COMMISSION G4	PULSATING STARS

PRESIDENT	**Robert Szabo**
VICE-PRESIDENT	**Jadwiga Daszynska-Daszkiewicz**
PAST PRESIDENT / ADVISOR	**Jaymie Matthews**
SECRETARY	**Maria Pia Di Mauro**
ORGANIZING COMMITTEE	**Victoria Antoci, Daniel Huber,**
	Steven D. Kawaler, Marcella Marconi
	Konstanze Zwintz

TRIENNIAL REPORT 2018-2021

1. Introduction

Over the last three years, thanks to the successful photometric space missions CoRoT, NASA/Kepler and NASA/TESS and BRITE-Constellation, supported by several spectroscopic ground campaigns, asteroseismology has continued to contribute to the extraordinary revolution happening in astrophysics, unveiling a wealth of results on the physical properties of the stars over a large part of the HR diagram and enabling us to characterize the structure and evolution of the planetary systems, studying the formation and dating of our Galaxy and the universe's chemical evolution.

The international community accummulated expertise in theoretical modelling and analysis of oscillation data for stars of different spectral types, and at present is highly involved in the preparation of future space mission ESA/PLATO and is engaged in fighting the new challenges of modern stellar physics.

2. Notable scientific results and publications

During the period 2021-2023, the Pulsating Stars community has contributed to science with almost a thousand publications, of which at least 600 are refereed articles. Among those, the most cited is the general review by C. Aerts (2021) published in Reviews of Modern Physics. In this period, the most important results have been obtained by merging asteroseismic, spectroscopic (e.g. APOGEE, APOKASC, LAMOST), and GAIA astrometric constraints. Among these results, it is important to point out the study of the age-chemo-kinematic properties of the Galaxy, which revealed evidences for occurrence of catastrophic events and for an efficient radial migration of stars in the thin disc (e.g. Miglio et al. 2021; Montalbán et al. 2021).

In addition, other examples of asteroseismic direct inferences relevant for the advancement of stellar physics include: studies on the mass-loss efficiency along evolution (e.g, Yu et al. 2021), measurement of the magnetic field strengths in the interior of the stars and constraints on the field topology (e.g, Li et al. 2022, 2023), inferences on the dynamo action and balance between rotation and convection (e.g. Corsaro et al. 2021; Bonanno et al. 2022), and evolution of the magnetic activity (Mathur et al. 2023).

In addition, we try to give below a not exhaustive list of other interesting results on pulsating stars:

2021

Soszyński et al. (2021) announced the discovery and presented the basic characteristics of over 24,000 δ Scuti stars in the Galactic Bulge and Disk from the OGLE Survey.

Miszuda et al. (2021) studied, for the first time, the effect of binary evolution on pulsational properties of δ Scuti star models. They demonstrated that due to the mass transfer, the outer layers of the main component are enormously enriched with helium and depleted of hydrogen. This in turn affects the instability of pulsational modes.

Murphy et al. (2021) analysed the TESS data of HD 139614 which is a a 14-Myr-old pre-main-sequence star in the Sco-Cen OB association in the Upper Centaurus-Lupus subgroup. Asteroseismic, grid-based modelling allows a precise age, mass and global metal abundance determination, representing the first asteroseismic determination of the bulk metallicity of a λ Boo star. The precise age and metallicity offer a benchmark for age estimates in Upper Centaurus-Lupus, and for understanding disc retention and planet formation around intermediate-mass stars.

Saio et al. (2021) investigated the period spacing versus period of dipole prograde g modes in 16 γ Doradus stars. They found that the majority of these objects rotate nearly uniformly, while convective cores tend to rotate slightly faster than the g-mode cavity in less evolved stars.

Pedersen et al. (2021) provide core-to-surface mixing profiles inferred from observed dipole gravity modes in 26 rotating stars with masses between 3 and 10 solar masses and find a wide range of internal mixing levels across the sample. The authors conclude that stellar models with stratified mixing profiles in the envelope reveal the best astero-seismic performance. These results provide observational guidance for three-dimensional hydrodynamical simulations of transport processes in the deep interiors of stars.

