Program and Abstract Book

Precision Asteroseismology:
Celebration of the Scientific Opus of Wojtek Dziembowski

Date: 19 – 23 August 2013, **Location**: Wrocław (Poland)

Scientific Organizing Committee:
Annie Baglin (France)
Bill Chaplin (UK)
Jørgen Christensen-Dalsgaard (Denmark)
Margarida Cunha (Portugal)
Jadwiga Daszyńska-Daszkiewicz (Chair, Poland)
Gilles Fontaine (Canada)
Joyce Guzik (USA)
Marcella Marconi (Italy)
Karen Pollard (New Zealand)
Hiromoto Shibahashi (Chair, Japan)
Juan Carlos Suárez (Spain)
Werner Weiss (Austria)

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Urszula Bąk-Stęślicka
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Zbigniew Kołaczkowski
Grzegorz Kopacki
Andrzej Pigulski (Chair)
Marek Stęślicki
Przemysław Walczak

PROGRAM OF THE SYMPOSIUM

DAY 1. August 19, Monday

Session 1. **Introduction**

Chair: Jadwiga Daszyńska-Daszkiewicz

8:00 – 9:00 Registration and setting up posters

9:00 – 9:20 Welcome and opening

9:20 – 10:20 **An overview of the scientific career of Wojtek Dziembowski** by Douglas Gough (30 min) & Alexey Pamyatnykh (30 min)

10:20 – 10:50 Coffee break

Chair: Jørgen Christensen-Dalsgaard

10:50 – 11:30 **Introductory talk: *What can we expect from precision asteroseismology*** (Gerald Handler)

Session 2. **Observations: from ground to space**

11:30 – 12:00 ***Pulsating variables from the OGLE and Araucaria projects*** (Grzegorz Pietrzyński, invited)

12:00 – 12:30 ***A review of pulsating stars from the ASAS data*** (Andrzej Pigulski, invited)

12:30 – 12:45 ***Asteroseismology with SuperWASP*** (Barry Smalley)

12:45 – 13:00 ***A new class of low amplitude periodic variable A and late-B stars*** (Nami Mowlavi)

13:00 – 14:30 Lunch

Chair: Karen Pollard

14:30 – 15:00 ***The latest pulsating results from MOST*** (Jaymie Matthews, invited)

15:00 – 15:30 ***Some highlights of CoRoT seismic results*** (Sebastien Deheuvels, invited)

15:30 – 16:00 ***Results on pulsating stars from the Kepler space mission*** (Hans Kjeldsen, invited)

16:00 – 16:40 Coffee break and poster session

Chair: Bill Chaplin

16:40 – 16:53 ***Subtle flickering in Cepheids: Kepler and MOST*** (Nancy Evans)

16:53 – 17:06 ***HD 51844: An eccentric δ Scuti binary system showing ellipsoidal variability*** (Markus Hareter)

17:06 – 17:20 ***The occurrence of non-pulsating stars and stars with unexpected frequencies in the γ Doradus and δ Scuti instability regions*** (Joyce Guzik)

17:20 – 17:45 ***BRITE-Constellation: two-color time resolved photometry of bright stars*** (Werner Weiss, invited)

17:45 – 18:10 ***First results from the SONG spectroscopic network*** (Frank Grundahl, invited)

20:00 **Welcome reception** at the Pergola Restaurant with a view of the Wrocław Multimedia Fountain (www.wroclawskafontanna.pl)

DAY 2. August 20, Tuesday

Session 3. **Resolving the rich oscillation spectra**

Chair: Annie Baglin

9:00 – 9:30 ***Extracting oscillation frequencies from data – various approaches*** (Chris Engelbrecht, invited)

9:30 – 10:00 ***Analysis of oscillation spectra with regular patterns*** (Bill Chaplin, invited)

10:00 – 10:15 ***On the necessity of a new intepretation of the stellar light curves*** (Javier Pascual Granado)

10:15 – 10:30 ***Theoretical properties of regularities in the oscillation spectrum of A-F, main sequence stars*** (Juan Carlos Suarez)

10:30 – 11:00 Coffee break and poster session

Chair: Gilles Fontaine

11:00 – 11:30 ***Identification of pulsation modes from photometry (including the BRITE photometry)*** (Michel Breger, invited)

11:30 – 12:00 ***Identification of pulsation modes from spectroscopy*** (Katrien Uytterhoeven, invited)

12:00 – 12:15 ***Interpretation of the oscillation spectrum of the Slowly Pulsating B-type star HD 50230 - a failure of richness*** (Wojciech Szewczuk)

12:15 – 12:30 ***Spectroscopic mode identification of γ Doradus Stars*** (Emily Brunsden)

12:30 – 14:00 Lunch

14:00 – 15:40 **A special session of Wojtek Dziembowski**

Chair: Hiromoto Shibahashi

Some memories of collaboration with Wojtek

• ***Helioseismology in the 1980s and 1990s*** by Phil Goode (20 min)

• ***Oscillations and Spins of Stars and Life*** by Alexander Kosovichev (20 min)

∗ ***Ups and downs in understanding stellar variability*** by Wojtek Dziembowski (30 min)

∗ *Questions, Answers & Advice* – discussion between the audience and Wojtek Dziembowski

15:40 – 16:15 Coffee break and poster session

Session 4. **Applications of pulsating stars in astrophysics**

Chair: Marcella Marconi

16:15 – 16:45 ***Distance determination from the P-L relation*** (Chow-Choong Ngeow, invited)

16:45 – 17:15 ***Pulsating stars as stellar population tracers*** (Gisella Clementini, invited)

17:15 – 17:45 ***Constraints on pre-main sequence evolution from stellar pulsations*** (Michael Casey, invited)

17:45 – 18:00 ***The Baade-Wasselink projection factor of pulsating stars*** (Nicolas Nardetto)

18:00 – 18:15 ***The population of confirmed pre-main sequence pulsators in the HR diagram and an overview of their properties*** (Konstanze Zwintz)

19:00 – 20:30 **Public lecture:** *The origin and fate of the Sun and helioseismology* (Joyce Guzik)

DAY 3. August 21, Wednesday

Session 4. **Applications of pulsating stars in astrophysics** (cont'd)

Chair: Gilles Fontaine

9:00 – 9:30 ***The Pulsation-Rotation Interaction: Greatest Hits and the B-side*** (Rich Townsend, invited)

9:30 – 10:00 ***Pulsation & rotation: transport of angular momentum in stars*** (Marie-Jo Goupil, invited)

10:00 – 10:15 ***Pulsations of rapidly rotating stars with compositional discontinuities*** (Daniel Reese)

10:15 – 10:30 ***A Working Hypothesis about the Cause of Be Stars: Episodic Outward Leakage of Low-Frequency Modes Excited by the Iron-peak κ-Mechanism*** (Hiromoto Shibahashi)

10:30 – 11:00 Coffee break and poster session

Chair: Karen Pollard

11:00 – 11:30 ***Pulsation – convection interaction*** (Friedrich Kupka, invited)

11:30 – 12:00 ***Atomic diffusion and element mixing in pulsating stars*** (George Alecian, invited)

12:00 – 12:15 ***Radiative hydrodynamic simulations of turbulent convection and pulsations of Kepler-target stars*** (Irina Kitiashvili)

12:15 – 13:45 Lunch

Chair: Joyce Guzik

13:45 – 14:15 ***Pulsation of magnetic stars*** (Hideyuki Saio, invited)

14:15 – 14:45 ***Pulsation and Mass Loss Across the HR Diagram: From OB stars to Cepheids to Red Supergiants*** (Hilding Neilson, invited)

14:45 – 15:00 ***Asteroseismic Signatures of Magnetic Activity Variations in Solar-type Stars*** (Travis Metcalfe)

15:00 – 15:15 ***Pulsations as a mass-loss trigger in evolved hot stars*** (Michaela Kraus)

15:15 – 15:45 ***Testing microphysics data*** (Przemysław Walczak, invited)

15:45 – 16:00 ***Opacities : focus on the iron group in the envelopes of massive stars*** (Maelle Le Pennec)

Free time

19:30 – 22:30 **Conference dinner** in the HP Park Plaza Restaurant

DAY 4. August 22, Thursday

Session 5. **New solutions to old problems and new challenges**

Chair: Juan Carlos Suarez

9:00 – 9:30 ***Blazhko effect in Cepheids and RR Lyr stars*** (Robert Szabo, invited)

9:30 – 10:00 ***Multimode oscillations in classical Cepheids and RR Lyrae stars - new results*** (Paweł Moskalik, invited)

10:00 – 10:15 ***Cepheids and the Blazhko-effect – a comprehensive analysis of V473 Lyrae*** (Laszlo Molnar)

10:15 – 10:30 ***RR Lyrae studies with Kepler – showcase RR Lyr*** (Katrien Kolenberg)

10:30 – 10:45 ***Bisector analysis of RR Lyrae: atmosphere dynamics at different Blazhko phases*** (Elisabeth Guggenberger)

10:45 – 11:30 Coffee break and poster session

Chair: Annie Baglin

11:30 – 12:00 ***Mode selection analysis*** (Radosław Smolec, invited)

12:00 – 12:30 ***Pulsations in White Dwarf Stars*** (Gilles Fontaine, invited)

12:30 – 12:45 ***Massive pulsating white dwarf stars*** (Barbara Castanheira)

12:45 – 13:00 ***New findings on the internal structure of ZZ Ceti stars using quantitative asteroseismology*** (Noemi Giammichele)

13:00 – 14:30 Lunch

Chair: Werner Weiss

14:30 – 15:00 ***The origin and pulsation of hot subdwarfs*** (Suzanne Randall, invited)

15:00 – 15:30 ***The origin and pulsation of extreme helium stars*** (Simon Jeffery, invited)

15:30 – 15:45 ***Reaching the 1% accuracy level on stellar mass and radius determinations from asteroseismology*** (Valerie Van Grootel)

15:45 – 16:00 ***Being Rich Helps, Case of KIC 010670103 sdBV*** (Jurek Krzesinski)

16:00 – 16:45 Coffee break and poster session

16:45 – 17:15 ***Pulsations in hot supergiants*** (Malenie Godart, invited)

17:15 – 17:30 ***Pulsations of blue supergiants before and after helium core ignition*** (Jakub Ostrowski)

19:00 – 20:30 **Public lecture:** *Planets and Pulsations: The New Keplerian Revolution* (Don Kurtz)

DAY 5. August 23, Friday

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**

Chair: Hiromoto Shibahashi

9:00 – 9:30 ***Solar-like oscillation in subgiants and red giants*** (Saskia Hekker, invited)

9:30 – 10:00 ***Stochastically excited modes in the upper main sequence stars*** (Vichi Antoci, invited)

10:00 – 10:15 ***Energetical aspects of solar-like oscillations in red giants*** (Mathieu Grosjean)

10:15 – 10:30 ***The evolution of the internal rotation of solar-type stars*** (Maria Pia di Mauro)

10:30 – 11:00 Coffee break and poster session

Chair: Jadwiga Daszyńska-Daszkiewicz

11:00 – 11:30 ***Application of helioseismic methods to stellar oscillations*** (Yvonne Elsworth, invited)

11:30 – 11:45 ***Sunquakes and Starquakes*** (Alexander Kosovichev)

11:45 – 12:15 ***Seismic studies of planet harbouring stars*** (Sylvie Vauclair, invited)

12:15 – 12:45 **Closing remarks** (Joergen Christensen Dalsgaard & Steve Kawaler, in duo)

12:45 Lunch

ABSTRACTS OF TALKS

Session 1. **Introduction**
Time: Monday, August 19, 10:50 – 11:30
Type of talk: Invited

What can we expect from precision asteroseismology?

