and Oscillations of stars (PLATO) space mission, which is scheduled for launch in January 2027. Alternatively, it is possible to identify new CHT candidates by taking advantage of the non-single-stars catalog from Data Release 3 of the ESA Gaia space mission. Thus, the present project aims to contribute to our understanding of the circumbinary desert in the era of Gaia, TESS, and PLATO.

P-031: Asteroseismic Models of the Magnetic Binary HD 156424

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HD 156424 is a hot magnetic star in the Sco OB4 association, and has previously been identified as part of a binary system. Spectropolarimetric results show that the companion star is also strongly magnetic, and thus this is a rare example of a doubly magnetic hot binary. In this work, we present a more detailed analysis of Transiting Exoplanet Survey Satellite (TESS) data, including phase variation. We find short term phase variation consistent with an oblique magnetic rotator, as well as long term phase variation consistent with the third element proposed by Shultz et al. (2021). We performed asteroseismic modelling of the star, and determined the pulsations are most likely associated with the primary of the system. Our best fit models are universally young, and we find the star is well fit by a model with M=8.1 $M_{\odot}$. In our models, the observed p modes are all associated with the primary star. Although previous work on magnetic stars suggests the fields may be the result of past mergers, the characteristics of HD 156424 make this origin unlikely.

P-035: Dynamical Masses for Asteroseismic Benchmarks: The Devil Is in the Details

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Accurate stellar masses provide essential benchmarks for asteroseismology and stellar modelling. Mapping the orbits of multiple-star systems offers a way to measure such masses with minimal reliance on stellar models. Reaching sub-percent precision, however, requires careful treatment of effects that are often negligible in less demanding analyses.

In this talk, I will present our ongoing project to determine precise dynamical masses for high-quality asteroseismic targets. I will focus on two nearby benchmark systems: the quadruple system μ Herculis, for which we have recently obtained sub-percent dynamical masses including $M_{\rm Aa} = 1.134 \pm 0.007\,M_{\odot}$, and the triple system 171 Pup, where similar modelling challenges arise. These systems illustrate how dynamical masses can provide independent tests of asteroseismic scaling relations and stellar models.

Using μ Herculis and 171 Pup as examples, I will show that seemingly small modelling choices that are often overlooked can shift inferred stellar masses by a few percent. These effects include partially resolved observations and orbital curvature in Gaia and Hipparcos astrometry, blending in high-resolution spectra, and the approximation of proper motions as straight-line motion in the tangent plane.

P-040: Spectroscopic insights into HD 133729: Probing the physical parameters of the first blue large-amplitude pulsator (BLAP) in a binary system.

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HD 133729 (TIC 75934024) remains to this day the only spectroscopically confirmed binary system in which one of the stars is a blue large-amplitude pulsator (BLAP). The known distance to the system ($D \approx 480$ pc) reveals that the BLAP component (the secondary) is not only the brightest ($V \approx 11$ mag), but also the closest among all known BLAPs. Due to the presence of a brighter, late B-type main-sequence companion, the observed amplitude of the BLAP is significantly reduced, compared to the canonical $0.1 - 0.4$ I-band magnitude range. The brightness of this BLAP permits the acquisition of high-resolution, time-resolved spectra in which the lines of both components are visible. This, combined with the known orbital elements from the $O - C$ analysis of the Transiting Exoplanet Survey Satellite (TESS) observations, allows for the determination of BLAP's physical properties. We present here preliminary results from the comprehensive analysis of 26 high-resolution ($R \approx 37000$) optical/near-IR spectra of HD 133729, obtained using the High Resolution Spectrograph (HRS) mounted on the 11-m Southern African Large Telescope (SALT). Using the two-dimensional cross-correlation technique, we determine the radial velocities of both components and use them to disentangle their individual spectra. From the obtained radial velocity curves and the fitted spectral energy distribution (SED), we derive the orbital parameters and provide constraints on the masses and radii of both components.

P-057: Unveiling stellar multiplicity: high-resolution spectroscopic follow-up of LAMOST discoveries

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The evolution of a star within a gravitationally bound stellar system can be significantly influenced by the proximity of its companion(s). However, the full extent of these effects is still not fully understood. Double-lined binaries and higher-order multiple-lined systems offer a particular advantage, as the properties of more than one component can be derived from high-resolution spectroscopy, thereby providing stronger constraints for stellar modelling. In 2023, we initiated a spectroscopic follow-up programme using the High Efficiency and Resolution Mercator Echelle Spectrograph (HERMES), mounted on the 1.2-m Mercator Telescope at the Roque de los Muchachos Observatory (La Palma, Canary Islands, Spain). The objective is to obtain high-resolution spectroscopic data for an initial characterisation of candidate double-lined and triple-lined systems recently identified by Frasca et al. (2022, A&A 664, A78) based on medium-resolution observations from the Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) survey at Xinglong Observatory (Xinglong, China). For a comprehensive analysis, these new spectra will be combined with complementary ground-based observations from other facilities, as well as with space-based photometric light curves obtained by the *Kepler* and *TESS missions*. This multi-technique approach aims to improve our understanding of the physical properties and evolutionary behaviour of these systems. In this poster, we present preliminary results from the characterisation of these multiple systems.

P-068: Asteroseismic and Evolutionary Constraints on the Interacting Blue Straggler SX Phoenicis Star V60 in M55

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We present a detailed seismic study of an SX Phoenicis star, V60, a member of the globular cluster M55 and a component of an eclipsing binary system. The pulsating primary is a blue straggler star (BSS), and the system has a short orbital period ($P \approx 1.18$ d) with evidence of ongoing mass transfer. Thus, V60 offers a rare opportunity to probe the internal structure of an interacting BSS in a low-metallicity environment ($[Fe/H] \approx -2.0$).

Using CASE data, we confirm the dominant pulsation frequency at 32.38 d^{-1} and interpret it as a radial mode, providing a key constraint for seismic interpretation. Combining this identification with a very precise determination of the mass and radius of V60, we construct its seismic models based on binary evolution calculations.

Our results highlight the potential of asteroseismology as a tool to investigate the interior structure and formation pathways of blue stragglers, and demonstrate its applicability to SX Phoenicis variables in globular clusters.

P-088: Binary Fingerprints in Red Giant Power Spectra

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Binary systems are important probes of stellar evolution and population studies, but their identification remains challenging because the components are observationally unresolved. They are traditionally identified through astrometric motion, eclipses, or spectroscopic radial-velocity variations. We investigate whether asteroseismic power spectra themselves contain additional signatures of stellar multiplicity that can be used as an alternative and complementary binary diagnostic.

We present a physically motivated framework for identifying binary red giants using synthetic asteroseismic PSDs constructed to reproduce *Kepler* long-cadence observations, containing both single and binary systems. The simulated spectra include stellar backgrounds with activity, granulation, white noise, and observational effects. Oscillating stars additionally include oscillation power envelopes with Lorentzian mode forests. Binary systems are modeled as the flux-weighted combination of two stellar PSDs, allowing merged, overlapping and widely separated oscillation components, as well as cases where one or both stars show weak/absent oscillations.

A balanced synthetic dataset of 40,000 PSDs is used to train gradient-boosted tree classifiers. the classifier is designed to learn global PSD morphology, and identify binaries through the presence of multiple background components rather than relying only on oscillation signatures. Initial tests on Kepler Eclipsing Binary Catalogue demonstrate that our trained model reproduces known classifications with fairly good accuracy. Performance is strongest for systems in which the ν_{max} of the two stars are well separated in frequency space and share comparable mass and luminosity ratios, making their combined PSD signatures more distinguishable.

This work demonstrates that physically informed synthetic PSD populations can provide an effective route for identifying binary red giants directly from asteroseismic spectra. The framework is readily extendable to larger *Kepler* samples and may support future population studies using PLATO data, offering a path toward population-level studies of unresolved binaries in evolved stars.

P-090: Asteroseismology of SX Phoenicis stars in binary systems: KZ Hydrae as a product of Bondi–Hoyle–Littleton accretion

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KZ Hydrae is a field SX Phoenicis star pulsating predominantly in a radial mode with a frequency of 16.804,d^{-1}. Its low metallicity ([Fe/H] < -2) and kinematic properties indicate membership in the Galactic halo. The star is also the primary component of a long-period binary system with an orbital period of 26.8 ± 0.2 yr. Its companion, with a minimum mass of 0.83,$M_{\odot}$, is most likely a white dwarf. This configuration suggests that KZ Hya is a blue straggler formed via mass transfer.

We performed a frequency analysis of TESS observations from Sectors 63, 90, and 100. In addition to the know dominant frequency, we detected three additional independent peaks at 17.587, 23.925, and 24.765 d^{-1}, which can be attributed to nonradial modes.

We then carried out seismic modelling of KZ Hya. First, we assumed single-star evolution and applied Bayesian inference to reproduce the observed effective temperature, luminosity and dominant radial-mode frequency. Next, using the binary module of the MESA code, we computed binary evolution models considering both Bondi–Hoyle–Lyttleton accretion and wind Roche lobe overflow (WRLOF), subject to observational constraints on the effective temperature, luminosity and orbital parameters. We adopted a white dwarf companion with a mass of at least 0.8 $M_{\odot}$ and an orbital period of 26.8 yr.

Our modelling indicates that KZ Hya most plausibly formed through stellar wind accretion, with the accretor increasing its mass by up to approximately 10 per cent. This study highlights the potential of asteroseismology combined with binary evolution modelling to constrain the formation pathways of blue stragglers in binary systems.