Mercury-manganese stars are late-B upper main sequence stars exhibiting large over-abundances of heavy elements, and slow rotation. Kochukhov et al. (2021) analysed 64 of them with TESS 2-min cadence data and found found rotational variability in most of the targets, indicating ubiquitous presence of star-spots on their surfaces. Rotational period measurements revealed some fast-rotating stars, as well. The authors also identified several HgMn stars showing multiperiodic g-mode pulsations, tidally induced variation and eclipses in binary systems.

Based on CoRoT, TESS, and spectroscopic data, as well as MESA models, Steindl et al. (2021) studied the pulsational and mass accretion properties of pre-main-sequence stars, i.e. accreting protostellar seeds. This is a fundamental step towards the asteroseismic characterization of pre-main-sequence stars.

Netzel & Kolenberg (2021) looked at the potentially observable spectroscopic signs of additional pulsational modes discovered in photometric time series observations of classical pulsators (Cepheids, RR Lyrae stars) pulsating in the first radial overtone mode. Based on their investigations the detection of these low-amplitude modes is challenging, but not impossible.

De Somma et al. (2021) derived period-age and multi-band period-age-colour relations for Classical Cepheids that also take into account variations in the mass-luminosity (ML) relation. The relations were applied to Gaia Early Data Release 3 Cepheids to obtain their ages and age distributions.

In addition, the Frontiers research topic *Asteroseismology in the Kepler Era* containing 11 papers was also published in 2021.

2022

Kurtz (2022) gave an excellent overview of the rapid growth of asteroseismology beyond solar-like oscillators and red giants thanks to the *Kepler* and *TESS* space missions.

It focused on massive upper main sequence OBAF stars, pre-main-sequence stars, peculiar stars, classical pulsators, white dwarfs and subdwarfs, and tidally interacting close binaries.

Mombarg et al. (2022) computed a new generation of MESA stellar models of intermediate mass dwarfs with radiative levitation and shear mixing to explain the periods of trapped gravity modes in γ Doradus stars observed with Kepler and TESS.

For 60 γ Doradus stars observed with TESS, Garcia et al. (2022) the obtained the pulsation mode identification, internal rotation, and buoyancy travel time. The authors can constrain the internal rotation and buoyancy travel time to a precision of 0.03 d^{-1} and 400 s, respectively, which is about half as precise as literature results based on 4-yr-long Kepler light curves of γ Dor stars.

Jayaraman et al. (2022) presented the first conclusive discovery of tidally tilted pulsations in a subdwarf B star, HD 265435 based on TESS 20-sec cadence observations. This sdB star forms a close binary system with a white dwarf on a 1.65 hr period and is one of the nearest potential Type Ia supernova progenitors.

Steindl et al. (2022) established using asteroseismic data that accretion history leaves a potentially detectable imprint on the stars' interior structures. This has profound consequences on understanding stellar structure studies in the earliest stages of stellar evolution.

By combining polarimetry with space-based photometry and archival spectroscopy Cotton et al. (2022) detected polarization variations due to non-radial modes in the β Cephei star β Crucis for the first time. Polarization measurements allow mode identification and detailed seismic analysis in this case.

Marconi et al. (2022) computed a set of updated nonlinear RR Lyrae pulsation models that were transformed into the Vera C. Rubin Observatory Legacy Survey of Space and Time (Rubin-LSST) photometric system to help the exploitation of the upcoming revolutionary sky survey.

Netzel & Smolec (2022) computed pulsation models for overtone RR Lyrae stars (RRc) that exhibit the characteristic extra periodicities with a period ratio of 0.61 with the radial overtone mode. Assuming that the origin of these frequencies are nonradial modes, this is one of the first attempts of doing asteroseismology on classical pulsating stars.

Bhardwaj (2022) discussed the evolutionary stages of RR Lyrae and type II Cepheids, as well as their pulsation properties, including the light curves, color–magnitude and period–amplitude diagrams, and period–luminosity relations in globular clusters at optical and infrared wavelengths.

Molnár et al. (2022) presented the first results on 118 nearby RR Lyrae stars based on the TESS mission Sector 1 and 2 data. Among other things they found that 28% of the RRab stars are not Blazhko-modulated.

Forró et al. (2022) investigated background pixels of the *Kepler* mission and identified and characterized 26 new, faint RR Lyrae stars which nicely complement the sample of already known Kepler RR Lyrae stars having unprecedented, uninterrupted high-precision optical photometry.