Gerald Handler

Nicolaus Copernicus Center, Warsaw

The term "precision asteroseismology" has been coined some 20 years ago when the first precise model fits to white dwarf pulsation spectra had been obtained. Nowadays, precise asteroseismic inferences are available for many types of pulsating stars, thanks to the ever improving observational accuracy and sophistication of theoretical models. I shall briefly review present results of precision asteroseismic studies, discuss some limitations, and shall dare to speculate what can be expected in the near future.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 11:30 – 12:00
Type of talk: Invited

Pulsating variables from the OGLE and Araucaria projects

Grzegorz Pietrzyński

Warsaw University Observatory

We will briefly review the extended catalogs of pulsating stars published by the OGLE consortium. Then we will concentrate on several extremely scarce pulsating stars, components of eclipsing binary systems presented in those catalogs and studied in details in the course of the Araucaria project. The impact of our new results on theories of stellar evolution and pulsation, and on the precise calibration of the cosmic distance scale will be discussed.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 12:00 – 12:30
Type of talk: Invited

A review of pulsating stars from the ASAS data

Andrzej Pigulski

Instytut Astronomiczny, Uniwersytet Wrocławski

The data from the All Sky Automated Survey (ASAS) appeared to be extremely useful in finding the census of bright variable stars in the sky. An overview of the discoveries based on the ASAS data and related to pulsating stars will be presented by an enthusiastic user of these data.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 12:30 – 12:45
Type of talk: Contributed

Asteroseismology with SuperWASP

Barry Smalley

Keele University

The highly successful SuperWASP planetary transit-finding programme has surveyed a large fraction of both the northern and southern skies. There now exists in the its archive over 300 billion photometric measurements for more than 30 million stars. SuperWASP provides good quality photometry with a precision exceeding 1% per observation in the approximate magnitude range $9 < V < 12$. The archive enables long-baseline, high-cadence studies of stellar variability to be undertaken. An overview of the SuperWASP project will be presented, along with results which demonstrates the survey's asteroseismic capabilities.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 12:45 – 13:00
Type of talk: Contributed

A new class of low amplitude periodic variable A and late-B stars

Nami Mowlavi, F. Barblan, Sophie Saesen, L. Eyer

Geneva Observatory, Switzerland

We present a potentially new class of periodic variable A and late-B stars, with amplitudes between 1 and 4 mmag and periods from 0.1 and 0.7 days for the majority of them. They have been discovered following a 7-year ground-based photometric monitoring campaign of the open cluster NGC3766. The new class of variable stars is located in the Herzsprung-Russel diagram on the main-sequence between the δ Scuti and the Slowly Pulsating B stars, a region where no sustained pulsation is predicted by standard models. The origin of this mysterious class of variables is unknown, but may be related to the interaction between pulsation and stellar rotation. Those findings complement results published from CoRoT data that support a similar claim.

We present the characteristics of these new variable stars as found from our multi-band monitoring campaign.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 14:30 – 15:00
Type of talk: Invited

The latest pulsating results from MOST

Jaymie Matthews

Department of Physics & Astronomy, University of British Columbia, Canada

By the time of this Symposium, MOST will have spent more than a decade in space, having monitored 225 Primary Science Target fields and generated over 5000 light curves. Those data cover a wide swath of the sky and almost every part of the HR Diagram.

When the target fields were young clusters or associations, MOST collected seismic data on PMS δ Scuti pulsators (and maybe PMS SPB pulsators) as well as Wolf-Rayet stars. Even when the target field was not considered an asteroseismic one, excited modes excited astronomers. Consider the transiting exoplanet system WASP-33. The planet - in a 1.22-day orbit - has apparently excited (or filtered) δ Scuti pulsations in its parent star, for which MOST photometry also reveals γ Dor pulsations. A hybrid pulsator tidally excited by a planet in a tight retrograde orbit! That's an astrophysical lab worth more exploration with theories and more data, and indeed, MOST returned to this target a year after its first visit.

A target to which MOST now returns every year is the red giant epsilon Ophiuchi. Why keep filling our light bucket at this particular photon well? Because the stochastic nature of the p-modes of eps Oph has allowed us to string together five widely separated MOST light curves to produce a time series spanning 8 years without aliasing. The resulting seismology of this expanding data set means narrowing the star's physical parameters, and the data are on the verge of resolving the star's mixed mode period spacings. Higher in luminosity in the HR Diagram, supergiants have also been very fruitful hunting grounds for MOST, from the red supergiant Betelgeuse (from which MOST photometry has captured the power envelope of its turbulent convection) to the classical Cepheid SZ Tauri, which may be only the second example of the "flickering" phenomenon first seen by Kepler (in the only Cepheid in its field of view).

In 30 minutes, I'll only be able to touch on a few highlights, but there may be MOST results appearing in the talks later this week by Mike Casey, Rich Townsend, Hideyuki Saio, Robert Szabo and Vichi Antoci. All have been PIs on MOST observing runs and all have produced impressive results from the resulting data.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 15:00 – 15:30
Type of talk: Invited

Some highlights of CoRoT seismic results

Sebastian Deheuvels

Observatoire Midi-Pyrénées, France

Since its launch in December 2006, the CoRoT satellite has provided photometric data precise down to the micro-magnitude level for about 150 bright stars and 150,000 fainter ones. These stars have been observed over runs covering up to 160 days with a 90% duty cycle. Seismic data of such precision had been longed for by the scientific community for decades, and expected as a way of making progress in our understanding of stellar structure and evolution. The analysis and interpretation of the CoRoT seismic data have indeed made it possible to place observational constraints on several key aspects of stellar structure and evolution, such as the size of mixed convective cores, magnetic activity, mass loss. We here present some highlights of the CoRoT results and their implications in terms of internal stellar structure.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 15:30 – 16:00
Type of talk: Invited

Results on pulsating stars from the Kepler space mission

Hans Kjeldsen

Stellar Astrophysics Centre, Aarhus University, Denmark

In the past four years we have experienced a revolution in the way we observe stars thanks to the huge amount of high quality nearly continuous time series data obtained by the NASA Kepler mission. The Kepler data (more than 100.000 stars observed) provide information on the existence and properties of exoplanets as well as information on stellar properties in general including rotation, convection and core fusion processes. I will in the present talk describe some of the most exciting results from Kepler concerning asteroseismology and I will describe the future prospects of space time series photometry which will be possible with the launch of TESS in 2017.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 16:40 – 16:53
Type of talk: Contributed

Subtle flickering in Cepheids: Kepler and MOST

Nancy Remage Evans[1], Robert Szabo[2], Laszlo Szabados[2], Aliz Derekas[2], Laszlo Kiss[2], Jaymie Matthews[3], Chris Cameron[3], The MOST Team

[1]*SAO,* [2]*Konkoly Obs.,* [3]*UBC*

Fundamental mode classical Cepheids have periods steady enough that we can watch them evolve (change period). The new level of accuracy and quantity of data with the Kepler and MOST satellites probes this further. An intriguing result was found in the long time-series of Kepler data for V1154 Cyg the one classical Cepheid (fundamental mode) in the field. It has short term changes in period (20 minutes), correlated for 10 cycles (period jitter). To follow this up, we obtained a month long series of observations of the fundamental mode Cepheid RT Aur and the first overtone pulsator SZ Tau. RT Aur shows the traditional strict repetition of the light curve, with the Fourier amplitude ratio R_1/R_2 remaining constant (varies by only a percent). The light curve of SZ Tau, on the other hand, fluctuates in amplitude ratio at the level of approximately 50%. Furthermore prewhitening the RT Aur data with 10 frequencies reduces the Fourier spectrum to noise. For SZ Tau, considerable power is left after this prewhitening in a complicated variety of frequencies.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 16:53 – 17:06
Type of talk: Contributed

HD 51844: An eccentric delta Scuti binary system showing ellipsoidal variability

Markus Hareter

Konkoly Observatory, MTA, Hungary

The star HD 51844 was observed in a CoRoT long run as a target for asteroseismology. The 117 days long light curve revealed δ Scuti pulsation in the range of $\approx$ 6 to 15 c/d with amplitudes larger than 100 ppm. Additionally, the light curve exhibits a brightening event recurring every 33.5 days with a maximum of 2 mmag and a duration of about 5 days. Thus, this star can be considered as the first CoRoT heartbeat candidate. The radial velocity curves from spectroscopy reveals an eccentric binary system with nearly identical masses and physical parameters. The brightening event of the light curve coincides with the maximum radial velocities. A good fit to the observed composite spectrum is obtained by using two synthetic spectra with the same parameters ($T_{\rm eff} = 6800$ K, $\log g = 3.5$, solar abundances). One component displays large line profile variations, while the other does not show significant variations. A preliminary frequency analysis indicates frequency modulation (Shibahashi & Kurtz 2012) due to the orbital motion of the pulsating star(s).