7 *Posters: Galactic archeology*

P-010: The APOGEE Asteroseismic Target List: Building the Foundations for an APO-TESS Catalog

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The all-sky TESS mission provides an unprecedented opportunity to study the oscillations in red giants in a wide range of Milky Way stellar populations. When combined with large spectroscopic surveys, these asteroseismic measurements enable precise estimates of stellar masses, radii, and ages. Despite efforts to target asteroseismic candidates within the APOGEE DR19 survey, only 12% of red giants with literature TESS asteroseismic detections have corresponding APOGEE spectra. To investigate the cause of this disparity, we have constructed an APOGEE asteroseismic target list to identify stars with high potential for detectable oscillations. Using spectroscopic surface gravities and effective temperatures from APOGEE DR19, we estimate oscillation detection probabilities for all giant stars in the survey. For stars with detection probabilities greater than 50%, we further calculate a crowding metric to assess potential contamination arising from the large TESS pixel scale, enabling prioritisation of relatively isolated targets for future analysis.

This APOGEE Asteroseismic Target List is a precursor for an APO-TESS catalog, which will build upon the successful legacies of APOKASC and APO-K2 that are widely used in Galactic archaeology studies. Preliminary estimates suggest that we will be able to seismically and spectroscopically characterise 316,000 stars in APO-TESS, which is an increase by an order of magnitude compared to the Kepler-APOGEE catalogs. This larger sample of well-characterised stars will enhance investigations of Galactic archaeology, and also allow for analyses of diverse stellar populations that were not as accessible with the small fields of view of the Kepler missions. Moreover, this work provides a valuable framework for future missions such as Roman, which is also expected to yield large seismic samples of 300,000 stars in the Galactic bulge.

P-100: Robust Mass, Radius, and Age Measurement of a Nearly Pristine Star

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The most metal-poor stars currently known are key to understanding the process of galaxy formation. Measurement of their individual properties, particularly their mass and age, provides valuable benchmarks for understanding the early environments in which stars and galaxies formed. Here, we present the detailed asteroseismic analysis of SDSS J0715-7334, the most metal-poor star currently known (log Z/Zsun < -4.3). Despite its kinematically-confirmed residence in the halo of the Large Magellanic Cloud, the intrinsic brightness of this luminous red giant branch star allows detailed identification of individual asteroseismic modes with TESS. Using the asteroseismic information alone, we recover the surface gravity and distance of this star in strong agreement with and to higher precision than earlier spectrokinematic analysis. We then combine constraints of stellar properties from high-resolution spectroscopy and detailed kinematics with our asteroseismic results to measure a stellar radius of 42.7 +/- 3.5 Rsun, mass of 0.85 +/- 0.15 Msun, and age of >11 Gyr, demonstrating that stellar spectroscopy and asteroseismology are consistent at the absolute metallicity floor measurable in the nearby Universe, and the combination of high-resolution spectroscopy and detailed asteroseismology can be used for robust stellar characterization in extremely metal-poor environments. Confirming these results will determine when substantial star formation began in the birth environment of this star, testing theories of environment dependence in Population III star properties.

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Posters: O- and B-type stars

P-017: Effect of detailed atmosphere models on the pulsations of massive stars

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Massive stars in the post-main sequence often develop extended, dynamic atmospheres dominated by line-driven winds and outside local thermodynamic equilibrium. These outer layers are usually treated with simplified grey atmospheric boundary conditions in stellar structure and pulsation calculations, although they may strongly affect the stratification of density, temperature, and opacity near the stellar surface. Such changes can introduce temperature or density inversions and modify the location and strength of opacity bumps. In this work, we investigate how unified non-LTE photosphere-wind atmosphere models affect the pulsation properties of hot massive stars beyond the main sequence. Stellar structure models are computed with MESA and coupled with CMFGEN atmosphere models to obtain a more realistic description of the outer layers. Pulsation models are then developed with GYRE and compared with models using simplified grey atmospheres. We examine how changes in the density, temperature, and opacity profiles affect the Brunt–Väisälä and Lamb frequency profiles and the propagation cavities. This allows us to test whether realistic atmospheric models can lead to new pulsation spectra in massive stars at the post-main-sequence.

P-034: Pol-Quake! Polarimetric Asteroseismology of Massive Hot Stars

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The evolution of the galaxy is inextricably linked to the evolution of massive stars, and yet they are some of the stars we know least about. Asteroseismology is an indispensable tool for exploring the structures of stars, but it has a basic problem: determining mass, radius, age, and internal structure requires a mode solution. The pulsations in massive stars are complex to disentangle—often with multiple solutions being geometrically feasible from photometric or spectroscopic data alone. Polarimetric observations can provide the necessary insight into the spatial structure of massive stars needed to reduce the number of possible mode solutions.

Here we report on the progress of our observing program and highlight the results from our preliminary analysis of our two pilot-program stars. Three observing teams spanning a third of the globe have obtained data on a dozen β Cep/SPB stars. From our initial polarimetric observations the most promising candidates for further analysis include ε Per, ν Eri, and λ Sco; the larger polarimetric signals, attributable to pulsations, are thus far seen in the β Cep targets compared to SPBs. An update on β Cru with double the amount of polarimetric data recovers the previously published results, and identifies possible new frequency matches in the polarimetric data. Our initial examination of β Cen indicates several frequencies identified in both photometry and polarimetry as well.

P-044: A rapidly-rotating B star observed by Kepler and TESS

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Massive stars are important across many fields of astrophysics due to their interactions with their surroundings. They energise their environments with their radiation and provide chemical enrichment through mass loss. At the ends of their lives, their supernova explosions provide metals for later generations of stars and planets, thus driving galactic chemical evolution. However, our understanding of massive stars is ultimately reliant on how well we know the stellar interior and physical processes such as rotation and mixing. For example, if and when a massive star explodes as a supernova and leaves behind a neutron star or a black hole depends on its interior rotation and mixing profiles. Since stellar pulsations directly probe a star's interior physics, asteroseismology is an invaluable tool for constraining rotation and mixing, and for improving our understanding of the impact of massive stars on the universe.

Whilst the number of massive stars in the nominal Kepler field of view was very limited, the advent of repeated visits to the Kepler field by the NASA TESS mission has afforded us with an unique opportunity: combining Kepler and TESS light curves to improve our analyses. In this poster, I will present the asteroseismic analysis of a unique rapidly-rotating massive star in the Kepler field with long-term amplitude and frequency variability in its pulsations, which is best studied from a combined analysis of both Kepler and TESS light curves. Complementary spectroscopy suggests that the star is an emission-line early-B star in quiescence. Therefore, whilst TESS's survey approach is advantageous for studying large samples of massive stars as an ensemble, continued interest in the Kepler mission is providing important results for massive star asteroseismology.

P-055: Fourier Analysis of SPB Period-Spacing Patterns as an Age Diagnostic

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Stellar ages are difficult to measure despite their importance for a wide range of studies, including galactic archaeology and exoplanetary systems. Asteroseismic studies, specifically the analysis of gravity-mode oscillations, can provide valuable information about how much hydrogen remains in the cores of stars, which in turn helps us estimate their ages. As core hydrogen depletes due to nuclear burning and the convective core recedes, a chemical gradient is formed which traps the g-modes and leads to deviations in the period spacing patterns. Internal mixing modifies the gradients thus changing the mode trapping and morphology of the patterns. Therefore, we can constrain internal mixing and stellar ages by performing asteroseismic modelling of the period spacing patters.

Recently, Guo (2026) proposed an alternative method for estimating the ages of slowly pulsating B stars that does not rely on detailed asteroseismic modelling and extensive grids of stellar models. Their work suggests a linear relation between the dominant frequencies in the Fourier transform of gravity-mode period-spacing patterns and the central hydrogen abundance of these stars. Once calculated, this relation can be used to estimate stellar ages directly from the period spacing patterns with comparable accuracy but reduced computational cost. Deriving this relation requires fewer stellar models; however, a variety of constraints and initial parameterizations still need to be explored to test this relation and its dependencies.

My preliminary work has focused on investigating one of these constraints: the dependence of these relations on interior mixing processes. I tested this method using models with similar masses, overshoot parameters, and envelope mixing coefficients to those used by Guo (2026) and then compared the differences resulting from variations in the overshoot parameter. Here I present my preliminary results from this comparison.

P-058: Multi-D simulations of blue supergiants: the origin of the stochastic low frequency variability.

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The overabundance of blue supergiant stars (BSG) in observations as compared to predictions of classical stellar evolution theory is often referred to as the "Blue Supergiant problem". Recent discoveries in both observations and theory have opened the path to test potential answers to the discrepancy. Asteroseismological observations (Bowman+2024, Ma+2024) of BSGs in the LMC show a power excess at the low frequency end of the amplitude/power spectra (so called Stochastic Low Frequency Variability (SLFV)) with typical characteristic periods of around 5 days. On the theory side, Henneco+2024 found H-burning convective shells (that are characteristic of BSGs) in 1D evolutionary models of massive merger products to be enhanced and long lasting post-merger.

Our aim is to test whether the predicted post-merger structure is consistent with the observed SLF variability. We run fully compressible multi-D hydrodynamical simulations of such H-burning shells and the propagation of the excited signal toward the stellar surface with the in-house developed finite volume code Phlegethon (Leidi+2026). In our simulations we self-consistently capture the convective excitation of internal gravity waves by turbulent flows, the influence of radiative diffusion on their propagation in the stable layers of the star, wave breaking and interactions with supersonic subsurface convection.

This poster presents predictions of wave spectra extracted from the simulations at different locations in the star showing how the signal changes as it propagates through the star. The spectra are directly compared to observations, we report that initial results are able to reproduce the observations. This may be evidence that BSGs can be the products of mergers.