Period variations and fluctuations of 148 galactic Classical Cepheids are presented in the work of Csörnyei et al. (2022). The authors extended the time-series data to cover more than a century in many cases. One of the findings is that O-C variations of non-evolutionary origin are common in many objects.

2023

Daszyńska-Daszkiewicz et al. (2023) demonstrated a strong sensitivity of seismic models of double-mode radial δ Scuti stars on the adopted opacity data. Only the OPAL

seismic models are caught within the observed error box in the H-R diagram. Seismic models computed with the OP and OPLIB data are much cooler and less luminous. This "seismic opacity" discrepancy requires further studies.

Molnár et al. (2023) investigated the globular cluster M80 with the Kepler/K2 mission, Gaia and spectroscopic observations. They identified a preciously overlooked subclass of RRc stars that show peculiar modulations.

The Gaia Data Release 3 (Vallenari et al. 2023) is a major step forward in stellar astrophysics research in general and pulsating stars in particular. Rimoldini et al. (2023) classified 9 million variable objects out of which more than 5 million are pulsating or oscillating stars. De Ridder et al. (2023) detected low-amplitude modes in 100,000 OBAF main-sequence pulsators, i.e. intermediate- and high-mass stars across the whole sky. Clementini et al. (2023) published the largest, most homogeneous, and parameter-richest catalogue of all-sky RR Lyrae stars containing over 200,0000 objects. Ripepi et al. (2023) published 15,000 Cepheids observed by Gaia in the Galaxy and in the closest extragalaxies.

Using asteroseismology, TESS photometry, GAIA astrometry, and high-resolution spectroscopy, Burssens et al. (2023) deduced the convective core mass and demonstrated non-rigid radial rotation in the supernova progenitor HD 192575. This star is a unique anchor point for studying interior rotation and mixing processes, and thus also angular momentum transport mechanisms inside massive stars.

Aerts & Mathis (2023) provide a numerical counterpart of the theoretical expressions for the mode-coupling coefficients, ϵ and $\tilde{\epsilon}$, by using asteroseismic forward models of 26 SPB stars and 37 γ Dor stars. The authors revealed that young, fast-rotating γ Dor stars are most suitable for undergoing couplings between inertial modes in the rotating convective core and gravito-inertial modes in the radiative envelope. The phenomenon has been found in 2.4% of such pulsators with detected period spacing patterns, whereas it has not been seen in any of the SPB stars so far.

3. Conferences

Due to the COVID situation, many meetings focusing on pulsating variable stars were cancelled, postponed, or went online, especially at the beginning of the reporting period. Our community got more engaged in in-person and hybrid meetings as the pandemic situation improved. Many postponed meetings got organized finally, thus a vivid conference and workshop scene emerged.

2021

The annual meeting of the European Astronomical Society was held again online (28 Jun – 2 Jul, 2021).

The TESS Science Conference II was held online between 2-6 August in 2021 organized by MIT (Cambridge, MA, USA).

The 2021 MESA School was held between 9-20 August with a significant pulsation curriculum.

The PLATO Mission Conference 2021 'Exploring exoplanets in the habitable zone of solar-like stars, held from 11 to 15 October 2021 as online event.

In October-December 2021 we had the KITP institute program, *Probes of Transport in Stars* and an associated conference in November.

2022

The MW-Gaia Workshop *Fundamental stellar parameters from asteroseismology in the era of Gaia* was organized in Aarhus between 13th and 15th June, 2022.

The annual meeting of the European Astronomical Society was held in-person in Valencia, Spain from 27 Jun to 1 Jul, 2022.

The TASC6/KASC13 Workshop *Asteroseismology in the Era of Surveys from Space and the Ground: Stars, Planets, and the Milky Way* took place in Leuven, Belgium from 11 to 15 July in 2022.

The fourth edition of the RRLCEP meetings: RR Lyrae/Cepheids 2022 – *Large-scale surveys as bridges between spectroscopy and photometry* took place in the island of La Palma (Canary Islands, Spain) from 26 to 30 September, 2022.