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 17:06 – 17:20
Type of talk: Contributed

The occurrence of non-pulsating stars and stars with unexpected frequencies in the gamma Doradus and delta Scuti instability regions

Joyce A. Guzik[1], Paul A. Bradley[1], Jason Jackiewicz[2], Katrien Uytterhoeven[3], Karen Kinemuchi[4]

[1]*Los Alamos National Laboratory, Los Alamos,* [2]*New Mexico State University, Las Cruces,* [3]*Instituto Astrofisica de Canarias,* [4]*Apache Point Observatory, Sunspot*

We examine a sample of about 1800 stars observed in long cadence by the *Kepler* spacecraft as part of the Guest Observer program. Most of these stars are faint (*Kepler* magnitude 14-16), and fall near or within the effective temperature and log g range of the γ Doradus and delta Scuti instability strips. We find that the pulsating stars are obvious from inspection of the light curves and Fourier transforms, even for these faint stars. However, we find that a large number of stars are "constant", i.e. show no frequencies in the 0.2 to 24 cycles/day range above the 10-20 ppm level. We discuss the statistics for the constant stars, and some possible physical reasons for lack of pulsations (e.g., they are higher-frequency solar-like oscillators, they are pulsating in higher-degree modes, they are outside the instability strips, diffusive settling has weakened the pulsation driving). On the other hand, hybrid γ Dor/ δ Scuti candidates have been found in the *Kepler* data spread throughout the instability regions of both types, even though theoretical models predict only a small overlap region where hybrids should exist. We revisit mechanisms to produce g- or p-mode pulsations in conditions when these modes are not expected to be unstable via the He-ionization kappa effect or convective blocking mechanisms (e.g., Fe concentration by settling/levitation, convective driving, stochastic excitation, and tidal forcing).

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 17:20 – 17:45
Type of talk: Invited

BRITE-Constellation: two-color time resolved photometry of bright stars

Werner Weiss

University of Vienna, Austria

With the launch of UniBRITE and BRITE-Austria on February 25th, the first pair of nanosatellites, an international cooperation, BRITE-Constellation, on high precision, high cadence and long photometric data sets has been inaugurated, The partners are Poland and Canada, with each country providing another pair of nanosatellites, optimized respectively for blue and red colors. BRITE-Constellation will be presented and the first results discussed.

Session 2. **Observations: from ground to space**
Time: Monday, August 19, 17:45 – 18:10
Type of talk: Invited

First results from the SONG spectroscopic network

Frank Grundahl

Stellar Astrophysics Centre, Aarhus University, Denmark

The Stellar Observations Network Group (SONG) has completed the installation of the first prototype node at Observatorio del Teide during mid 2013. In this contribution an overview of the status for the telescope and instruments will be given. Initial results for velocity precision and overall performance will be presented. The plans for future SONG nodes will be discussed.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 9:00 – 9:30
Type of talk: Invited

Extracting oscillation frequencies from data - various approaches

Chris Engelbrecht

University of Johannesburg

Asteroseismology depends absolutely on the detection of authentic pulsation signatures in stars. A variety of mathematical and statistical tools have been developed to extract such signatures from photometric and spectroscopic time series. The earliest tools were developed on the platform of Fourier analysis, and Fourier-based methodology still plays a major part in the detection of pulsation signatures in the present day. Alternative approaches have been gaining ground in recent years. One of the most important considerations in the extraction of periodic signals from time series is the statistical significance of a provisional detection. An arsenal of statistical theorems has been developed for time series acquired at precisely equal time intervals. However, by its very nature, the acquisition of astronomical data very often produces non-equally-spaced time series, negating the many statistical tools available for equally-spaced time series. This talk will review the major advances in the methodology for detection of authentic periodic signals in astronomical time series over the past few decades, including examples of their pitfalls and successes.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 9:30 – 10:00
Type of talk: Invited

Analysis of oscillation spectra with regular patterns

William Chaplin

University of Birmingham

In this talk I shall review the rich and diverse range of analysis techniques that are being applied to the analysis of oscillation spectra that show near-regular patterns in frequency, concentrating on solar-like oscillations.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 10:00 – 10:15
Type of talk: Contributed

On the necessity of a new intepretation of the stellar light curves

Javier Pascual Granado, Rafael Garrido Haba

Instituto de Astrofsica de Andaluca - CSIC

The power of asteroseismology relies on the ability to infer the stellar structure from the unambiguous frequency identification of the corresponding pulsation mode. Hence, the use of a Fourier transform is in the basis of asteroseismic studies. Nevertheless, the difficulties with the interpretation of the frequencies found in many stars lead us to reconsider if Fourier analysis is the most appropiate technique to identify pulsation modes.

We have found that the data, usually analyzed using Fourier techniques, present a non-analyticity originated from the lack of connectivity of the underlying physical phenomena. Therefore, the conditions for the Fourier series to converge are not fulfilled.

On the light of these results, we examine in this talk some stellar light curves from different asteroseismology space missions (CoRoT, Kepler and SOHO) in which the interpretation of the data in terms of Fourier frequencies becomes difficult. We emphasise the necessity of a new interpretation of the stellar light curves in order to identify the correct frequencies of the pulsation modes, and we also explore the possibility to overcome this drawback.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 10:15 – 10:30
Type of talk: Contributed

Theoretical properties of regularities in the oscillation spectrum of A-F main sequence stars

Juan Carlos Suarez[1], Andres Moya[2], Antonio Garcia Hernandez[3], Carlos Rodrigo[2], Enrique Solano[2], Rafael Garrido[1]

[1]*IAA-CSIC,* [2]*CAB (INTA-CSIC),* [3]*CAUP*

Stellar interiors of the Sun and solar-type stars can be revealed thanks to the study of regular patterns in their rich oscillation spectrum. Similar studies in hot, more-massive-than-the-Sun stars have become a challenge to the astrophysicists. Among them, the δ Scuti stars have shown regular patterns, although their physical properties remain unknown. Here we unveil a relation between such periodicities and the average density of these stars, similar to that found in the Sun. This places tight constraints on stellar evolution theory and on the physical properties of planets orbiting δ Scuti stars.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 11:00 – 11:30
Type of talk: Invited

Identification of pulsation modes from photometry (including BRITE photometry)

Michel Breger

University of Vienna

The identification of the detected pulsation modes in terms of the spherical harmonic quantum numbers is crucial for asteroseismology. Light curves obtained in different passbands have become an important tool. We demonstrate this for different types of pulsators and review recent successes from earth-based measurements, especially in determining the important ℓ values.

Photometric mode identification relies on wavelength-dependent amplitudes and phase shifts. The extensive amount of accurate data needed to determine small phase shifts and accurate amplitude ratios suggests multicolor measurements using space satellites. This motivated the multicolor BRITE satellite project, for which the first two satellites have already been launched successfully. We demonstrate the potential from models computed for the BRITE wavelengths.

Most of the excellent presently available satellite photometry is not multicolor, although frequencies with amplitudes as small as a few parts-per-million have been detected and confirmed. The talk briefly discusses mode identifications from frequency patterns, including the use of correlations between phase and amplitude changes.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 11:30 – 12:00
Type of talk: Invited

Identification of pulsation modes from spectroscopy

Katrien Uytterhoeven

Instituto de Astrofisica de Canarias

Associating (l, m) mode values to observed pulsational frequencies are of critical importance for asteroseismic modelling. For massive pulsators on the Main Sequence the only resource so far for extracting information on both the degree l and the azimuthal number m has been time series of high-resolution spectra. I will present an overview of spectroscopic mode-identification techniques and some recent observational results.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 12:00 – 12:15
Type of talk: Contributed

Interpretation of the oscillation spectrum of the Slowly Pulsating B-type star HD 50230 - a failure of richness

Wojciech Szewczuk[1], Jadwiga Daszyńska-Daszkiewicz[1], Wojciech Dziembowski[2]

[1]*Instytut Astronomiczny, Uniwersytet Wrocławski,* [2]*Centrum Astronomiczne im. Mikołaja Kopernika Polskiej Akademii Nauk*

From ground-based observations we know a lot of B-type main sequence pulsators but in non them more than a dozen of pulsation frequencies have been detected. Now, in the era of spacecraft observations, the situation has changed dramatically as we are able to detect oscillations with amplitudes by two order of magnitude lower than before.

The dream of dense oscillation spectra in the B-type stars has come true. An example is the Slowly Pulsating Star (SPB) HD 50230 for which Degroote at al. (2010) measured over 500 frequencies. Moreover, they showed that eight frequencies are nearly equal spaced in period which they interpreted according to asymptotic theory as modes with the same spherical harmonic degree, ℓ, azimuthal order, m, and consecutive radial orders, n. If this interpretation were correct the door to identification of modes and hence to precision asteroseismology of the object would have been opened.

Unfortunately, our survey of large number of possible models of the star did not yield any plausible interpretation of the dominant frequencies in HD 50230. Instead, in each of our models we found equally-spaced sequences of similar quality to that found by Degroote at al. in the data but with different angular numbers ℓ and m. We believe that this sequence is merely a coincidence, which is not so unlikely in so dense oscillation spectrum.

Our conclusion is that realistic seismic models cannot be found without a credible assessment of angular degrees based on amplitude data for dominant modes. Multi-colour photometric and/or spectroscopic observations are indispensable. Furthermore our simulations demonstrate that a common assumption used for ground- based observations that we can see modes with the spherical harmonic degree up to 4 is not longer valid. Observations from such satellites as Corot or Kepler are precise enough to detect modes with the degree, ℓ, at least up to 10. However, in models we have too many unstable modes, especially with the higher spherical degrees, and the problem of selection modes became urgent.

Session 3. **Resolving the rich oscillation spectra**
Time: Tuesday, August 20, 12:15 – 12:30
Type of talk: Contributed

Spectroscopic mode identification of gamma Doradus Stars

Emily Brunsden

University of Canterbury

The MUSICIAN programme at the University of Canterbury has been successfully identifying pulsation modes in many γ Doradus stars using hundreds of high-resolution ground-based spectroscopic observations. I will describe our methods and analysis techniques as well as give a few examples of stars with successful identifications. These include recently published results for HD135825 and HD12901. The latter is particularly interesting as we fit five $(l, m) = (1, 1)$ modes to the frequencies. New results for the very interesting hybrid γ Doradus / δ Scuti star HD49434 are also presented. This star remains an enigma despite the analysis of more than 1700 multi-site high-resolution spectra. An interesting new result for this star is the observation of distinct line profile variations for the γ Doradus and δ Scuti frequencies.