P-070: Meticulously modelling many massive main-sequence-star momenta making use of more modern methods

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Rotation plays a major role in the structure and evolution of stars. Internal rotation gradients trigger angular momentum transport and mixing throughout the star. Such mixing smooths chemical gradients, brings processes heavy elements to the surface, and extends the star's lifetime by refuelling burning regions. These effects are especially prominent during the long main sequence phase, which in turn impacts the post-main sequence evolution. Therefore, it is of great importance to know the rotation profiles of main sequence stars and how they evolve due to the transport of angular momentum. Asteroseismology can constrain the interior rotation rates and the rotation profiles of various types of pulsators. Past asteroseismic studies of stars, mostly based on Kepler photometry, concluded that main sequence stars more massive than the Sun ($M > 1.2\,\mathrm{M}_\odot$) usually show little or no differential rotation. These flat rotation profiles stand in stark contrast to the strong differential rotation predicted from theory, suggesting that one or more transport mechanisms are missing from current models of stellar structure and evolution. However, main sequence B-type stars with masses greater than about 3 $\mathrm{M}_\odot$ may offer a different trend than those with a lower mass as a handful of them do feature differential rotation. Unfortunately, the data necessary to constrain the internal rotation profiles of B-type stars was until recently only available for a small number of targets. As TESS continues to monitor these stars, it enables the asteroseismic modelling of more high- and intermediate-mass main sequence pulsators. Consequently, our understanding of the internal rotation of main sequence stars is rapidly improving. In this talk, I will summarise recent and upcoming asteroseismic measurements of the internal rotation profiles of main sequence stars and show how the sample of pulsators more massive than 3 $\mathrm{M}_\odot$ has recently grown substantially. I will also highlight the new methodologies that enabled the study of these new targets. These new observational constraints will help us identify and calibrate angular momentum transport mechanisms and provide clues on how these ought to be implemented into models of stellar structure and evolution.

P-096: Towards Asteroseismic Samples of Massive Stars: A New β Cep Catalog and Modern Mode Identification from Combined TESS and Ground-Based Observations

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TESS has the potential to revolutionize our understanding of massive stars by providing high-quality light curves that allow pulsation frequencies to be determined to high precision. However, in the case of β Cep stars, complete asteroseismic modeling requires mode identification, which very often relies on color information from continuous long-term ground-based observations. This challenge has kept the number of massive stars with complete seismic analysis at fewer than ten. With the Global Asteroseismology Project (GAP) we have more than doubled this sample by combining TESS data with the Las Cumbres Observatory global network of telescopes. In order to select the targets, we compiled an up-to-date β Cep catalogue, re-examining all previously reported β Cep classifications, finding new ones, and obtaining additional data for several of them. This catalog contains over a thousand β Cep stars with detailed frequency analyses derived from TESS data. I will present their statistical properties as well as peculiar objects we identified. I will also present the first results from our mode identification on newly observed β Cep stars and describe a new tool we developed for this purpose tailored to the era of modern MESA and GYRE grids.

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Posters: Rotation

P-014: Near-Degeneracy-Aware OLA Inversions Applied to Kepler Red-Giant Observations

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Red giants (RG) are prime targets for probing the dynamics of stellar interiors, as their oscillation modes carry information from both the deep core and the outer envelope. Measuring their internal rotation is essential for understanding angular-momentum transport, one of the major open problems in stellar evolution. In particular, stellar rotation splits modes of the same degree into multiple frequency components, providing the only direct probe of internal rotation profiles. Rotation can also induce coupling between closely spaced modes through near-degeneracy effects (NDE). These effects break the symmetry of rotational multiplets and have been shown to bias standard inversion methods, with systematic errors increasing with both rotation rate and evolutionary stage (i.e., decreasing $\Delta\nu$). We use a new OLA-based rotational inversion implementation that explicitly accounts for near-degeneracy effects, including modes of arbitrary degree. The method has been validated using synthetic data and is applied here to real Kepler RG targets exhibiting asymmetric rotational splittings. By paving the way for generalized seismic inversion methods on the RG branch, this methodology will provide critical insights into the physical processes that shape stellar evolution.

P-015: Pulsation Assessment through SpecTRoscopY (PASTRY): A novel modern software tool to analyse time-series spectroscopy.

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Time-series spectroscopy played a major role in asteroseismology prior to the beginning of the space era some two decades ago. Line-profile variations (LPVs) were the primary observable used to identify non-radial pulsation modes through modeling of time-dependent absorption-line profiles. With the advent of high-cadence space photometry missions such as CoRoT, Kepler, and TESS, which provide mode identifications for tens to hundreds of pulsation modes, considerably less attention has been devoted to incorporating our improved understanding of pulsational velocity fields into spectroscopic analyses. While several methodologies for spectroscopic mode identification exist in the literature (e.g. the FAMIAS software package; Zima et al. 2008), many - if not all - now appear outdated in light of the rapid advances in asteroseismology over the past two decades.

Here, we introduce a novel open-source, user-friendly software suite for the analysis of LPVs caused by non-radial pulsations, representing a substantial improvement over existing methodologies both in terms of numerical implementation and physical realism. In particular, this contribution focuses on the treatment of rotation within our PASTRY methodological framework, where we distinguish between the following three regimes: 1) Fast pulsation modes in slowly rotating stars, treating the Coriolis acceleration perturbatively to first order in the rotation frequency; 2) Fast modes in rapidly rotating stars, accounting for both Coriolis acceleration and centrifugal deformation perturbatively up to second order; 3) Slow modes in rapidly rotating stars within the framework of the Traditional Approximation of Rotation (TAR). We present validation tests for all three cases, along with a case study of a prototype beta-Cep pulsator to demonstrate the capabilities of the code.

P-021: Pulsating hot B subdwarfs in the Kepler field I. Eight g-mode rich pulsators

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We present a homogeneous analysis of eight g-mode pulsating hot subdwarf B (sdB) stars observed by Kepler. Using the full short-cadence data set and the FELIX software package for iterative prewhitening, we extracted pulsation modes and investigated rotational multiplets and mode stability. All eight stars exhibit rotational multiplets, and five of them show sub-synchronous rotation. Most dominant modes display significant amplitude and frequency variability, demonstrating that mode instability is ubiquitous among g-mode sdB pulsators. Our homogeneous frequency catalog provides a foundation for future asteroseismic modeling and shows that mode instability should be considered in long-term studies based on pulsation timing or evolutionary period changes.

P-050: Mixing by Internal Gravity Waves in Solar-type Stars

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Asteroseismic and spectroscopic observations of solar type stars reveal efficient extraction of angular momentum in the radiation zone as well as surface abundance variations of light elements such as Lithium (Li) – features that are unexplained by standard stellar evolution models. With asteroseismology providing direct constraints on stellar interiors, numerous studies have incorporated additional transport mechanisms to reproduce the observations; however, the current improvements have not yet succeeded in the robust modeling of angular momentum and chemical transport. Internal Gravity Waves (IGWs) are a leading contender to efficiently transport angular momentum from the core and to subsequently reproduce the observed Li abundance variations [Talon and Charbonnel, 2005].

In this work, we investigate the chemical mixing induced by IGWs in solar-type stars and provide a parameterisation for implementing in 1D stellar evolution models. We carry this out by introducing tracer particles into two-dimensional (2D) equatorial hydrodynamic simulations in solar type stars ($1.0, 1.2\ M_\odot$) across a wide range of rotation rates ($1, 3, 9, 14$ and $21\ \Omega_\odot$). We find that the diffusion coefficient scales with the square of the wave amplitude and decreases with increasing rotation rates, consistent with the results obtained in massive stars.

Finally to get an insight into the physical mechanism causing the wave mixing, we compared our simulation profiles to the theoretical prescriptions on wave mixing due to wave shear-induced turbulence [Garcia Lopez and Spruit, 1991, Zahn, 1992], and Stokes displacement theory [Schatzman, 1993], both of which have been widely explored in atmospheric and oceanic studies. Our findings indicate that shear from IGWs play a major role in mixing, despite not satisfying the vertical shear instability criterion [Varghese et al., 2025]. Utilizing the observational data from current and upcoming asteroseismic space mission [Rauer et al., 2025], these findings provide a major step in implementing realistic parameterizations of wave mixing in stellar evolution models.

P-066: Evolution of active-region lifetimes from the main sequence to the subgiant branch

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The advent of long-term space-based photometric observations has opened a new avenue for constraining the rotational and magnetic properties of solar-like stars. In particular, brightness variations caused by active regions crossing the visible stellar disk have enabled measurements of average surface rotation and magnetic activity levels for unprecedentedly large stellar samples. Recovering more detailed information, such as differential rotation and active-region properties, however, remains challenging. Previously, we showed that the decay timescale of the autocorrelation function (ACF) of stellar light curves, although representing a lower limit to the true active-region lifetime, can still serve as a useful proxy. In this work, we estimate ACF decay timescales and investigate their dependence across stellar parameter space through an MCMC analysis comparing four ACF models. We explore under which conditions a linear decay better describes the data than an exponential decay, and investigate the number and amplitudes of interpulse terms (secondary peaks in the ACF), which can provide insight into the spatial distribution of active regions. We find that active-region lifetimes generally decrease with increasing effective temperature, with F-type stars exhibiting particularly short lifetimes. Lifetimes also show a strong correlation with the magnetic activity proxy Sph, being longer for more active stars. Interestingly, stars rotating slightly slower than the intermediate-rotation gap associated with spin-down stalling exhibit enhanced lifetimes. This phenomenon is possibly linked to the enhanced activity observed after stars crossing this transition. Finally, slow-rotating subgiants exhibit long active-region lifetimes. These results provide new constraints on the evolution of stellar magnetic activity and active-region emergence, offering insight into the magnetic dynamos operating in solar-like stars.