2023

After several postponements, the IAU Symposium No. 376 *At the crossroads of astrophysics and cosmology: Period-luminosity relations in the 2020s* was held in Budapest, Hungary (17-21 April) and a related International Spring School titled *Modern methods of cosmic distance determination* was organized by Konkoly Observatory from 12 to 15 April.

The PLATO Stellar Science Conference 2023 was organized in Milazzo (Italy) between 26-30 June, 2023.

The annual meeting of the European Astronomical Society was held in-person in Kraków, Poland (10 Jul – 14 Jul, 2023).

The MIAPbP scientific program on *Stellar astrophysics in the era of Gaia, spectroscopic, and asteroseismic surveys* took place from 31 July to 25 August, in Garching, Germany.

The next edition of the MESA Summer School was held in Budapest, Hungary (28 Aug - 1 Sep) for first time outside the United States.

3.1. *Conferences and meetings in preparation*

At the time of writing preparations are underway for the MESA School (*MESA Down Under*) in Sydney, Australia in June 2024. The TESS science conference will be held at MIT from 29 July to 2 August, 2024. The 3rd LAMOST-Kepler/TESS workshop, *Synergies between ground-based spectroscopic surveys and space-based photometric missions* Beijing (China) from the 21st to the 24th of May, 2024.

Just as the IAU General Assembly, the next RRLCEP conference will be held in Africa for the first time. The event titled *Frontiers of Classical Pulsators – Theory and Observations* is organized in Marrakesh, Morocco in November, 2024 along with the Oukaimeden International School of Astrophysics (OISA2024) for students.

The European Astronomical Society Annual Meeting will be heled in Padua (Italy) between 1-5 July 2024. It will feature relecant sessions for the Commission: Special Session 21: *The PLATO mission: Towards new horizons in Exoplanet and Stellar Science* and Symposium S8: *Asteroseismology in multiple-star systems in the era of large photometric surveys* among others.

The 8th TESS/15th Kepler Asteroseismic Science Consortium Workshop will be in Porto, Portugal, 15-19 July, 2024. The *BRITE Side of Stars* conference celebrating the 10th Anniversary of BRITE Constellation will be held in Vienna (Austria) between 20-23 August, 2024. The conference *Unveiling the interiors of stars to grasp stellar populations* will take place in Cefalù (Italy), on September 23-27, 2024.

4. Awards and prizes

The **2022 Kavli Prize in Astrophysics** has been awarded to Conny Aerts, Jørgen Christensen-Dalsgaard (both are Comm G4 members) and Roger Ulrich for the development of methods that allow precise study of the interiors of stars, i.e. for their pioneering work on helio- and asteroseismology.

The **European Research Council (ERC)** awarded a prestigious **Synergy Grant** to KU Leuven astrophysicist Conny Aerts. As coordinating principal investigator, she joined forces with Stéphane Mathis (CEA Paris-Saclay) and Michel Rieutord (University of Toulouse) from France and with Aaron Dotter (Dartmouth College) from the USA. The four principal investigators received almost 10 million euros for their project 4D-STAR, which develops and delivers innovative numerical models of rotating magnetic stars in three spatial dimensions throughout their evolution.

An **ERC Starting Grant** was awarded for Dominic Bowman in 2023 to investigate massive stars using asteroseismology in the project called SYMPHONY. Victoria Antoci was awarded the **ERC Consolidator Grant** for the project MAGNIFY (The Quest for MAGNetIc Fields in A and F TYpe Stars).

The prestigious **Crafoord Prize** was awarded to Conny Aerts (KU Leuven, Belgium), Jørgen Christensen Dalsgaard (Aarhus University, Denmark) and Douglas Gough (University of Cambridge, UK) (all are Commission G4 members) "for developing the methods of asteroseismology and their application to the study of the interior of the Sun and of other stars."

We wish to congratulate to all recipients for their successes.

5. PhD theses

The following PhD theses (sorted in alphabetical order) related to our field were defended in the reporting period†:

Jeroen Audenaert (KU Leuven, Belgium): Artificial Intelligence in Astronomy: Unravelling variable stars with machine learning and the NASA Kepler and TESS space missions (2023).

Camilla Borre (Aarhus University, Denmark): The Song and Dance of Our Stars: Determining Ages of Merger Remnant Stars with Asteroseismology (2022).