A special session of Wojtek Dziembowski
Time: Tuesday, August 20, 14:00 – 14:20
Type of talk: Invited

Helioseismology in the 1980s and 1990s

Phil Goode

Big Bear Solar Observatory

For more than 20 years, Wojtek Dziembowski and I collaborated on nearly forty papers, which were mostly concentrated in helioseismology through the 1980s and 1990s. Here I will discuss the most significant results of this collaboration and some of the underlying sociology that contributed to the intensity and duration of the collaboration. Our works began with placing limits on the Sun's buried magnetic field and ended with extracting from the cycle dependent oscillation frequency changes the roles of competing dynamical drivers.

A special session of Wojtek Dziembowski
Time: Tuesday, August 20, 14:20 – 14:40
Type of talk: Invited

Oscillations and Spins of Stars and Life

Alexander Kosovichev

Stanford University, USA

About 25 years ago, during a very turbulent period in our life, Wojtek suggested to look at low-frequency oscillation modes with periods comparable with the stellar rotation period. This collaboration led to interesting results which later found connections to a wide range of phenomena, from the solar tachocline to X-ray binaries, and also caused new life turns.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Tuesday, August 20, 16:15 – 16:45
Type of talk: Invited

Distance determination from the P-L relation (Cepheids, RR Lyrae) and Red Clump stars

Ngeow Chow-Choong[1], Wolfgang Gieren[2]

[1]*National Central University, Taiwan,* [2]*Universidad de Concepción, Chile*

Cepheids and RR Lyrae are important pulsating variable stars in distance scale work to serve as standard candles. Cepheids are young population I stars hence they are found mostly in spiral and irregular galaxies. Cepheids follow well-defined period-luminosity (P-L) relations from optical to near-infrared bands, and extending to mid-infrared with observations from Spitzer Space Telescope. On the other hand, RR Lyrae are old population II stars, they are mostly found in globular clusters and dwarf galaxies. The RR Lyrae P-L relations only exist in the near-infrared and mid-infrared bands, as their optical luminosities are quite constant on the H-R diagram (and follow the M_V – [Fe/H] relation). In this talk, we review some of the recent development and calibration of Cepheids and RR Lyrae P-L relations. For Cepheids, we focus on the calibration of the P-L relation via the Galactic and LMC (Large Magellanic Cloud) routes, as well as issues regarding metallicity dependency and possible non-linearity of the P-L relations. We end the talk with some prospects of using red clump stars in distance determination.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Tuesday, August 20, 16:45 – 17:15
Type of talk: Invited

Pulsating stars as stellar population tracers

Gisella Clementini

INAF Osservatorio Astronomico Bologna, Italy

Pulsating stars are powerful tools to trace different stellar generations in galaxies because pulsating variables of different types are in different evolutionary phases, thus tracing stellar components of different age in the host system. Specifically, the Classical Cepheids trace a young stellar component with ages from a few to a few hundred Myr, the Anomalous Cepheids trace an intermediate age stellar generation ($t \sim 1 - 2$ Gyr), and the RR Lyrae stars, being comparably old and about 3 magnitude brighter than the old Main Sequence Turn Off, allow to unravel the oldest stars born more than 10 Gyr ago. As the light variation caused by the periodic expansion/contraction of the surface layers makes the pulsating stars much easier to recognize than normal stars, their role becomes crucial to disentangle different stellar generations in systems where stars of different age and metal abundance share the same region of the color magnitude diagram. Their main parameter, the pulsation period, is measured at great precision, is unaffected by distance and reddening, and is directly related to stellar intrinsic parameters such as the star mass, radius, and luminosity. Among pulsating variables the Cepheids are one of the brightest stellar "standard candle". Their characteristic Period-Luminosity relation makes them primary distance indicators in establishing the cosmic distance scale.

I will present an overview of the role played by the pulsating variable stars in our understanding of the structure and evolution of Local Group galaxies.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Tuesday, August 20, 17:15 – 17:45
Type of talk: Invited

Constraints on pre-main sequence evolution from stellar pulsations

Mike Casey[1], Konstanze Zwintz[2], David B. Guenther[1]

[1]*Saint Mary's University,* [2]*Research Foundation Flanders*

Pulsating pre-main-sequence (PMS) stars afford the earliest opportunity in the lifetime of a star to which the concepts of asteroseismology can be applied. PMS stars should be structurally simpler than their evolved counterparts, thus (hopefully!) making any asteroseismic analysis relatively easier. Unfortunately, this isn't necessarily the case. The majority of these stars (around 80) are δ Scuti pulsators, with a couple of γ Doradus, γ Doradus - δ Scuti hybrids, and slowly pulsating B stars thrown into the mix. The majority of these stars were only discovered within the last ten years, with the community still uncovering the richness of phenomena associated with these stars, many of which defy traditional asteroseismic analysis.

A systematic asteroseismic analysis of all of the δ Scuti PMS stars was performed in order to get a better handle on the properties of these stars as a group. Some strange results have been found, including one star pulsating up to the theoretical acoustic-cutoff frequency of the star, and a number of stars in which the most basic asteroseimic analysis suggest problems with the stars' positions in the Herzsprung-Russell Diagram. An overview of this study will be presented, emphasizing the nature of the problems associated with this class of star, both observational and theoretical. Some idea of the constraints — or lack thereof — that these results put on PMS stellar evolution will be given.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Tuesday, August 20, 17:45 – 18:00
Type of talk: Contributed

The Araucaria Project: the Baade-Wasselink projection factor of pulsating stars

Nicolas Nardetto et al.

Observatoire de la Côte d'Azur

The projection factor used in the Baade-Wesselink methods of determining the distance of Cepheids makes the link between the stellar physics and the cosmological distance scale. A coherent picture of this physical quantity is now provided based on high resolution spectroscopy and hydrodynamical modelling. We present the lastest news on the expected projection factor f or different kinds of pulsating stars in the HR diagram.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Tuesday, August 20, 18:00 – 18:15
Type of talk: Contributed

The population of confirmed pre-main sequence pulsators in the HR diagram and an overview of their properties

Konstanze Zwintz

Institute of Astronomy, KU Leuven

Pre-main sequence (PMS) stars can become vibrationally unstable during their evolution to the zero-age main sequence. As they gain their energy from gravitational contraction and have not started nuclear fusion in their cores yet, their inner structures are significantly different to those o f (post-) main sequence stars and can be probed by asteroseismology.

Using photometric time series from ground and from space (MOST, CoRoT & Spitzer) the number of confirmed pulsating PMS stars has increased significantly within the last years and allowed to find members of new classes of PMS pulsators. Apart from the well-established group of δ Scuti type PMS stars, members of the groups of PMS γ Doradus, PMS δ Scuti – γ Doradus hybrid and PMS slowly pulsating B (SPB) stars have been discovered.

These unique high-precision space data were combined with dedicated high-resolution spectra to probe the parameter space in the HR-diagram and study the properties of PMS pulsators in comparison to their more evolved (post-) main sequence counterparts. The latest results of this analysis will be presented.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 9:00 – 9:30
Type of talk: Invited

The Pulsation-Rotation Interaction: Greatest Hits and the B-side

Rich Townsend

University of Wisconsin-Madison

It's long been known that rotation can have an appreciable impact on stellar pulsation — by modifying the usual p and g modes found in the non-rotating case, and by introducing new classes of mode. However, it's only relatively recently that advances in numerical techniques and computer hardware have enabled us to model these phenomena in any great detail. In this talk I'll review highlights in this area (the 'Greatest Hits'), before considering the flip side (or the 'B-side', for those of us old enough to remember vinyl records!) of the pulsation-rotation interaction: how pulsation can itself influence internal rotation profiles, and thereby exert a measure of control over stars' evolution and ultimate fate.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 9:30 – 10:00
Type of talk: Invited

Pulsation & rotation: transport of angular momentum in stars

Mariejo Goupil

Observatoire de Paris

I will discuss the interpretation of recent seismic (Kepler and CoRoT) data that provide information on internal rotation of stars in various stages of evolution.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 10:00 – 10:15
Type of talk: Contributed

Pulsations of rapidly rotating stars with compositional discontinuities

Daniel Reese[1], Francisco Espinosa Lara[2], Michel Rieutord[2]

[1] *Universit'e de Liége* [2] *Institut de Recherche en Astrophysique et Planétologie*

Recent observations of rapidly rotating stars have revealed the presence of regular patterns in their pulsation spectra (e.g. Garcia Hernandez et al. 2009, Breger et al. 2012). This has raised the question as to their physical origin, and in particular, whether they can be explained by an asymptotic frequency formula for acoustic modes, recently discovered through theoretical considerations and numerical calculations (Lignieres & Georgeot 2008, 2009, Reese et al. 2009, Pasek et al. 2011, 2012). In this context, a key question is whether compositional/density gradients can adversely affect such patterns to the point of hindering their identification. In order to examine this question, we calculate frequency spectra in stellar models from the ESTER project (Espinosa Lara & Rieutord 2013). These models use a multidomain spectral approach, thereby allowing us to place a compositional discontinuity at one of the interfaces between adjacent domains while retaining a high numerical accuracy. Based on these calculations, we analyse the effects of such discontinuities on both the frequencies and eigenfunctions of pulsation modes in the asymptotic regime. We check whether this can affect the identification of frequency patterns in observed spectra.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 10:15 – 10:30
Type of talk: Contributed

A Working Hypothesis about the Cause of Be Stars : Episodic Outward Leakage of Low-Frequency Modes Exited by the Iron-peak kappa-Mechanism

Hiromoto Shibahashi

University of Tokyo

I propose a working hypothesis about the cause of Be stars by taking account of the effect of leaky waves upon angular momentum transfer. If low-frequency prograde nonradial oscillations are selectively excited by the κ-mechanism of the iron bump, they transport angular momentum from the driving zone to the damping zone. As a consequence, the angular momentum is gradually deposited near the stellar surface, while the rotation velocity is still kept below the break-up velocity. However, this will result in a gradual increase in the "critical frequency for g-modes", leading eventually to have g-modes leak outward. Once nonradial oscillations start to leak out, angular momentum is lost from the star and a circumstellar disk is formed. On the other hand, the oscillation itself will be soon damped owing to kinetic energy loss. Then the envelope of the star spins down and angular momentum loss stops soon. The star returns to being quiet and remains calm until nonradial oscillations are newly built up by the κ-mechanism to sufficient amplitude and a new episode begins. According to this scenario, the interval of episodic Be-star activity corresponds to the growth time of the oscillation, and it seems in good agreement with observations.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 11:00 – 11:30
Type of talk: Invited