P-071: Probing internal rotation and structure in SPB stars from TESS asteroseismology

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The internal structure and rotation of Slowly Pulsating B (SPB) stars can be probed through their gravity-mode spectra, offering key constraints on angular momentum transport in intermediate-mass stars. We analyse a homogeneous sample of SPB stars observed by TESS using a frequency-domain diagnostic that identifies linear sequences in the ν–$\sqrt{\Delta\nu}$ diagram associated with prograde sectoral g modes. Of the 320 candidates selected using Gaia parameters and variability criteria, 67 objects exhibit well-defined mode patterns suitable for seismic modelling. For these stars, we infer near-core rotation rates, $\nu_{\rm rot}$, and buoyancy travel times, P_0, yielding a coherent seismic mapping of the sample in the ($\nu_{\rm rot}$, P_0) plane. The distribution shows a clear trend of decreasing rotation with stellar evolution, consistent with efficient internal angular momentum redistribution along the main sequence. We also examine the behaviour of different prescriptions for the eigenvalue $\lambda_{\ell,m}(s)$ and identify regimes in which simplified asymptotic descriptions reproduce radial orders comparable to those obtained under the Traditional Approximation of Rotation. The derived radial orders cluster around $\langle n \rangle \simeq 24$, in line with previous studies. These results provide a uniform seismic reference set for SPB stars and establish a foundation for constraining mixing processes and core overshooting through forward modelling.

P-072: Beyond linear rotational inversions

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All stars rotate. This omnipresence makes rotation a crucial ingredient in stellar structure and evolution models. However, current models of stellar rotation cannot reproduce asteroseismic observations of internal rotation rates of red-giant stars. This discrepancy is generally attributed to the inefficient transport of angular momentum in the models. In this work, we developed a new asteroseismic inversion method to measure more accurate core and envelope rotation rates, thereby providing tighter constraints on the angular momentum transport mechanisms at play. For the first time, we go beyond the first-order expression for rotational splittings in inversions. We demonstrate that this largely eliminates previously found systematic errors in linear rotational inversion results (e.g. Ahlborn et al. 2025b). Our method therefore provides an important diagnostic of the evolution of angular momentum along the red giant branch, especially for the most evolved and fastest-rotating red giants.

P-079: Dervish: second-order rotational perturbations to mixed modes

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A major issue in stellar modeling is the incomplete picture of angular momentum transport along evolution. Post-main-sequence stars frequently display mixed-mode oscillations from which we can extract information on the physical conditions – including their rotation rates – in their interior. The asteroseismic diagnostic used to constrain internal rotation rates in these stars is a rotationally split oscillation mode frequency multiplet. These multiplets are usually only modeled by first-order expansions of the oscillation equations in the rotation rate, causing significant systematic errors in the models of more evolved and/or more rapidly rotating post-main-sequence stars.

We introduce 'Dervish': a Fortran code focused on second-order rotational effects on mixed modes. Dervish models perturbations to oscillation frequencies up to the second order and perturbations to mixed-mode eigenfunctions to first order. The second-order rotational frequency perturbations generate asymmetric signatures in the frequency multiplets. In this talk we discuss the conditions under which these asymmetries become significant. We furthermore show how this sensitivity analysis can help to provide tighter constraints on rotation profiles and angular momentum transport processes in post-main-sequence stars.

P-085: Settling angular momentum transport theories with mixed f/g modes

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The core of evolved stars rotates slower than if angular momentum was locally conserved through their lives, thus it must be distributed in outer layers by some mechanism for which several theories compete. An efficient way to discriminate between them is to test them on the case of the Sun, as their efficiencies differ in deep layers. However, the rotation rate of the deepest 20% layers of the Sun are still out of reach, preventing the identification of the dominant internal transport process and its correct modelling in stellar evolution codes.

In this presentation, I rely on the fact that there is a key coupling between the gravity modes (g) and the fundamental modes (f) of the Sun, and therefore that mixed f/g modes should exist as low frequency oscillations ($\sim$300 μHz). Since the f modes reach the surface and have already been observed, and since the g modes should probe the solar core, their coupling offers a unique opportunity to measure the core's properties. I present the unprecedented potential of adding this new type of mixed modes in a seismic rotation inversion method. I estimate precisely how many such modes are expected in the Sun's oscillation spectrum, as well as the strength of their coupling and their exact sensitivity to the rotation of the core. By including these modes in the inversion of rotation, one can precisely place the value of the rotation at 7% in radius.

This point is the deepest observable to date and reaches a sufficient depth to make a clear distinction between current theories of angular momentum transport and resolve this persistent problem in stellar physics. This exciting prospect of measuring rotation at the Sun's core is possible by ongoing observations and data processing focused on the Sun's low-frequency oscillations. This would be the first core rotation measure in a low-mass main sequence star, which may signify similar breakthroughs in internal characterization soon to come.

P-089: Near-Degeneracies in Evolved Stars: Rotation and Magnetic Prescriptions Revised

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The internal transport of angular momentum and magnetic fields remains a major challenge in stellar physics, as observations reveal a much smaller core-envelope rotation contrast than predicted by standard models. Asteroseismology provides the only direct probe of stellar interiors, yet current seismic analyses often neglect near-degeneracy effects, i.e., the coupling between modes of closely spaced frequencies. These effects have been shown to bias measurements of internal rotation and are typically ignored in studies of internal magnetic fields. We introduce a formalism that incorporates rotationally and magnetically induced mode coupling while retaining the simplicity of asymptotic descriptions, avoiding the computational cost of full numerical modelling. This approach unlocks the diagnostic potential of quadrupolar (l=2) mixed modes, which probe regions complementary to dipolar modes but are often underutilised because of their low amplitudes and near-degeneracy-induced distortions of their splittings. When implemented in a global Bayesian pipeline, our method reduces uncertainties on core and envelope rotation rates by approximately a factor of two, proving to be a robust foundation for tightening constraints on internal rotation. In addition, this framework extends the domain of validity of perturbative magnetic approaches beyond that of previous studies. Preliminary results further indicate that including near-degeneracy effects significantly improves the quality of asymptotic fits in stars exhibiting large magnetic frequency shifts. Ultimately, such a treatment of near-degeneracy effects brings us to a more precise understanding of the rotational and magnetic history of stars.

P-101: Spin-down of red clump stars by mixed modes

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Current stellar models predict core rotation rates for low-mass red giant branch (RGB) stars that are orders of magnitude higher than those inferred from asteroseismic observations. This highlights the need for transport processes that can efficiently redistribute angular momentum (AM) within radiative interiors. For instance, mixed modes in solar-like oscillators have been shown to extract some AM from the cores of RGB stars.

Here, we present the first calculations of AM transport by mixed modes all the way to the red clump. We find a significant spin-down of the core in the red clump, demonstrating that mixed modes can efficiently redistribute AM at this stage. To obtain a more complete picture of AM transport, we also include other physical processes, such as meridional currents and the magnetic Tayler instability, and determine their combined effect on the rotation profiles.

10 Posters: Exoplanets and their host stars

P-052: A Data-Driven Framework for Transit Detection and Period Estimation in TESS Light Curves

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We present a scalable, data-driven framework for detecting and characterizing planetary transits in TESS light curves across diverse stellar populations. Our Conv-Transformer architecture integrates convolutional layers that capture localized transit signatures with lightweight transformer modules that model long-range temporal structure, enabling joint transit detection and period estimation on both real and transit-injected data. Current results are derived from TESS light curves of predominantly main-sequence stars, providing a baseline for evaluating signal recovery and period stability under realistic noise conditions. These tests show consistent recovery of injected signals and reliable period estimates. Ongoing work extends the framework to cooler and younger stellar populations, including M dwarfs and young stellar objects, where stellar activity plays a more prominent role in shaping photometric variability. Injection–recovery experiments and comparisons with classical pipelines highlight the potential of hybrid deep-learning methods for scalable and robust transit searches in current and future photometric surveys.

P-075: Uniform Spectroscopic Analysis of Prime Gas-Giant Exoplanet Hosts in the PLATO Field

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ESA's *PLATO* (PLAnetary Transits and Oscillations of stars) mission is expected to significantly improve stellar and planetary characterisation through high-precision photometric observations. However, many gas-giant exoplanet host stars in the *PLATO* southern field still lack homogeneous atmospheric parameters and detailed chemical abundances. We aim to provide a homogeneous set of atmospheric parameters and detailed chemical abundances for 13 bright transiting gas-giant host stars in the *PLATO* southern field. High resolution spectroscopy was used to determine atmospheric parameters through spectral synthesis. Detailed chemical abundances for upto 30 elements were determined including lithium from the Li I 6707.8 Å line. The study provides abundance for all the 13 stars of which 7 stars previously lacked chemical abundances characterisation. Two systems, KELT-14 and TOI-481, exhibit unusually high lithium abundances relative to their inferred evolutionary ages. These lithium abundances are inconsistent with the expected depletion in evolved solar-type stars and may indicate external enrichment processes such as the engulfment of planetary material. This work delivers a homogeneous spectroscopic atmospheric parameters and chemical-abundance catalogue for benchmark gas-giant exoplanet hosts in the *PLATO* field, useful for future asteroseismic modelling and improved stellar and planetary characterisation.

P-092: Chemical paradox in a binary system: Exploring the metal discrepancy in HD 81809 system

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Signals of planets being engulfed by their host stars are rare. Chemical transport mechanisms such as convection, atomic diffusion, turbulent mixing, and thermohaline mixing erase the chemical enrichment left by the planet. However, binary stars, which form together from the same material are expected to have the same initial chemical composition. From an observation point of view they could be used to detect chemical differences caused by the accretion of a planet. Despite the fact that various investigations have identified chemical discrepancies of 0.1–0.2 dex in stellar binaries, these variations could be attributed to atomic diffusion alone.