Siemen Burssens (KU Leuven, Belgium): Massive star asteroseismology with K2 and TESS. Instability regions and in-depth modelling of the β Cep star HD192575 (2022).

Susmita Das (University of Delhi, India): Light curve structure of variable stars and its applications (2021).

Sarah Gebruers (KU Leuven, Belgium): Combining spectroscopic and asteroseismic modelling tools for ensembles of BAF-type stars (2023).

Piotr Kołaczek-Szymański (University of Wrocław, Poland): Eccentric ellipsoidal variables and their tidally excited oscillations (March, 2023).

Mathias Michielsen (KU Leuven, Belgium): Forward seismic modelling of B-type stars (2022).

Amadeusz Miszuda (University of Wrocław, Poland): Evolution and pulsations of β Cephei and δ Scuti stars in eclipsing binary systems (March, 2023).

Joey Mombarg (KU Leuven, Belgium): Asteroseismic Modelling of Intermediate-Mass Stars (2022).

Henryka Netzel (Nicolaus Copernicus Astronomical Center, Warsaw, Poland): Investigation of stars of the classical instability strip by asteroseismology methods (2021).

† We apologize if we unintentionally missed someone.

Raffaele Reda (University of Rome Tor Vergata, Italy): A Synergic Strategy to Characterize the Habitability Conditions of Exoplanets Hosted by Solar-Type Stars (2023).

Sanjay Sekaran (KU Leuven, Belgium): Liber Stellae: comparing the observational and theoretical parameters of binary systems with pulsating components (2021).

Thomas Steindl (Universität Innsbruck, Austria): On an improved early stellar evolution phase for the numerical modelling of pre-main sequence asteroseismology (2023).

Jordan Van Beeck (KU Leuven, Belgium): Asteroseismology of Kepler B stars: internal magnetism and nonlinear mode coupling (2023).

6. Developments within the past triennium

6.1. *Projects in space*

The European Space Agency's GAIA continued its observations that started a decade ago, and will continue to do so for a few more years. Currently the most probable limiting factor is the available onboard propellant. Gaia Early Data Release 3 (EDR3) was published in December 2020, Gaia Data Release 3 (DR3) went online in June 2022, while Gaia Focus Products Release (FPR) appeared in October 2023.

BRITE-Constellation has been operational in the last triennium. Currently, the three remaining satellites, BRITE-Austria, BRITE-Toronto and BRITE-Heweliusz, are still active. Observations with the BRITE satellites, and thus the entire mission, are expected to be completed by the end of 2024.

Launched in 2018, NASA's Transiting Exoplanet Survey Satellite (TESS) mission finished observations of both the southern and the northern ecliptic hemispheres observing many pulsating variable stars while searching for transiting exoplanets. The mission was extended by the NASA Senior Reviews. In the extended mission the satellite covered again the southern and northern hemisphere and also ecliptic regions with modified cadence and target lists. Currently TESS is in its 6th year of operations and continues to work flawlessly scanning the entire sky. At the time of writing TESS has started its 161st orbit and Sector 77 observations.

ESA's M4 mission, PLATO with a strong seismology component is on track for its launch scheduled for the year 2026.

In November 2022 the ESA Science Programme Committee (SPC) selected the space mission HAYDN for further study for the M7 mission opportunity. HAYDN (PI. A. Miglio, L. Girardi) is an asteroseismological mission focused on homogeneous, controlled large samples of stars to provide calibrators for several aspects of fundamental astrophysics, fostering the understanding of stellar physics and the internal structure of stars, inaccessible with other techniques. In 2023 unfortunately, it was not downselected in the ESA process.

The CubeSpec mission designed to provide time-series spectroscopic observations (a niche area) of bright, massive stars Bowman et al. (2022) was in its implementation phase during the reporting period with launch planned for the first half of 2024.

6.2. *Projects on the ground*

SONG (Stellar Observations Network Group) continued operations. The main node of the network of dedicated spectrographs for asteroseismology is in Tenerife (Hertzsprung telescope). However, additional nodes were added to the network. The Chinese node is located at Delingha Observatory in the Qinghai province. The building, telescope and spectrograph are completed and manual observations have started. Two 70cm telescopes has been set up at the Mt. Kent Observatory in Southern Queensland, Australia.