Pulsation – convection interaction

Friedrich Kupka, Eva Mundprecht, Herbert J. Muthsam

Faculty of Mathematics, University of Vienna

A lot of efforts have been devoted to the hydrodynamical modelling of Cepheids in one dimension. While the recovery of the most basic properties such as the pulsational instability itself has been achieved already a long time ago, more delicate properties such as the observed double-mode pulsation of some objects and the red-edge of the classical instability strip and their dependence on metallicity has remained a delicate issue. The uncertainty introduced by adjustable parameters and further physical approximations introduced in one-dimensional model equations motivate an investigation based on numerical simulations which use the full hydrodynamical equations. In this talk, results from such two-dimensional numerical simulations of a short period Cepheid are presented. The importance of a carefully designed numerical setup, in particular of sufficient resolution and domain extent, is discussed. The problematic issue of how to reliably choose fixed parameters for the one-dimensional model is illustrated. Results from an analysis of the interaction of pulsation with convection are shown which are based on work integrals directly evaluated from the simulations. Considering the potential of hydrodynamical simulations and the wealth of ever improving observational data an outlook on possible future work in this field of research is given.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 11:30 – 12:00
Type of talk: Invited

Atomic diffusion and element mixing in pulsating stars

Georges Alecian

LUTH, Observatoire de Paris, CNRS, Université Paris Diderot, France

Stellar plasmas are multicomponent anisotropic gases. Each component (chemical element) of these gases experiences specific forces related to its properties, which leads each element to diffuse with respect to the others. There is no reason why a stellar plasma should remain homogeneous except if mixing motions enforce homogeneity. Because atomic diffusion is a very slow process, the element separation only occurs in places where mixing motions are weak enough not to erase the effect of the ineluctable tendency of chemical elements to migrate. In this talk, I will present how atomic diffusion and mixing processes compete in stars (interiors as well as atmospheres), and I will show various cases where atomic diffusion is believed to have noticeable effects. This concerns several types of stars throughout the HR diagram, including pulsating ones.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 12:00 – 12:15
Type of talk: Contributed

Radiative hydrodynamic simulations of turbulent convection and pulsations of Kepler-target stars

Irina Kitiashvili

Stanford University

The problem of interaction of stellar pulsations with turbulence and radiation in stellar convective envelopes is central to our understanding of the excitation mechanisms, oscillation amplitudes and frequency shifts. Realistic ("ab initio") numerical simulations provide unique insights into the complex physics of the pulsation-turbulence-radiation interactions, as well as into the energy transport and dynamics of convection zones, beyond the standard evolutionary theory. I will present results of 3D radiative hydrodynamics simulations for several Kepler-target stars, from M- to A-class along the Main Sequence, obtained using a new "StellarBox" code, which takes into account all essential physics and includes subgrid scale turbulence modeling. The results reveal dramatic changes in the convection and pulsation properties among the stars of different mass. For relatively massive stars with thin convective envelopes, the simulations allow us to investigate the dynamics of the whole convection zones including the overshoot zone, and also look at the excitation of internal gravity waves. Physical properties of the turbulent convection and pulsations, and also initial comparison of the simulations with Kepler asteroseismology data will be discussed.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 13:45 – 14:15
Type of talk: Invited

Pulsation of magnetic stars

Hideyuki Saio

Tohoku University, Japan

About 40 cool Ap stars with magnetic fields of $1 \sim 20$ kG are known to pulsate in high order p-modes; they are called roAp (rapidly oscillating Ap) stars. In addition, at least one hot DQ (white dwarf) variable (probably a g-mode pulsator) is found to have a strong (~ 1 MG) magnetic field. Magnetic fields modify the property of pulsations. Pulsation frequency of a p-mode generally increases as the strength of magnetic field increases, but it occasionally decreases suddenly. Although the large separation of high-order p-modes is hardly affected, small separations are modified considerably due to the magnetic field, indicating that including the magnetic effect is essential to accurately fit theoretical frequencies with observed ones. The magnetic field also affects the latitudinal amplitude distribution on the surface, and hence modifies the rotational amplitude modulations. I will discuss mainly the property of axisymmetric p-mode oscillations influenced by strong dipole magnetic fields and show some comparisons between theoretical and observed frequencies.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 14:15 – 14:45
Type of talk: Invited

Pulsation-driven mass loss across the HR diagram: from OB stars to Cepheids to red supergiants

Hilding Neilson

East Tennessee State University

Both pulsation and mass loss are commonly observed in stars and are important ingredients for understanding stellar evolution and structure, especially for massive stars. There is a growing body of evidence that pulsation can also drive and enhance mass loss in massive stars and that pulsation-driven mass loss is important for stellar evolution. In this review talk, I will discuss recent advances in understanding pulsation driven mass loss in massive main sequence stars, classical Cepheids and red supergiants and present some challenges remaining.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 14:45 – 15:00
Type of talk: Contributed

Asteroseismic Signatures of Magnetic Activity Variations in Solar-type Stars

Travis Metcalfe

Space Science Institute

Observations of magnetic activity cycles in other stars provide a broader context for our understanding of the 11-year sunspot cycle. The discovery of short activity cycles in a few stars, and the recognition of analogous variability in the Sun, suggest that there may be two distinct dynamos operating in different regions of the interior. Consequently, there is a natural link between studies of magnetic activity and asteroseismology, which can characterize some of the internal properties that are relevant to dynamos. I will provide a brief historical overview of the connection between these two fields (including prescient work by Wojtek Dziembowski in 2007), and highlight some exciting results that are beginning to emerge from the Kepler mission.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 15:00 – 15:15
Type of talk: Contributed

Pulsations as a mass-loss trigger in evolved hot stars

Michaela Kraus[1], Dieter H. Nickeler[1], Lydia S. Cidale[2], Maximiliano Haucke[2], Sanja Tomic[3]

[1] *Astronomical Institute AVCR, Ondrejov, Czech Republic,* [2] *Universidad Nacional de La Plata, La Plata, Argentina,* [3] *Belgrade University, Belgrade, Serbia*

The post-main sequence evolution of massive stars (> 8 solar masses) encompasses several short-lived transition phases, in which the stars undergo strongly enhanced, sometimes eruptive mass loss events. But also blue supergiants, which should maintain a stable line-driven stellar wind, often display strong photometric and spectroscopic variability, which was recently identified as due to stellar pulsations. We started to monitor a sample of evolved massive stars, including blue supergiants, using spectroscopic facilities at Ondrejov Observatory (Czech Republic), Dominion Astrophysical Observatory (DAO, Canada), and Complejo Astronomico El Leoncito (CASLEO, Argentina). Our investigation aims at identifying and understanding the triggering mechanism for the mass-loss behaviour in these objects. Here, first results will be presented for a subset of objects. In particular we found that the Halpha emission in many blue supergiants strongly varies in time. It hence serves as an ideal tracer for the effect of pulsations at the base of the wind. Similar results are found for other stars in transition, supporting the idea of pulsations as a suitable trigger for mass loss in evolved massive stars.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 15:15 – 15:45
Type of talk: Invited

Testing microphysics data

Przemysław Walczak

Uniwersytet Wrocławski, Instytut Astronomiczny

Microphysics data like opacities are a key ingredient in stellar modelling. However, frequently used data bases like the OPAL (Iglesias & Rogers 1996, ApJ 464, 943) or OP (Seaton 2005, MNRAS, 362, L1) data show quite large discrepancies and contain still a lot of uncertainties. Different values of the opacity coefficient can be found also in the new Los Alamos opacities calculated with an updated version of the LEDCOP code (Magee et al. 1995, in ASP Conf. Ser. 78, 51).

Such differences have significant impact on the asteroseismic data like eigenfrequencies and eigenfunctions. A comparison of the observational quantities with the theoretical counterparts can yield strong constraints on opacities. The suitable targets for such studies are the main sequence B-type pulsators (β Cephei, SPB), which have relatively simple internal structure. The excitation of their pulsations depends directly on the opacity bump caused by elements heavier than helium. Our aim is to present seismic analysis of such stars and show directions for further improvements of the microphysics data.

Session 4. **Applications of pulsating stars in astrophysics**
Time: Wednesday, August 21, 15:45 – 16:00
Type of talk: Contributed

Opacities : focus on the iron group in the envelopes of massive stars

Maelle Le Pennec, Sylvaine Turck-Chieze

CEA

Opacities are key ingredients for stellar evolution. They are fundamental to understand the radiative transport in stellar plasma and to properly identify and interpret the present spatial missions (SoHO, COROT, KEPLER...). In the presentation, I will focus on the envelopes of massive stars. The envelope of β Cephei, where the excitation of the oscillations (κ-mechanism) is due to the opacity peak of the iron group, is yet poorly understood (difference between the computed modes and the observed modes, see Pamyatnykh 1999) I will show the results of an experiment performed in LULI (in 2010 and 2011) aiming at measuring the opacity of key elements for the κ-mechanism: iron and nickel, and its comparison with computed opacities from different codes (HULLAC (Bar Shalom et al. 2001), OPAL, OP, ATOMIC). Then I shall conclude on the relevance of OPAL or OP calculations and on the directions of progress.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 9:00 – 9:30
Type of talk: Invited

Blazhko effect in Cepheids and RR Lyrae stars

Róbert Szabó

MTA CSFK, Konkoly Observatory, Budapest, Hungary

The Blazhko effect is the conspicuous amplitude and phase modulation of the pulsation of RR Lyrae stars that was discovered in the early 20th century. The field of study of this mysterious modulation has recently been invigorated thanks to the space photometric missions (CoRoT, Kepler) providing long, uninterrupted, ultra-precise time series data.

In this talk I will give a brief overview of the new observational findings related to the Blazhko effect (extreme modulation, irregular modulation cycles, additional periodicities). I will argue that these findings together with dedicated ground-based efforts now provide us with a fairly complete picture and a good starting point to theoretical investigations.