HD 81809 is a binary star system with the primary component being a subgiant G-type star, and the secondary component being a main sequence G-type star. Recent spectroscopic analyses revealed a difference in abundance, finding that HD 81809A is a metal-poor star with [Fe/H] = -0.57 dex, whereas HD 81809B is estimated to have solar abundances with [Fe/H] = 0.00 dex. This large discrepancy cannot be explained by atomic diffusion alone. This makes the HD 81809 system a unique laboratory in which to test whether planet engulfment could explain the chemical discrepancy between the stellar companions. Using stellar models from MESA that include accretion, we explored whether it was possible to enrich the surface of HD 81809B to the observed values starting from a composition similar to that of HD 81809A. Simulations suggest that a recent accretion event involving the capture of 25–75 Earth masses of rocky material by HD 81809B could partially explain the chemical dichotomy in the binary system.

P-093: Stellar Spin Rates & Orbit Alignments: A 3D View of Single and Binary Stars

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The upcoming Gaia Data Release 4 (December 2026) will open new opportunities for statistical studies of two billion stars and their fundamental dynamical properties. True spin–orbit angles are intrinsically 3D, requiring both stellar spin orientation ($i_\star$) and orbital geometry, yet most population studies still rely on the projected angle λ. We deliver a population-level, 3D view of stellar rotation and spin–orbit alignment that exoplanet architecture studies depend on. Spectroscopic *v*broad provides a complementary rotation channel to asteroseismic rotational splittings, extending coverage to millions of stars without seismic detections.

1. We derive empirical stellar rotation priors for $T_{\rm eff}$ = 6,000–8,000 K and $\log g$ = 3.5–4.5 from over 300,000 Gaia DR3 spectra. The parameter range is mapped in 50 K × 0.1 dex bins, yielding more than 300 individual rotation models. These calibrated velocity distributions will serve as benchmarks for 3D exoplanet-architecture studies.

2. We examine trends in spin–orbit alignment in wide binaries, extending the BANANA project's close-binary results (Albrecht et al. 2012) into the 100–1,000 AU regime. Combining detailed orbital kinematics with high-precision *v*broad measurements, we trace how stellar spin axes evolve with binary separation. We identify a clear transition: where BANANA found partial alignment for close (~1–10 AU) binaries, our wide-binary sample (>100 AU) displays spin–orbit distributions consistent with random orientations.

Albrecht, S., Winn, J. N., Fabrycky, D. C., Torres, G., & Setiawan, J. (2012). The BANANA Survey: Spin-Orbit Alignment in Binary Stars. *Proceedings of the IAU Symposium* No. 282, 397–398. doi:10.1017/S1743921311027906

11 Posters: Solar-like oscillations

P-002: Precise p-Mode Spectrum of Arcturus from a Decade of SONG Radial Velocities

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Arcturus is a benchmark luminous red giant in the northern hemisphere. We will present a complete analysis of nearly ten years of high-precision SONG radial-velocity observations of Arcturus, obtained between 2016 and 2025. The data set contains more than 15,000 individual velocities and provides an exceptionally high signal-to-noise ratio in the oscillation power spectrum. After rebinning into 3-hour noise-weighted averages and high-pass filtering to remove long-period variability, the resulting spectrum reveals a remarkably clean pattern of solar-like p modes with low radial orders extending down to $n = 1$.

The central result is that the SONG velocity data allow individual p-mode frequencies in Arcturus to be measured with a precision and frequency resolution that are difficult to achieve for stars at a similar evolutionary stage. Compared with luminous red giants observed by Kepler, the SONG observations combine a longer time baseline, a much higher contrast between oscillation power and background noise per mode, and a substantially reduced granulation background in radial velocity compared with intensity. Kepler studies of luminous red giants have revealed related radial and non-radial mode patterns, but typically with lower contrast and less precise individual frequencies, because the Kepler light curves span at most about four years and the oscillation signal is embedded in stronger stellar background noise.

For Arcturus, the p-mode power excess peaks at $\nu_{\rm max} = 4.18 \pm 0.13, \mu$Hz. By prewhitening the time series, we reconstruct a deconvolved oscillation spectrum and identify 13 secure modes with degrees $l = 0, 1,$ and 2, and radial orders up to $n = 5$ for the radial modes. The radial-mode sequence gives a large separation of $\Delta\nu_0 = 0.968 \pm 0.015, \mu$Hz.

A further striking result is the narrowness of the mode profiles, indicating a very long mode lifetime of the order of one year, or possibly longer. These long lifetimes, together with the low noise and decade-long baseline, make Arcturus a uniquely valuable test case for mode identification, damping, and excitation in luminous red giants. The SONG observations therefore provide what may be the most precise p-mode frequency set yet obtained for a star at this evolutionary stage.

P-003: Peakbagging for asteroseismic binaries, extreme low signal-to-noise and super-Nyquist power spectra

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The individual mode frequencies of solar-like oscillators provide strong constraints on stellar structure and properties. PBjam is effective at identifying oscillation modes in high signal-to-noise power spectra for single stars that follow the simple frequency patterns. The analysis potential of PBjam is more limited for low signal-to-noise spectra, oscillations in the super-Nyquist regime, or spectra containing signals from asteroseismic binaries.

To address these cases, we developed PBjimmy: a bespoke analysis tool that has been tailored toward these three challenging regimes. PBjimmy follows the same core philosophy as PBjam - utilising a large prior dataset of stars to inform mode identification. However, an autoencoder is now used to perform dimensional reduction while retaining the important relations between the parameters of the power spectrum. The effectiveness of this approach is tested with a number of single and binary stars, using both synthetic examples and Kepler observations.

PBjimmy achieves the identification of individual mode frequencies in the super-Nyquist regimes and for asteroseismic binaries. For low signal-to-noise power spectra, it can provide estimates on $\nu_{\max}$ and thereby constraining broader stellar properties, such as the surface gravity of the star. PBjimmy increases the diversity of stars that can undergo analysis with asteroseismic techniques, which can be applied to observations from Kepler, TESS and for the future PLATO mission.

P-013: What to do?

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A lot of progress has been made in asteroseismology over the last couple of decades. This has to a large extent been driven by the vast increase in the quantity and quality of data. With PLATO due to be launched soon, continued observations by existing spacecraft and observatories and expected improvements to ground based observatories, we may expect substantial further progress.

In view of this, the key question is what one should work on? Apart from being interesting and having a reasonable chance of being successful, it should preferably be something that few or no people are already working on.

To help with this search I will describe a selection of problems I have thought of below and what might be done. The readers are invited to answer the important questions for each: Is it actually interesting? Does it make sense? Has it already been done? Are you already working on it? Interested in collaborating, whether you are working on it or not?

P-020: Modular Machine Learning Framework for Automated Asteroseismic Characterization of TESS Red Giants

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Asteroseismology probes the internal structure of stars and yields precise constraints on their mass, radius, and age. The TESS mission, with its near-full-sky coverage, is expected to yield over 300,000 oscillating red giants, many with multi-sector observations. However, extracting high-precision seismic parameters at this scale requires robust, automated techniques capable of handling varying signal-to-noise ratios (SNR). We present a modular machine learning framework designed for the automated inference of the frequency of maximum power (ν_{max}) and the large frequency separation ($\Delta\nu$). Our approach utilizes a multi-stage architecture: first, a 1D Convolutional Neural Network (CNN) infers νmax directly from the raw power spectral density (PSD) without manual preprocessing. This νmax value is then used to dynamically crop the PSD for a second specialized network. To achieve high precision in $\Delta\nu$, this second network integrates both the flattened PSD and the Power Spectrum of Power Spectrum (PSPS). By leveraging the PSPS, which peaks at harmonics of $\Delta\nu$, our model can infer $\Delta\nu$ very precisely and maintains robustness even for low-SNR targets where a direct PSD-based inference could fail. We demonstrate the efficacy of this pipeline on a sample of approximately 20,000 TESS red giants with 10 or more sectors of data, showing strong agreement with auto-correlation based inferences for high-SNR cases while providing superior reliability in the low-SNR regime. Our current efforts are focused on extending this high-precision PSPS-based inference to stars with as few as three sectors of TESS data. Furthermore, we are developing a specialized module to extract mixed-mode parameters, specifically the period separation of gravity-modes ($\Delta\Pi$) and the coupling factor (q). This module targets high-confidence, high-SNR stars identified in earlier stages of the pipeline for mixed-mode characterization where signal quality permits. Overall, this framework establishes a scalable, automated solution for analyzing massive datasets from TESS and future large-scale surveys such as Roman and PLATO.

P-047: Photometry of highly saturated TESS stars

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Saturation in TESS complicates simple aperture photometry, as flux can be lost to bleeding outside the target pixels. Halo photometry can nevertheless reconstruct good light curves of these stars, as a weighted linear combination of pixel time series from the unsaturated wings of the PSF. We have applied this to extract light curves for 98 bright TESS stars: we detect variability in 77, including 15 red giants, 5 δ Scuti variables, 8 stochastic low-frequency variables, and 8 eclipsing binaries. For the very brightest stars, such as α Cen, Procyon, and Capella, the saturation is too severe even for halo photometry. We therefore also present preliminary work on forward modelling the TESS detector by simultaneously fitting the PSF, intra-pixel sensitivity, and flux. We aim to achieve high-precision photometry using this method to detect variability and rule out transiting exoplanets at the ppm level.