The US-led Vera C. Rubin Observatory in Chile will start its 10-yr multi-color Legacy

Survey of Space and Time photometric survey in late 2025. The Transients and Variable Stars, as well as the Stars, Milky Way, Local Volume Science Collaborations cover science cases involving pulsating stars. The LSST Transients and Variable Stars Roadmap was published (Hambleton et al. 2023).

The multi-object spectrograph of the WEAVE survey installed on the 4.2m William Herschel Telescope on La Palma, Canary Islands reached its first light in December, 2022. The WEAVE survey will observe Cepheids and RR Lyrae stars as part of its SCIP (Stellar, Circumstellar and Interstellar Physics) and Galactic Archaeology programs, respectively.

SDSS-IV has finished its operation in 2020, while SDSS-V started to operate with the Milky Way Mapper – a time-domain optical+IR spectroscopic survey of Milky Way stars of all types – relevant for this Commission. Large number of pulsating stars are being or will be delivered by other large sky surveys, like ZTF, SuperWASP, ASAS-SN, and Everyscope.

Last, but not least, AAVSO – The American Association of Variable Star Observers — continues to collect ground-based data on pulsating and other variable stars. In several cases the light curves span more than a century – an extremely valuable resource.

7. About the future

The stellar pulsation/oscillation/seismology community is large and growing. Research of pulsating and oscillating stars – asteroseismology –is an active and lively branch of astrophysics. With several ground-based (LSST) and space-born (e.g. PLATO) missions to come online, as well as dedicated theoretical and computational efforts resulting in exciting new results this topic will make scientist busy for several more triennia to come. Organizing Committee members of Commission G4 invite everyone who is interested to join this fantastic endeavour.

Róbert Szabó
President of the Commission

References

Aerts, C. 2021, Rev. Mod. Phys. 93, 15001, doi:10.1103/RevModPhys.93.015001

Aerts, C. & Mathis, S. 2023, Astronomy & Astrophysics, 677, A68. doi:10.1051/0004-6361/202347196

Bhardwaj, A. 2022, Universe, 8, 122, doi:10.3390/universe8020122

Bonanno, A., Corsaro, E., Mathur, S. et al.

Bowman, D. M., Vandenbussche, B., Sana, H., et al. 2022, Astronomy & Astrophysics, 658, A96. doi:10.1051/0004-6361/202142375

Burssens, S., Bowman, D. M., Michielsen, M., et al. 2023, Nature Astronomy, 7, 913. doi:10.1038/s41550-023-01978-y

Clementini, G., Ripepi, V., Garofalo, A., et al. 2023, Astronomy & Astrophysics, 674, A18. doi:10.1051/0004-6361/202243964

Corsaro, E., Bonanno, A., Mathur, S. et al.2021 A&A, 652, L2, doi: 10.1051/0004-6361/202141395

Cotton, D. V., Buzasi, D. L., Aerts, C., et al. 2022, Nature Astronomy, 6, 154. doi:10.1038/s41550-021-01531-9

Csörnyei, G., Szabados, L., Molnár, L., et al. 2022, Monthly Notices of the Royal Astronomical Society, 511, 2125. doi:10.1093/mnras/stac115

Daszyńska-Daszkiewicz, J., Walczak, P., Pamyatnykh, A. A., et al. 2023, The Astrophysical Journal Letters, 942, 38. doi:10.3847/2041-8213/acade2

De Somma, G., Marconi, M., Cassisi, S., et al. 2021, Monthly Notices of the Royal Astronomical Society, 508, 1473. doi:10.1093/mnras/stab2611

Forró, A., Szabó, R., Bódi, A., et al. 2022, The Astrophysical Journal Supplement Series, 260, 20. doi:10.3847/1538-4365/ac5

Gaia Collaboration, Vallenari, A., Brown, A. G. A., et al. 2023, Astronomy & Astrophysics, 674, A1. doi:10.1051/0004-6361/202243940

Garcia, S., Van Reeth, T., De Ridder, J., et al. 2022, Astronomy & Astrophysics, 668, A137. doi:10.1051/0004-6361/202244365

Gaia Collaboration, De Ridder, J., Ripepi, V., et al. 2023, Astronomy & Astrophysics, 674, A36. doi:10.1051/0004-6361/202243767