Indeed, new, unpredicted dynamical phenomena have been discovered (period doubling, high-order resonances, three-mode pulsation, chaos) that led to the proposal of new explanations to this century-old enigma. I will discuss the latest theoretical efforts and advances and demonstrate how the the observations exclude certain types of mechanisms. I will close my talk by referring to similar modulations in Cepheids.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 9:30 – 10:00
Type of talk: Invited

Multimode oscillations in classical Cepheids and RR Lyrae stars – new results

Paweł Moskalik

CAMK PAN, Poland

Majority of Pop. I Cepheids and RR Lyrae-type stars are simple, sigle-mode radial pulsators. But this is not always the case. I will review different types of multimode pulsations observed in these classical variables. My presentation will concentrate on the newest results, with special emphasis on non-radial oscillations, which have recently been detected in Cepheids and in RR Lyrae stars.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 10:00 – 10:15
Type of talk: Contributed

Cepheids and the Blazhko-effect – a comprehensive analysis of V473 Lyrae

László Molnár[1], László Szabados[1], Robert Dukes Jr[2], Róbert Szabó[1]

[1]*Konkoly Observatory,* [2]*College of Charleston*

Among the Galactic, singe-mode Cepheids, V473 is the only object known to experience periodic amplitude modulation, similar to the Blazhko-effect. With the help the most complete photometric and radial-velocity data sets of the star, we carried out the first truly detailed analysis the modulation properties. Phenomenologically, the variations are very similar to those of modulated RR Lyrae stars. Both the amplitude and phase of the pulsation mode are modulated and individual modulation cycles show deviations both in length and strength. We also conducted a hydrodynamic model survey to search for nonlinear second-overtone models and possible mode resonances that may be connected to the modulation.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 10:15 – 10:30
Type of talk: Contributed

RR Lyrae studies with Kepler – showcase RR Lyr

Katrien Kolenberg

Harvard-Smithsonian Center for Astrophysics, USA

Four years into the Kepler mission, an updated review on the results for RR Lyrae stars is in order.

More than 40 RR Lyrae stars in the Kepler field are observed with Kepler and each one of them provides us with new insight in this class of pulsating stars. Previously, we already reported a ∼50% occurrence rate of modulation in the RRab stars, the large variety of modulation behavior, period doubling in several Blazhko stars, the detection of higher overtone radial modes, probable non-radial modes and new types of multiple-mode RR Lyrae pulsators, both among the RRab and the RRc stars. Ground-based spectroscopy of the Kepler targets allows us to narrow down their physical parameters. In addition, quasi-continuous photometry obtained over several years allows to observe changes in Blazhko behavior and additional longer cycles. The above-mentioned observations have sparked new theoretical modelling efforts.

One of the targets, the showcase RR Lyr (itself!), has been observed with Kepler in short cadence, and some fascinating features if its pulsation behavior are unveiled in this long-studied prototype.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 10:30 – 10:45
Type of talk: Contributed

Bisector analysis of RR Lyrae: atmosphere dynamics at different Blazhko phases

Elisabeth Guggenberger

University of Vienna, Austria

An analysis of line bisectors of metal absorption lines is presented for RR Lyrae, the prototype of its class of pulsators. The extensive data set used for this study consists of a time series of spectra obtained at various pulsation phases as well as different Blazhko phases. This setup allows a comparison of the atmospheric behaviour, especially of the function of radial velocity versus depth at differing Blazhko phases, but (almost) identical pulsation phase, making it possible to investigate whether the modulation causes a change in the atmospheric motion of RR Lyrae. While the nature of the Blazhko modulation has often been investigated photometrically and described as a change in the light curve, studies on time series of high resolution spectra are rare. We present for the first time a comparison of line bisectors at different Blazhko phases of RR Lyr.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 11:30 – 12:00
Type of talk: Invited

Mode selection analysis

Radosław Smolec

Nicolaus Copernicus Astronomical Center, PAS, Poland

I this review I will focus on the mode selection mechanisms in pulsating variable stars. The two basic processes, the saturation of the driving mechanism and resonant mode coupling will be discussed using the large amplitude pulsators as an example. Methods for studying the mode selection problem in low-amplitude, non-radial pulsators will be described and a rather scarce progress in the theoretical work during the recent years will be reviewed. Finally, I will discuss the space mission observations for different groups of pulsators and their impact on our understanding of mode selection.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 12:00 – 12:30
Type of talk: Invited

Pulsations in White Dwarf Stars

Gilles Fontaine

Université de Montréal

White dwarf stars are characterized by extremely high average densities compared to normal stars and, as such, present particular challenges to pulsation theory. A total of six distinct families of pulsating white dwarfs are now known, each corresponding to a different evolutionary phase in the life of these objects. Only low- to mid-order low-degree g-modes have been detected in white dwarfs so far, although p-modes of order $\sim$1 s are also predicted by theory but have apparently eluded detection. I will review the current status of the field, including the most recent discoveries such as extremely low mass white dwarfs of the ZZ Ceti type (products of binary evolution), and of the second pulsating DA white dwarf sufficiently massive to have part of its interior to be crystallized.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 12:30 – 12:45
Type of talk: Contributed

Massive pulsating white dwarf stars

Barbara Castanheira

University of Texas, Austin, USA

Using the SOAR 4.1m telescope and the 2.1m Otto Struve telescope, we report on the discovery of nine new massive pulsating white dwarf stars. Our results represent an increase of about 30of massive pulsators. We have detected both short and long periods, low and high amplitude pulsation modes, covering the whole range of the ZZ Ceti instability strip.

I will also present a first seismological study of the new massive pulsators based on the few frequencies detected. Our analysis indicate that these stars have masses higher than average, in agreement with the spectroscopic determinations. In addition, we study for the first time ensemble properties of the pulsating white dwarf stars with masses above $0.8 M_{\odot}$. We found a bimodal distribution of the main pulsation period with the effective temperature for the massive DAVs. This effect had been observed previously, when just a small number of DAVs were known.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 12:45 – 13:00
Type of talk: Contributed

New findings on the internal structure of ZZ Ceti stars using quantitative asteroseismology

Noemi Giammichele, Gilles Fontaine, Pierre Brassard

Université de Montréal

We explore for the first time the low but sufficient sensitivity of oscillation modes to both the core composition and the details of the chemical stratification of pulsating white dwarfs. ZZ Ceti variables are nonradially g-mode pulsating white dwarfs with a hydrogen-dominated atmosphere. Until recently, applications of quantitative asteroseismology to pulsating white dwarfs have been far and few, and have often suffered from an insufficient exploration of parameter space. To remedy this situation, we apply to white dwarfs the same double-optimization technique that has been used quite successfully in the context of pulsating hot B subdwarfs. Based on the frequency spectra of the pulsating white dwarfs R548 and GD 165, we are able to unravel in a robust way the unique onion-like stratification and the chemical composition of the star. Independent confirmations from both spectroscopic analyses and detailed evolutionary calculations including diffusion provide crucial consistency checks and add to the credibility of the inferred seismic models. More importantly, these results boost our confidence in the reliability of the forward method for sounding white dwarf internal structure with asteroseismology.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 14:30 – 15:00
Type of talk: Invited

Origin and pulsation of hot subdwarfs

Suzanna Randall et al.

ESO Garching

I will review the status quo of pulsating hot subdwarfs, and outline ways in which the pulsations can be used to better understand these enigmatic stars' origin and evolution. While hot subdwarfs are believed to be the progeny of red giant stars that lost a large fraction of their envelope mass, the details of their formation and the evolutionary link between the different types of hot subdwarf remain unclear. Asteroseismology, in conjunction with detailed evolutionary modelling, could hold the key to answering some of the major outstanding questions in this area. Several different types of pulsator are now known to exist among hot subdwarfs, spanning temperature ranges all along the Extreme Horizontal Branch, exhibiting both p- and g-modes, and existing in different environments such as the Galactic field and globular clusters. For some of these pulsators asteroseismology is already being applied very successfully, while for others we are still struggling to explain their very existence. In all cases we expect the exploitation of the pulsational nature of these objects to provide us with insights beyond those that can be gained using traditional techniques.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 15:00 – 15:30
Type of talk: Invited

The origin and pulsation of extreme helium stars

Simon Jeffery

Armagh Observatory

Stars consume hydrogen in their interiors but, generally speaking, their surfaces continue to contain some 70% hydrogen (by mass) throughout their lives. Nevertheless, many types of star can be found with hydrogen-deficient surfaces, in some cases as little as one hydrogen atom in 10 000. Amongst these, the luminous B- and A-type extreme helium stars are genuinely rare - with less than 15 known within a very substantial volume of Galaxy.

Evidence from surface composition suggests a connection to the cooler R Coronae Borealis variables and some of the hotter helium-rich subdwarf O stars. Arguments currently favour an origin in the merger of two white dwarfs; thus there are also connections with AM CVn variables and Type Ia supernovae. This talk will examine recent models and other evidence in favour of and against such an origin.

Pulsations in many extreme helium stars provide an opportune window into their interiors. These pulsations have unusual properties, some being "strange" modes, and others being driven by Z-bump opacities. They have the potential to deliver distance-independent masses and to provide a unique view of pulsation physics. This talk will review recent progress and continuing challenges in studies of helium-star pulsations.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 15:30 – 15:45
Type of talk: Contributed

Reaching the 1% accuracy level on stellar mass and radius determinations from asteroseismology

Valerie Van Grootel[1], Stephane Charpinet[2], Gilles Fontaine[3], Pierre Brassard[3], E.M. Green[4]

[1] *University of Liege, Belgium,* [2] *IRAP, France,* [3] *Université de Montréal, Canada,* [4] *Steward Observatory/University of Arizona, USA*

Asteroseismic modeling of subdwarf B (sdB) stars provides measurements of their fundamental parameters with a very good precision; in particular, the masses and radii determined from asteroseismology are found to typically reach a precision of 1containing various uncertainties associated with their inner structure and the underlying microphysics (composition and transition zones profiles, nuclear reaction rates, etc.). Therefore, the question of the accuracy of the stellar parameters derived by asteroseismology from the sdB models is legitimate.

I will present in this talk the seismic modeling of the pulsating sdB star in the eclipsing binary PG 1336-018, for which the mass and the radius are independently and precisely known from the modeling of the reflection/irradiation effect and the eclipses observed in the light curve. This allows us to quantitatively evaluate the reliability of the seismic method and test the impact of various uncertainties in our stellar models on the derived parameters. I will show that the sdB star parameters inferred from asteroseismology are precise, accurate, and robust against model uncertainties.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 15:45 – 16:00
Type of talk: Contributed

Being Rich Helps, Case of KIC 010670103 sdBV

Jurek Krzesiński

Pedagogical University of Cracow

KIC 010670103 is a gravity mode pulsating sdB star, which has one of the richest pulsating pattern among sdbVs, consisting of 28 frequencies (Reed et al. 2010). It is also the coolest star with the longest observed pulsation periods. Up to now, all we knew about pulsational behavior of that star come from one month of Kepler (Borucki et al. 2010, Koch 2010, Jenkins et al. 2010) exploratory phase data. Can we learn more having 2.5 year long time-series photometry of that star?