P-048: Automated identification of dipole mixed modes in *Kepler* red-giant stars

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Dipole mixed modes provide unique insights into the internal structure of red giants, as they carry information from both the convective envelope and the radiative core. Consequently, identifying these modes allows for the determination of evolutionary states and physical conditions of the stellar interior. This identification typically relies on comparing observed frequencies with theoretical ones computed using the mixed-mode asymptotic relation. However, the process is challenging due to parameter-space degeneracies, stellar rotation, as well as missing modes and spurious peaks.

We present a new method for dipole mixed-mode identification that uses a spectral overlap metric to evaluate the agreement between theoretical and observed frequencies. We use a genetic algorithm to maximise this metric, and subsequently use the optimal parameters to perform a global assignment of the oscillation modes. Validation using synthetic spectra that include stellar rotation demonstrates that our strategy recovers over 95% of the mixed modes across different evolutionary stages. This performance remains robust against common observational challenges, specifically spurious peaks and missing modes. Our analysis demonstrates the capability of our pipeline to provide a homogeneous seismic characterisation of evolved stars. Finally, we apply the pipeline to over 2,000 *Kepler* red giants, facilitating detailed studies of their internal structure.

P-051: Fitting detailed frequency-dependent mixed-mode parameters in Red Clump Stars: Comparing phaseshifts, glitches and coupling strengths.

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Red Giant Asteroseismology provides a wealth of information through mixed modes, which contain both p and g modes characteristics, which allow us to probe the envelope and the core of the star. However, extracting this information often relies heavily on stellar models. This becomes particularly challenging when analysing Red Clump stars. Besides the uncertainties arising from the impact of the He-Flash on the interior structure, the description of the boundary of the convective He-burning core and the surrounding radiative zone is under active research. The reliability of models to study these stars suffers, and observational constraints to test and improve the models become essential. Therefore, we developed a code to explore the limits of obtainable information from the l=1 mixed modes frequency spectra of red clump stars. Using high signal-to-noise ratio Kepler stars, we fit a template based on asymptotic theory, which allows for an order-dependent coupling strength (q) and frequency-dependent phase shifts for both the p and g mode components (ε_p, $epsilon_g$). This approach allows us to account for the impact of acoustic and buoyancy glitches, while also investigating the frequency dependence of q. Our ongoing work will provide a high-quality sample of Red Clump stars to not only compare various asteroseismic parameters but also for future stellar modelling projects.

P-054: Do Scaling Relations Need to be Modified to Fit Red Giants? A Case Study of γ Per A

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γ Persei is a long-period eclipsing binary system ($P \approx 14.6$ years), as well as a spectroscopic binary containing a red giant primary. We determined the seismic parameters $\nu_{\rm max}$, $\Delta\nu$, and the oscillation amplitudes of its primary component and estimated its seismic mass, which we compared to its estimated dynamic mass. We used TESS data obtained during Sectors 85 and 86 and complemented the space-based observations with high-resolution RV measurements acquired by SONG during two distinct epochs in 2017 and 2024. We inferred a seismic mass of 3.27 ± 0.13 $M_\odot$ γ Per A, which is slightly below the dynamical mass of 3.6 ± 0.2 $M_\odot$ (Diamant et al. 2023). We found the photometric oscillation amplitudes to be significantly lower than predicted from scaling relations – yet in line with other high-mass red giants. We also found that radial velocity amplitudes along the Hertzsprung-Russell diagram cannot be fitted uniformly with current scaling relations, with red dwarfs requiring $(L/M)^{1.5}$ scaling but γ Persei requiring $(L/M)^{0.7}$.

P-056: Precise seismic characterisation of TESS Luminaries in the PLATO LOP fields

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The NASA Transiting Exoplanets Survey Satellite (TESS) is delivering high-precision photometry for millions of stars. The upcoming PLAnetary Transits and Oscillations of stars mission (PLATO) will push this frontier even further, providing long-duration, high-precision observations of tens of thousands of bright stars to be characterised through asteroseismology. At the heart of PLATO lies a fully automated seismic pipeline, a first of its kind, designed to systematically extract oscillation frequencies across an unprecedented stellar sample. To ensure its reliability, well-characterised reference stars spanning a wide range of physical properties are essential.

In this presentation, I will present a sample of 32 main-sequence and subgiant stars from the TESS Luminaries sample, all located within PLATO's long-duration observation fields, 26 of which are characterised here for the first time. These nearby, bright solar-like oscillators span effective temperatures from about 5300K to 6900K, offering a rare window into stellar interiors with exceptional precision. By combining their seismic signatures with ground-based follow-up observations, we can rigorously test models of stellar structure and evolution. Using TESS data through Sector 88 and three independent pipelines, we extract and validate individual oscillation mode parameters, ensuring robust and homogeneous measurements. Our results are broadly consistent with previous studies, while also revealing current limitations in identifying mixed modes in subgiants, pointing to the need for longer time-series observations. Beyond their value as astrophysical laboratories, these stars form a key reference sample for PLATO, supporting the early calibration and optimisation of its asteroseismic pipeline and helping secure the mission's full scientific potential.

P-059: Spectroscopically confirmed asteroseismic binaries with solar-like oscillators

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Solar-like oscillations provide powerful constraints on the current structure of a star's interior. However, key uncertainties on the model physics can still be a limiting factor when studying individual oscillators. Binary stars with two oscillating red giants offers a way to precisely study two co-eval stars with almost the same initial mass. I will first present spectroscopic follow-up observations aimed at confirming several candidate binary systems. Then, I will demonstrate how the observations of frequencies from a second oscillator can provide orthogonal information, allowing us to constrain stellar physics beyond what is typically feasible in field stars.

P-060: Asteroseismology of Red Giants in TESS Continous VIewing Zone

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TESS (Transiting Exoplanet Survey Satellite) has produced long-term photometry for millions of stars across the sky. In this work, we present an asteroseismic catalogue of 19,151 red giants in the TESS Continuous Viewing Zones using sectors 1–87 (Years 1–7). We visually assessed the power spectra for oscillations, and then applied the computationally efficient nuSYD method to confirm reliability. We identified an increase of 80% in the number of previously known oscillating red giants at a TESS magnitude > 8. We determined the frequency of maximum power and the large frequency separation using the pySYD pipeline, achieving typical precisions of 1.5 % and 1.0 %, respectively. We classified the stars into Red Giant Branch (RGB) and Core Helium Burning (CHeB) classes using a Convolutional Neural Network. Using spectroscopic data for 10,298 stars with reliable asteroseismic measurements, we have been able to measure stellar mass and radii with precisions of 7.5% and 2.8%, which is comparable to that from 4-yr Kepler data. A comparison of the seismic radii with independent radii measurements shows excellent agreement. With three years of TESS data, the asteroseismic parameters are precise enough to identify the RGB bump and delineate the Zero Age Helium Burning edge. Combined with Gaia data, these parameters reveal established trends across the Galactic plane, providing a valuable set of uniformly determined asteroseismic parameters for Galactic Archaeology.

P-067: Potential of Gaia XP spectra in red giant star asteroseismology: a deep-learning approach

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Context : Red giants are key tracers of stellar evolution and Galactic structure, and their asteroseismic properties — particularly the large frequency separation ($\Delta\nu$), the frequency of maximum oscillation power ($\nu_{\rm max}$), and the dipole-mode period spacing ($\Delta\Pi_1$) which — provide direct insight into their internal structure, masses, and evolutionary states. Until now, seismic inferences on large stellar samples have relied primarily on high-quality light curves from missions such as *Kepler* and *TESS*, or on moderate-resolution spectroscopy (LAMOST : $\mathcal{R} \sim 1,800$ and APOGEE : $\mathcal{R} \sim 22,500$) that clearly preserve information correlated with these seismic quantities.

Aims : With Gaia XP spectra ($\mathcal{R} \sim 15$–85), the possibility arises to extend asteroseismic measurements to orders of magnitude more stars, despite the much lower spectral resolution. Our goal is to assess whether XP spectra retain enough information that enable reliable seismic inference for red giants.

Methods : We develop hybrid Convolutional Neural Network (CNN)-Long Short-Term Memory (LSTM) models trained on red giants with seismic parameters measured from *Kepler* photometry. The networks learn the subtle spectral signatures — imprinted through global stellar properties — that correlate with $\Delta\nu$, $\nu_{\rm max}$, and $\Delta\Pi_1$.

Results : The models recover all three global asteroseismic parameters from Gaia XP spectra with accuracies comparable to results based on moderate-resolution surveys such as LAMOST, demonstrating that even low-resolution spectrophotometry carries sufficient information for seismic prediction. Saliency analysis reveals wavelength regions most strongly associated with seismic sensitivity and highlights physically distinct spectral behavior between RGB and RC stars. Applying our models to Gaia DR3 yields seismic predictions for more than 2.5 million bright red giants, enabling population-level asteroseismic studies on an unprecedented scale. We also identify a small subset of low-$\Delta\nu$ red clump candidates showing unusual spectral-seismic correlations, offering new avenues for investigating evolved stellar populations.