Hambleton, K. M., Bianco, F. B., Street, R., et al. 2023, Publications of the Astronomical Society of the Pacific, 135, 105002. doi:10.1088/1538-3873/acdb9a

Jayaraman, R., Handler, G., Rappaport, S. A., et al. 2022, The Astrophysical Journal Letters, 928, L14. doi:10.3847/2041-8213/ac5c59

Kochukhov, O., Khalack, V., Kobzar, O., et al. 2021, Monthly Notices of the Royal Astronomical Society, 506, 5328. doi:10.1093/mnras/stab2107

Kurtz, D. W. 2022, Annual Review of Astronomy and Astrophysics, 60, 31. doi:10.1146/annurev-astro-052920-094232

Li, G., Deheuvels, S., Ballot, J., & Ligniéres, F. 2022, Nature, 610, 43

Li, G., Deheuvels, S., Li, T., Ballot, J., & Ligniéres, F. 2023, A&A 680A, 26

Marconi, M., Molinaro, R., Dall'Ora, M., et al. 2022, The Astrophysical Journal, 934, 29. doi:10.3847/1538-4357/ac78ee

Mathur, S., Claytor, Z. R., Santos, A. R. G. et al. 2023 The Astrophysical Journal952, 2, doi:10.3847/1538-4357/acd118

Miszuda, A., Szewczuk, W., Daszyńska-Daszkiewicz, J. 2021, Monthly Notices of the Royal Astronomical Society, 505, 3206. doi:10.1093/mnras/stab1597

Miglio, A., Chiappini, C., Mackereth, J. T. et al., Astronomy & Astrophysics645, A85, doi: 10.1051/0004-6361/202038307

Montalbán, J., Mackereth, J. T., Miglio, A., et al. 2021 Nature Astronomy, 5, 640, doi:10.1038/s41550-021-01347-7

Molnár, L., Bódi, A., Pál, A., et al. 2022, The Astrophysical Journal Supplement Series, 258, 8. doi:10.3847/1538-4365/ac2ee2

Molnár, L., Plachy, E., Bódi, A., et al. 2023, Astronomy & Astrophysics, 678, A104. doi:10.1051/0004-6361/202346507

Mombarg, J. S. G., Dotter, A., Rieutord, M., et al. 2022, The Astrophysical Journal, 925, 154. doi:10.3847/1538-4357/ac3dfb

Murphy, S. J., Joyce, M., Bedding, T. R., et al. 2021, Monthly Notices of the Royal Astronomical Society, 502, 1633. doi:10.1093/mnras/stab144

Netzel, H. & Kolenberg, K. 2021, Monthly Notices of the Royal Astronomical Society, 508, 3508. doi:10.1093/mnras/stab2829

Netzel, H. & Smolec, R. 2022, Monthly Notices of the Royal Astronomical Society, 515, 3439. doi:10.1093/mnras/stac1793

Pedersen, M. G., Aerts, C., Pápics, P. I., et al. 2021, Nature Astronomy, 5, 715. doi:10.1038/s41550-021-01351-x

Rimoldini, L., Holl, B., Gavras, P., et al. 2023, Astronomy & Astrophysics, 674, A14. doi:10.1051/0004-6361/202245591

Ripepi, V., Clementini, G., Molinaro, R., et al. 2023, Astronomy & Astrophysics, 674, A17. doi:10.1051/0004-6361/202243990

Saio, H., Takata, M., Lee, U., et al. 2021, Monthly Notices of the Royal Astronomical Society, 502, 5856. doi:10.1093/mnras/stab482

Soszyński, I., Pietrukowicz, P., Skowron, J., et al. 2021, Acta Astronomica, 71, 189. doi:10.32023/0001-5237/71.3.1

Steindl, T., Zwintz, K., Barnes, T. G., et al. 2021, Astronomy & Astrophysics, 654, A36. doi:10.1051/0004-6361/202140818

Steindl, T., Zwintz, K., & Vorobyov, E. 2022, Nature Communications, 13, 5355. doi:10.1038/s41467-022-32882-0

Yu, J.,Hekker, S., Bedding, T. R. et al. 2021 MNRAS 501,4, 5135. doi:10.1093/mnras/staa3970