The study of 30 months Kepler data allowed for continuous sequence of $l = 2$ modes identification, finding frequency triplets, quintuplets and rough estimation of the star rotation.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 16:45 – 17:15
Type of talk: Invited

Pulsations in hot supergiants

Melanie Godart[1], Arlette Grotsch-Noels[2],
Marc-Antoine Dupret[2], Hiromoto Shibahashi[1]

[1]*Department of Astronomy, University of Tokyo,* [2]*Department of Astrophysics, University of Liege*

Massive stars are the cosmic engines that shape and drive our Universe. Many issues such as their formation, their stability and the mass loss effects for example, are nowadays far for being completely understood. To improve our understanding, asteroseismology provides a powerful tool and excellent results have been obtained over the last years. Recent ground-based and space observations have shown the presence of pulsations in massive MS and post MS stars, such as acoustic and gravity modes excited by the *kappa*-mechanism and even solar-like oscillations. Theoretical studies emphasized the presence of strange modes in massive models, excited by the strange mode instability mechanism and a strange mode candidate has been observed in a hot supergiant (Aerts et al. 2010). Moreover, recent theoretical analyses have shown that hot supergiants can also pulsate in oscillatory convective modes propagating in the superficial layers of these stars (Saio et al. 2011). We review here the instability domains of massive stars as well as their excitation mechanisms and present the latest results in the domain.

Session 5. **New solutions to old problems and new challenges**
Time: Thursday, August 22, 17:15 – 17:30
Type of talk: Contributed

Pulsations of blue supergiants before and after helium core ignition

Jakub Ostrowski, Jadwiga Daszyńska-Daszkiewicz

Instytut Astronomiczny, Uniwersytet Wrocławski, Poland

The discovery of pulsational frequencies in the light variations of the blue supergiant HD 163899 (B2 Ib/II) has prompted a few groups to re-analysis of pulsational stability in models after the Terminal Age Main Sequence (TAMS). The star has become a prototype of a new class of pulsating variables coined Slowly Pulsating B-type supergiants (SPBsg). The presence of g-mode pulsations in B-type post main sequence stars has been explained by a partial reflection of some modes at an intermediate convective zone related to the hydrogen burning shell or at chemical gradient zone surrounding the radiative core. However, these two interpretations are based on the assumption that HD 163899 is before helium core ignition, i.e., in the phase of hydrogen shell burning. This assumption does not have to be necessary adequate because the blue loop can reach temperatures of early B spectral types. Using a non-adiabatic pulsation code, we investigate and compare two SPBsg models: before and after He core ignition. We examine properties of propagation diagrams and instability parameter as well as kinetic energy density and work integrals of pulsation modes. Such comparative analysis can be of great value for establishing the evolutionary status of SPBsg stars and understanding the nature of their pulsations.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 9:00 – 9:30
Type of talk: Invited

Solar-like oscillations in subgiants and red giants

Saskia Hekker

University of Amsterdam

The space-borne missions CoRoT and Kepler have provided near-uninterrupted high-precision photometry for many subgiant and giant stars. These data have revealed many features in these stars that allows us to characterise them in detail.

Here I will give an overview of the latest groundbreaking results of solar-like oscillations in subgiant and red-giant stars.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 9:30 – 10:00
Type of talk: Invited

Stochastically excited modes in the upper main sequence stars

Vichi Antoci

Stellar Astrophysics Centre, Aarhus University

Convective envelopes in stars on the main sequence are usually connected only with stars of spectral types F5 or later. However, observations as well as theory indicate that the convective outer layers despite of being shallow are still effective and turbulent enough to excite solar-like oscillations. Because of the low amplitudes, exploring stochastically excited pulsations became possible only with space missions such as Kepler and CoRoT. In this talk I will give an overview over the recent results and discuss pulsators such as δ Scuti, γ Doradus, rapidly oscillating Ap, β Cephei and the Slowly Pulsating B-type stars in the context of solar-like oscillations.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 10:00 – 10:15
Type of talk: Contributed

Energetical aspects of solar-like oscillations in red giants.

Mathieu Grosjean[1], M.A. Dupret[1],
K. Belkacem[2], J. Montalban[1], R. Samadi[2]

[1] *University of Liege,* [2] *LESIA, Observatoire de Paris*

CoRoT and Kepler's observations of red giants are revealing very rich spectra of non-radial solar-like oscillations, thereby allowing us to probe their internal structure. Modelling the energetic aspects of these oscillations is required to predict and understand the peaks' parameters in the power spectrum: linewidths (damping rates), heights and amplitudes. We achieve such modelling with our non-radial non-adiabatic oscillation code (MAD) in combination with our stochastic excitation code, optimised for the numerically difficult case of red-giant oscillations. Comparing our theoretical predictions with observations yields new constraints on the internal structure of red giants. The lifetimes and amplitudes of modes trapped in the envelope (e.g. radial modes) constrain the characteristics of the convective envelope and its time-dependent interaction with oscillations. Those of mixed modes (mainly dipolar modes) strongly depend on mode trapping, thereby allowing us to probe the core of red giants. Because of the great importance of this last point, I will discuss more specifically under what circumstances mixed modes are predicted to be detectable for a large variety of red-giant stellar models at different evolutionary stages (along the red-giant branch and during the He-burning phase) and for a wide range of stellar masses (from 0.7 to $4M_{\odot}$).

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 10:15 – 10:30
Type of talk: Contributed

The evolution of the internal rotation of solar-type stars

Maria Pia Di Mauro[1], R. Ventura, D. Cardini,
J. Christensen-Dalsgaard, W. Dziembowski, L. Paterno

[1]*INAF-IAPS Roma, Italy*

The authors will discuss the potential of asteroseismic inversion to study the dynamics of the stellar interior of solar-type stars from the Sun to red-giant phase. In particular, they will consider the use of g- and mixed-modes and the application of different inversion methods.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 11:00 – 11:30
Type of talk: Invited

Application of helioseismic methods to stellar oscillations

Yvonne Elsworth

University of Birmingham

The natural oscillations of the Sun have been studied for many decades and, although there are unsolved problems, there is a wealth of experience of how to extract the mode parameters. One might think therefore that analysing stellar acoustic spectra would be very easy. However this is not true. Many of the ideas can be used but there are fundamental differences in the data for both main sequence and red giant stars. I will explore the similarities and differences.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 11:30 – 11:45
Type of talk: Contributed

Sunquakes and Starquakes

Alexander Kosovichev

Stanford University

In addition to well-known mechanisms of excitation of solar and stellar oscillations by turbulent convection and instabilities, the oscillations can be excited by impulsive localized force caused by the energy release in solar and stellar flares. Such oscillations have been well observed on the Sun ("sunquakes"), and created a lot of interesting discussions about physical mechanisms of the impulsive excitation and their relationship to the flare physics. The observation and theory have shown that most of the sunquake's energy is released in high-degree high-frequency p-modes. In addition, there have been reports on helioseismic observation of low-degree modes excited by strong solar flares. Much more powerful flares observed on other stars can cause "starquakes" of substantially higher amplitude. Observations of such oscillations can provide new asteroseismology information and also constraints on mechanisms of stellar flares. I discuss the theoretical predictions for starquakes, and initial attempts to detect flare-excited oscillations in Kepler short-cadence data.

Session 6. **From the Sun to the stars: the helio- asteroseismology connection**
Time: Friday, August 23, 11:45 – 12:15
Type of talk: Invited

Seismic studies of planet harbouring stars

Sylvie Vauclair

Institut de Recherche en Astrophysique et Planetologie, France

During the past decades, stellar oscillations and exoplanet searches were developed in parallel, and the observations were done with the same instruments: radial velocity method, essentially with ground-based instruments, and photometric methods (light curves) from space. The same observational data on one star could lead to planet discoveries at large time scales (days to years) and to the detection of stellar oscillations at small time scales (minutes), as for the star mu Arae. Since the beginning, it seemed interesting to investigate the differences between stars with and without observed planets. Also, a precise determination of the stellar parameters is important to characterize the detected exoplanets. With the thousands of exoplanet candidates discovered by Kepler, automatic procedures and pipelines are needed with large data bases to characterize the central stars. However, precise asteroseismic studies of well-chosen stars are still important for a deeper insight. Here I will emphasize the cases of a few solar-type exoplanet-host stars

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3. **Banyai**, Kiss, Bedding + members of KASC WG12
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   Helio and asteroseismology shedding light on
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ABSTRACTS OF POSTERS

1. 3D simulations of internal gravity waves in solar-like stars

Lucie Alvan, Allan Sacha Brun, Stephane Mathis

CEA

We perform numerical simulations of the whole Sun using the 3D anelastic ASH code. In such models, the radiative and convective zones are non-linearly coupled and in the radiative interior a wave-like pattern is observed. For the first time, we are thus able to modelize in 3D the excitation and propagation of IGWs in a solar-like star's radiative zone. We compare the properties of our waves to theoretical predictions and results of oscillation calculations. The good agreement obtained allow us to validate the consistency of our approach and to study the characteristics of IGWs, such as the form of the waves' spectrum, their lifetime, their comportement as function of the depth, and the formation of g-modes. The advantage of the numerical simulation is to allow us to see IGWs at every depth in the star. As we know exactly the form of the signal we should observe, we can investigate the visibility of g-modes at the surface, after their passage through the convective zone.

2. Error and bias from poorly-modelled surface effects in stellar model fits

Warrick Ball

Institut fuer Astrophysik, Georg-August-Universitaet Goettingen

I present recent results in characterizing the non-linear error of fitting stellar models to a resolved frequency spectrum. In particular, I consider the effects of failing to correctly model surface effects, either by not including them at all, or modelling them incorrectly in the fitting process. These effects appear both as changes in the uncertainties and in systematic offsets from the correct models, which I quantify.