P-069: Revealing mixed modes in compressible hydrodynamical simulations of red giant stars

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Mixed pressure-gravity modes are observed in many low-mass evolved stars. They provide information about the core rotation rates of these stars, which are lower than predicted by current stellar evolution models. The mixed modes themselves have been invoked as an angular momentum (AM) transport mechanism, but estimating their transport efficiency requires knowledge of their amplitudes. We constrain, for the first time, the mixed mode amplitudes in 2D hydrodynamical simulations of a $1.3M_\odot$ red giant using the code MUSIC. We compare the modes found in two simulations, with different outer radial truncations $r_o/r_\star = 0.90$ and $r_o/r_\star = 0.98$, with those found using both the stellar oscillation code GYRE and a DEDALUS eigenvalue solver. The eigenfunctions and eigenfrequencies of simulations and linear theory agree excellently. In both simulations the modes with low frequencies have the largest amplitudes and kinetic energies, which decrease rapidly with increasing frequency. The much smaller kinetic energies predicted by an empirical scaling law show a "Gaussian-like" shape centered on intermediate frequencies instead. Finally, the simulated modes are extrapolated to the stellar surface to determine their surface velocities, and thus observabilities. Only the modes in the simulation with outer radial boundary $r_o/r_\star = 0.98$ have comparable extrapolated surface velocities to the empirical prediction, with largest surface velocities located at higher frequencies than found using the empirical prediction. The extrapolated surface velocities of the low frequency modes are small, making them hard to observe. As a result, their contributions to AM transport have so far been neglected. Their large kinetic energies means these contributions could be significant, however, and should be considered when studying AM transport.

P-073: Limb-darkened Intensity Profiles of Red Giant Stars Using CHARA Interferometry

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Limb darkening, the dimming of a star's edge compared to its centre, affects how we measure its radius and temperature. Using optical long-baseline interferometry from the PAVO beam combiner at the CHARA Array, we can map this brightness across a star's disk with high precision and determine its angular size. By combining this with its parallax and spectra, we can infer accurate stellar radii and temperatures. Interestingly, the radii derived from PAVO appear to be systematically lower by about 2% than those predicted by the 3D STAGGER atmosphere models, suggesting potential refinements to theoretical prescriptions. An accurate description is also vital for exoplanet transit spectroscopy. Since our targets are bright evolved stars, most exhibit solar-like oscillations detectable in TESS power spectra. We also present a direct comparison between interferometric and asteroseismic scaling radii, providing a stringent cross-calibration of the two methods.

P-074: Seismic Characterization of a Homogeneous Sample of Solar-Type Stars

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We present a homogeneous catalog of fundamental stellar parameters for a sample of solar-type stars, including masses, radii, surface gravities, and ages, derived by combining asteroseismic and spectroscopic constraints. The analysis is based on a Bayesian inference framework, which enables a consistent and statistically robust determination of stellar properties while properly accounting for observational uncertainties and parameter correlations.

Our methodology incorporates global seismic observables, such as the frequency of maximum power and large frequency separation, together with spectroscopic measurements of effective temperature, metallicity and precise chemical composition. These inputs are compared against grids of stellar evolution models to infer posterior probability distributions for each stellar parameter.

To assess the reliability and accuracy of our results, we perform a detailed comparison with previous benchmark studies, including APOKASC-1, the Gaia-Kepler catalog, and the LEGACY sample. We analyze systematic offsets and dispersions in the derived parameters, highlighting the level of agreement as well as potential discrepancies arising from differences in input physics, modeling assumptions, or analysis techniques. These comparisons provide valuable insight into the robustness of seismic inferences and the impact of methodological choices on derived stellar properties.

Our catalog represents a step forward toward the construction of consistent and high-precision stellar parameter datasets, which are essential for exploiting the full potential of current and future asteroseismic and spectroscopic surveys. The methodology presented here is readily extendable to larger samples and can be adapted to incorporate additional observational constraints, paving the way for improved characterization of solar-type stars in the era of large-scale stellar surveys.

P-076: Interpreting and fitting asteroseismic frequency separation ratios with static stellar models

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The observed asteroseismic frequency separation ratios between the small and large frequency separations ($r_{\ell,\ell+2}(n)$) probe stellar core properties, providing a powerful diagnostic of the internal structures of main-sequence stars. Although these ratios are known to vary as stars evolve, the distinct effects of individual global and internal stellar parameters on them have not yet been clearly isolated and quantified. In this work, we compute static stellar models with systematically varied global properties and internal structures using `MESA`. By calculating oscillation mode frequencies and fitting linear combinations of Chebyshev polynomials to the relation between the separation ratios and radial-mode frequencies, we determine how $r_{\ell,\ell+2}(n)$ responds to changes in stellar mass, metallicity, core mass, central hydrogen abundance, and envelope hydrogen abundance. We further demonstrate how matching observed and model separation ratios can be used for asteroseismic inference, and compare results from static stellar models with those obtained from full evolutionary models.

P-087: New scaling relations from MESA models for mass and radius of subgiant stars: application to *Kepler* targets

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The precise determination of the fundamental parameters of stars is crucial for understanding stellar structure and evolution. In this regard, the asteroseismic parameters of solar-like oscillating stars obtained from space telescopes are very useful for determining the mass (M) and radius (R) of single stars using classical scaling relations. These relations still need to be improved. In this study, we develop alternative scaling relations based on reference frequencies ($\nu_{\rm min}$) due to helium ionization zone glitches, specifically for subgiant (SG) stars. We compile main-sequence (MS) and SG MESA models from the literature and derive new scaling relations for stellar R and surface gravity (g) of evolved stars. The expressions for R and g are obtained simultaneously as functions of the large frequency separation, $\nu_{\rm min}$, and metallicity. These new relations allow M and R to be reliably determined only from observational parameters, without the need for detailed stellar modelling. The resulting $\nu_{\rm min}$-based relations are applied to a sample of 31 *Kepler* SG stars with masses in the range 0.85–1.74 $M_\odot$ and radii between 1.03 and 2.82 $R_\odot$. Using simultaneous solutions, we estimate new mass and radius ranges of 0.89–1.62 $M_\odot$ and 1.04–2.95 $R_\odot$, respectively. The results demonstrate significant improvements in the determination of M and R for evolved *Kepler* target stars, highlighting the potential of the new scaling relations in asteroseismic analyses.

P-091: Solar-like oscillations in pre-MS stars

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The theoretically predicted class of pre-main sequence (pre-MS) solar-like oscillators is yet to be observationally validated. The task of detecting solar-like oscillations requires firstly a multi-modal background fit in Fourier space, composed of granulation variability and instrumental noise. Around a characteristic frequency, $\nu_{\rm max}$, oscillations may then exist as an excess in power. Identifying the oscillations therefore depends on the ability to obtain several independent estimates of $\nu_{\rm max}$ before a full fit is attempted. Following previous literature, with this work, we present two such methods: In the first, a 2D autocorrelation function (ACF) is calculated, and oscillations are identified by having significant ACF-power. In the second, the coefficient of variation (CoV = σ/μ) is calculated in sliding bins across the spectrum; the regions with oscillations similarly attain high CoV values. The methods are validated against red-giants and main-sequence stars observed with Kepler and TESS. This provides the necessary framework for establishing the first confirmed detection of solar-like oscillations in a pre-MS star.

P-097: Rapid automated seismic inference of red giants: a hierarchical pipeline for mixed modes and internal dynamics

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Red giant stars host gravity (g) modes in their deep interiors, which become observable as mixed modes through coupling with acoustic (p) modes. These mixed modes provide a powerful diagnostic of stellar structure and dynamics, enabling constraints on properties such as core rotation, internal magnetic fields, and the redistribution of angular momentum. Extracting this information, however, requires precise estimation of seismic parameters and detailed modelling of observed power spectra. We present a hierarchical analysis pipeline designed for the rapid and robust extraction of seismic parameters in red giants, while reducing human intervention in the fitting process to a minimum. In this framework, parameters of radial ($\ell = 0$) and quadrupole ($\ell = 2$) p-modes, along with the global properties of dipole ($\ell = 1$) mixed modes, are determined using a combination of machine learning techniques, Monte Carlo sampling, and complementary statistical methods. This approach enables efficient initialisation and convergence of detailed spectral modelling in a largely automated manner. Applying this pipeline to a large ensemble of long-duration observations of red giants, we perform a systematic study of their seismic properties. The resulting measurements provide statistical leverage on internal rotation profiles and offer constraints on the efficiency of angular momentum transport across stellar evolution. Our method significantly accelerates parameter estimation while maintaining accuracy, thereby facilitating scalable, ensemble-level investigations of stellar interiors in the era of large-scale stellar surveys.

P-099: A bumpy ride: the physical origin of the red-giant bump

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Stars with masses roughly below 2 $M_\odot$ evolving up the red-giant branch go through the so-called red-giant bump. At the bump, the stars experience a temporary decrease in luminosity, before the luminosity increases again. This zig-zag means that stars remain longer at roughly the same luminosity, which causes an over density of stars in observed stellar populations. This over density can be used to calibrate stellar models. These models play a crucial role in asteroseismic inferences.

The end-point of the bump is well-understood, i.e. this is when the hydrogen burning shell burns through the mean molecular weight discontinuity left behind by the receding base of the convection zone. However, the onset of the bump is still an enigma. In this talk I will discuss the physical origin of the onset of the luminosity bump through changes in the specific entropy at and around the mean molecular weight discontinuity.

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Posters: Other variables

P-001: Understanding White Dwarf Stellar Structure with Seismology

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White dwarfs with hydrogen-dominated atmospheres pulsate as they cool through a narrow temperature range from roughly 12,500-11,000 K. These pulsations are g-modes which penetrate deep into the interior of the star; their periods are sensitive to stellar structure, and especially the mass of the outermost hydrogen envelope. TESS and Kepler have observed more than 100 pulsating white dwarfs, a sample size which will allow us to perform statistically meaningful ensemble asteroseismology. I will present our ongoing efforts to pulsate the white dwarf cooling sequence models from the MESA Isochrones and Stellar Tracks (MIST) library, creating a high-resolution grid of asteroseismic data which takes into account the latest developments in the physics of white dwarf cooling, chemical diffusion, and crystallization. Additionally, I will present our ongoing efforts to analyze observed pulsators using this grid, with the ultimate goal of measuring the distribution of white dwarf hydrogen layer masses.

P-016: New Timescales of Variability in the Highest-Amplitude White Dwarf Pulsator

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WD 0158−160 (TIC 257459955) is a pulsating helium-atmosphere (DBV) white dwarf. TESS observed the star in Sectors 3, 30, and 97. Sector 3 exhibits a rich set of modes typical of DBVs, consistent with a sequence of dipole *g*-modes, with the dominant signal at $\sim$ 640 s and a peak-to-peak amplitude of 5.2%.

In Sector 30, the pulsations appear strikingly different. The dominant mode shifts to 641 s and grows to an amplitude of 10.6%, making WD 0158−160 the highest-amplitude white dwarf pulsator observed in the TESS bandpass. This mode exhibits a highly nonlinear pulse shape with four significant harmonics in the periodogram, while the other previously detected modes are notably absent.

In addition, there appear four low-amplitude signals tailing the lower-frequency side of the dominant signal and each harmonic signal in Sector 30, each with the same frequency separations. We interpret these as representing amplitude modulation of the high-amplitude pulsation on four discrete timescales: 652 s, 664 s, 675 s, and 677 s. Pulsation variations on these timescales have never been observed in a white dwarf, representing a new pulsational phenomenon.

By Sector 97, the star returns to behavior typical of a rich DBV pulsator.

P-018: Photometric analysis of KQ Pup, one of the closest red supergiants

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KQ Pup is among the handful of red supergiants, and thus SN progenitors, found within 1 kpc from the Sun. It is the largest member of a triple system, where the eclipsing binary nature of the secondary was recognized only recently from TESS observations. The light variations of the primary have been scarcely studied, but approximate periodicities have been identified from ground-based and HIPPARCOS photometry. Here we present the analysis of the most comprehensive photometric data of KQ Pup yet, combining multiple ground-based data sources with data from the HIPPARCOS and SMEI space missions. We detail the correction steps used to rectify the SMEI data, and estimate the oscillation periods of the star, which can be used for asteroseismic modeling in the future. We also present signatures of other types of photometric variation in the star, including periastron brightening and short eclipse-like features near apastron.

P-025: A detailed view of Antares: multiple pulsation modes and the long secondary period

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Antares is one of the nearest red supergiants, yet its variability has received much less attention than that of Betelgeuse. We present a detailed analysis of its photometric and radial velocity variability based on the longest and most precise light curve of Antares to date, constructed from nearly nine years of space-based observations of the Solar Mass Ejection Imager (SMEI), complemented by radial velocity measurements from the STELLA telescope and from the literature. The corrected light curve reveals variability on multiple timescales. We identify a long secondary period (LSP) on the order of several thousand days in the photometric data, with the radial velocity measurements showing a similar timescale. The phase difference between the two signals is comparable to that observed in Betelgeuse, indicating that a purely radial pulsation origin is unlikely and instead suggesting circumstellar dust modulation, possibly associated with a close, low-mass companion. After removing the long-period component, frequency analysis of the residual light curve reveals multiple pulsation modes. We identify the fundamental radial mode (∼260 days) and the first overtone (∼130–145 days), with a period ratio close to 2:1, and detect an additional ~95-day periodicity that may correspond to the second overtone. The first clear and simultaneous detection of these modes provides a more complete view of the pulsational behaviour of Antares than previously available. These results provide a coherent picture of the variability of Antares, highlighting its multi-periodic nature. If confirmed, the identification of the second overtone would place strong constraints on future asteroseismic models of Antares and would improve our understanding of variability in red supergiants in general.

P-038: Mode Instability and a Massive, Isolated Outburst in the Pulsating White Dwarf GD 1212

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We analyze a large brightening event that lasted for roughly half a day in the pulsating hydrogen-atmosphere white dwarf GD 1212 during K2 Campaign 12 of the extended Kepler mission. For the other 80 days of K2 observations, GD 1212 exhibited a rich spectrum of long-period (~1100 s) pulsations that underwent rapid variations in frequency and amplitude but did not exhibit any additional outbursts. We refine previous attempts at mode identification and find a likely sequence of dipole and quadrupole splittings that reveal an overall rotation rate of roughly 17.0 hr. The outburst at Day 61 is fully resolved by the 60-second-cadence K2 data, with the entire white dwarf becoming up to 17.5% brighter overall (from an ≈ 850 K increase in T_{eff}), with pulsational variability during the outburst showing shorter periods and higher amplitudes. Outbursts are believed to be the result of nonlinear mode coupling via parametric instability, whereby energy stored in linearly excited parent modes is rapidly transferred to damped child modes that dissipate near the surface of the white dwarf. Additionally, we characterize a "failed" outburst that caused correlated pulsation frequency changes (≈ 5 μHz increase) with a small (≈ 0.35%) corresponding brightness increase. GD 1212 is now the eighth pulsating hydrogen-atmosphere (DAV) white dwarf to show outburst behavior, although it exhibited the largest outburst yet and has the longest inferred recurrence timescale. This high-signal-to-noise record tracing pulsations through both large and small temperature excursions in GD 1212 provides unique insights into parametric resonance and nonlinear mode coupling in white dwarf pulsations.

P-064: Exploring hydrodynamical stellar tachoclines along the evolution of low-mass stars

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Stellar tachoclines are thin transition regions separating the radiative core from the convective envelope of solar-type stars. Because these have distinct rotation regimes, with important latitudinal differential rotation in the convective zone and a near solid-body rotation in the radiative zone, tachoclines are naturally the seat of strong shear and turbulence. Modelling transport and mixing within the tachocline is thus key to understand how dynamical processes in the convective envelope influence the long-term evolution of the radiative core. In particular, we expect the evolution of the differential rotation of the convective region to affect the secular evolution of the tachocline. Another key factor governing its long-term evolution is the dominant regime of heat transport: whether through a vertical microscopic diffusion as proposed by Spiegel & Zahn (1992) or through a strong horizontal turbulent transport, as proposed by Garaud et al. (2025).

To date, stellar evolution codes only consider a solar-like conical differential rotation profile in the convective envelope, characterised by a faster equator and slower poles, when modelling tachocline dynamics. However, this latitudinal differential rotation is expected to vary significantly over the course of stellar evolution, from cylindrical profiles during the early phases of evolution to conical anti-solar profiles (i.e. with a pole rotating faster than the equator) for stars older than our Sun. After demonstrating that the formalism of Mathis & Zahn (2004), within the thin-layer approximation, provides a consistent framework for describing hydrodynamical tachoclines as in Spiegel & Zahn (1992) and Garaud et al. (2025), we extend this approach to account for any regimes of differential rotation in the convective zone, as well as any regimes of heat transport in the radiative region. Notably, we find that fast cylindrical rotation tends to generate larger meridional circulation cells within the tachocline, thereby increasing the radial extent of the latitudinal differential rotation. This leads to enhanced in-depth mixing compared to other rotational regimes, suggesting that shear-induced mixing in stellar tachoclines is particularly efficient during the early main-sequence phase.

P-077: Strategic Improvements to White Dwarf Asteroseismic Fitting in the Gaia Era

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Pulsating white dwarf stars have complex interior structures that, in principle, can be probed by the resonant frequencies of their standing wave oscillations; these resonant frequencies manifest as measurable, periodic brightness variations at the surface of the star. The traditional approach used to match observed pulsation frequencies to those computed by stellar evolution models (to within uncertainties) is known as period-by-period asteroseismic fitting. However, there remain significant hurdles in achieving reliable results using the period-by-period fitting approach for white dwarfs, and improved methodologies are required to address these issues. In this poster, we present novel strategies to characterize precise asteroseismic solutions in the Gaia era. Firstly, we demonstrate that the computational burden of computing large grids of models can be reduced by interpolating model periods over coarse grids. Second, we show how by incorporating absolute magnitude from Gaia astrometry into the statistical quality function used in the period-by-period fitting, solution degeneracy is significantly reduced. Lastly, we present a new method of isolating seismic solutions in a degenerate solution space based on fixed mode identification. By fitting Gaussian distributions to the resulting solutions, we can more accurately characterize the precision and degeneracy of the asteroseismic constraints.

P-080: Non-radial modes in Cepheids of the Large Magellanic Cloud observed with TESS

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Classical Cepheid variables are essential in our understanding of stellar pulsation. Cepheids that pulsate in the first overtone mode often exhibit low-amplitude additional variability at the millimagnitude level. Signals that appear at period ratios $P_X/P_{1O} \in [0.60; 0.65]$ are theorized to be associated with non-radial modes and have been extensively studied in Cepheids of the Large Magellanic Cloud (LMC) with the Optical Gravitational Lensing Experiment (OGLE). Non-radial modes have also been detected in a significant fraction of the Galactic Cepheid sample with TESS.

In this work, we show that these low-amplitude features can also be detected in the LMC with TESS, despite its poor spatial resolution, which does not favor observations in crowded stellar fields. Most LMC Cepheids are located in the Continuous Viewing Zone, which allows the analysis of longer uninterrupted light curves and the detection of temporal variations. After careful detrending and stitching of the light curves, the required precision for a large fraction of LMC Cepheids can be achieved.

Our sample consists of nearly four hundred stars. We have analysed the currently available TESS-Gaia light curves extracted from Full Frame Images gathered with 30 minute and 10 minute cadence from the Prime and First Extended missions, respectively. We use standard Fourier techniques to recover the low-amplitude modes. We verify non-radial modes in 94 stars that were first detected with OGLE. The detectability of these modes with TESS and OGLE are compared. We also identify a number of new candidates for non-radial pulsation.