3. Pulsations of M giant stars based on Kepler photometry: general characteristics

Evelin Banyai[1], Laszlo Kiss[1], Tim Bedding[2] + members of KASC WG12

[1]*Konkoly Observatory,* [2]*University of Sydney*

M giants are among the longest-period pulsating stars, hence their studies have traditionally been restricted to analyses of low-precision visual observations, or more recently, accurate ground-based CCD data, such as those by the OGLE

project, delivering one point per night. In this talk we present a general overview of M giant variability on a wide range of time-scales, based on thirteen quarters of Kepler LC observations, with a time-span of 1000 days. The majority of the stars was selected from the ASAS-North survey, hence being a variability selected sample, supplemented with a randomly chosen M giant control sample.

Here we describe the difficulties we encountered in stitching together the light curves that is essential for studying M giants in Kepler data. Then we discuss the presence of regular patterns in the distributions of multiple periodicities and amplitudes. We find evidence of a distinction between the solar-like oscillations and those larger amplitude pulsations characteristic for Mira/SR stars in the period-amplitude plane. That could pinpoint the transition between two types of oscillations as we move upward along the giant branch. Finally, we discuss several cases that are similar to the classical Long Secondary Periods of AGB stars but on much shorter time-scales.

4. Are RRab stars fully radial?

József M. Benkő

Konkoly Observatory, MTA CSFK

Thanks to the space missions CoRoT and Kepler new oscillation frequencies have been discovered in the Fourier spectra of Blazhko RR Lyrae stars in the past few years. The period doubling (PD) yields half-integer frequencies such as $1/2f_0$, $3/2f_0$ etc, where f_0 denotes the frequency of the radial fundamental pulsation. The phenomenon is successfully modeled by a resonance between the fundamental and a high radial overtone so-called 'strange' modes. In many cases the first and/or second radial overtone frequencies also appear temporally. All of these frequencies can be explained by the radial structure of the stars. Some particular stars, however, show extra peaks that are seemingly not connected to radial pulsation. These frequencies were identified as potential non-radial modes. We show here that all such RRab frequencies can also be identified as different linear combinations of the radial fundamental and overtone frequencies. This interpretation can be checked with the existing hydrodynamical pulsation codes.

5. Helio and asteroseismology shedding light on

Marek Biesiada

University of Silesia, Institute of Physics, Department of Astrophysics and Cosmology, Poland

Interrelations between astronomy and physics have always been intimately close and mutually stimulating. Most often it was physics that served astronomy with its explanatory power. Today, however, we are increasingly witnessing the

reverse: astrophysical considerations are being used to constrain "exotic" physical ideas and moreover they are more efficient than laboratory experiments.

Two most important issues in modern science, are the dark matter problem and the phenomenon of accelerating expansion of the Universe (also known as the dark energy problem). They stimulate theoretical physicists to go beyond the standard physics and develop non-standard ideas, like: an assumption that our world might have more than four dimensions, the existence of new particles (supersymmetric particles, axions, etc.) or speculations that fundamental constants of nature might vary in time.

This talk reviews the ways helio and white dwarf asteroseismology - branches in which Wojtek Dziembowski played a prominent role - are used to constrain such exotic physical ideas.

6. Results of a Search for gamma Doradus and delta Scuti Stars with the KEPLER Satellite

Paul Bradley, Joyce Guzik, Lillian Miles,
Katrien Uytterhoeven, Jason Jackiewicz

Los Alamos National Laboratory

The light curves of 645 γ Doradus and δ Scuti star candidates observed as part of the KEPLER Guest Observer program are analyzed in a uniform manner to search for γ Doradus, δ Scuti, and hybrid star pulsations. These observations were carried out as part of a Guest Observer program and consists of data from quarters 2, 4, and 6 through 15. We discovered 68 γ Doradus stars, 17 δ Scuti stars, 12 binary systems, 117 stars that have slow modulations (which could be due to rotating starspots), and 6 stars that exhibit variation consistent with some other type of pulsations. We describe our fractional discovery rate and how this compares to what we would expect when we compare the Kepler Input Catalogue (KIC) Teff and log g values (with error bars) to the ground-based instability strip boundaries.

7. A new observational method to derive Cepheid masses

Joanne Breitfelder

ESO, Santiago, Chile / Observatoire de Paris, France

The mass is a fundamental stellar parameter and an essential key for our comprehension of stellar physics. For now, Cepheid masses are mainly derived from dynamic models, and only a handful of Cepheid masses have been determined observationally. We introduce a new method to derive the mass of Cepheids, based on the assumption that the photosphere is in free fall during the contraction phase. As other forces might oppose the gravitational acceleration, we

actually derive a minimum mass, which already leads to interesting outcomes. We can highlight two main results obtained by calculating the minimal mass of a dozen of Cepheids. Firstly, we find a correlation between this mass and the pulsation period. For very short periods we find minimum masses well below with model estimates. However, for long periods, the minimum masses can reach twice the values predicted by the models. This result suggests that the dynamics of Cepheid atmospheres is not governed by the same forces depending on their period. We also obtain very small minimal masses for the "s-Cepheids", what means that their maximum infall acceleration is much lower than their gravitation. They therefore do not enter in the framework of our free fall assumption.

8. Multicolour photometry of pulsating stars in the Galactic Bulge fields

Przemysław Bruś, **Zbigniew Kołaczkowski**

Instytut Astronomiczny Uniwersytetu Wrocławskiego, Poland

We present the study of photometric properties of very crowded stellar fields toward the Galactic Bulge. Among thousends of variable stars from OGLE-II survey we performed a search for pulsating stars supplemeted by our standard photometric measurements in four Johnson-Cousins passbands (UBVI). Using these data, we analysed the properties of objects located at different distances along the light of sight and, whenever possible, classified them.

9. Spectropolarimetric study of the classical Cepheid eta Aql: pulsation and magnetic field

Butkovskaya V.[1], Plachinda S.[1], Baklanova D.[1], Butkovsky V.[2]

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Magnetic field on later-type supergiants was proved by Plachinda (2005), who firstly detected non-zero longitudinal magnetic field on ϵ Gem and ϵ Peg, and Grunhut et al. (2010) who reported Zeeman signatures in Stokes V for 9 later-type supergiants (including η Aql). A possible pulsational modulation of stellar magnetic field is widely discussed in literature for RR Lyr (Babcock (1958), Preston (1967), Romanov et al. (1987, 1994), Chadid et al. (2004)). Butkovskaya and Plachinda (2007) firstly detected the pulsation modulation of the longitudinal magnetic field of the small-amplitude β Cephei-type star γ Peg (B2 IV) where the longitudinal component of the magnetic field varies during the 0.15-day pulsation period with the amplitude about 7 G. The pulsational modulation of the longitudinal magnetic field on η Aql was reported by Plachinda (2000). Wade et al. (2002) detected no statistically significant magnetic field on η Aql during 3 nights in 2002. So the question of the possible pulsation

modulation of the magnetic field on η Aql is open. We present the results of spectropolarimetric study of η Aql during 66 nights from 2002 to 2012.

10. Stellar Variability in the VVV Survey: An Update

Márcio Catelan

Pontificia Universidad Católica de Chile

The Vista Variables in the Vía Láctea (VVV) ESO Public Survey consists of a near-IR variability survey of the Milky Way bulge and an adjacent section of the mid-plane, using ESO's 4.1m VISTA telescope. It will take 1929 hours, over a timespan of about 5+ years, covering $\sim 10^9$ point sources within a sky area of 520 sq. deg, which includes 33 known globular clusters and ~ 350 open clusters. The survey is currently in its fourth year of operation. Here I provide a description of the project's current status, as well as some first results, with particular emphasis on the detection and classification of variable stars in the studied fields.

11. G-mode trapping and period spacings in hot B subdwarf stars

S. Charpinet[1], V. Van Grootel[2], P. Brassard[3], G. Fontaine[3]

[1]*IRAP/CNRS* [2]*Université de Liége,* [3]*Université de Montréal*

Hot B subdwarfs are hot and compact helium core burning stars of nearly half a solar mass that can develop pulsational instabilities driving acoustic and/or gravity modes. These evolved stars are expected to be chemically stratified with a nearly hydrogen pure envelope surrounding a helium mantle on top of a Carbone/Oxygen enriched core. However, the sdB stars pulsating in g-modes show regularities in their observed period distributions that, surprisingly (at first sight), are typical of the behavior of high order g-modes in chemically homogeneous (i.e., non stratified) stars. This led to a claim that hot B subdwarfs could be much less chemically stratified than previously thought. In this poster, we reinvestigate trapping effects affecting g-modes in sdB stars and we show that standard fully stratified models of sdB stars can also produce nearly constant period spacings in the low frequency range such as those that are found in g-mode spectra of sdB stars monitored with Kepler.

12. Physical uncertainties in core helium burning models and what we can learn from asteroseismology

Thomas Constantino

Monash University

The treatment of the convective core boundaries in models of core helium burning stars is a large source of uncertainty. Later evolution and nucleosynthesis depends on the structure after this phase and hence it is typically the point at which the results of different stellar evolution codes begin to diverge. Asteroseismology offers the first glimpse into this internal structure, long hidden from observational astronomy. This is made possible by the detection of mixed gravity- and p-modes which are dependent on the buoyancy frequency and are highly sensitive to the structure and composition of the core. We investigate the sensitivity of these oscillations to the uncertainties in physical inputs of our models such as convective overshooting, composition, equation of state, opacity, mixing length and reaction rates. We show that the mixed-mode period spacing $\Delta\Pi_1$ is linearly dependent on the radius of the fully convective core and critically dependent on He-burning luminosity. Our models typically have a $\Delta\Pi_1$ lower than that observed, suggesting they are not luminous enough. We aim to use these results to determine if a more radical revision of the mixing prescription in our models is required.

13. Asteroseismology with the new metallic opacity bump at lg T = 5.06

H. Cugier

Astronomical Institute of the Wrocław University

Although the κ-mechanism of pulsations is known for early-type stars, opacities and equation of state are still uncertain. Stellar models calculated for the OP data implemented with the new Kurucz's opacities at $\lg T < 5.2$ are investigated for different chemical compositions of elements. The additional metallic opacity bump at $\lg T = 5.06$, what occurs in the Kurucz's data changes markedly oscillation spectra of unstable modes. Basic properties of the new opacity bump are discussed and examples of seismic models are shown. B-stars observed in the Galaxy, LMC and SMC are considered. The problem was studied using Dziembowski's computer codes for linear, nonadiabatic and nonradial oscillations.

14. Spectroscopic and photometric study of two B-type pulsators in eclipsing systems

Dominik Drobek, Andrzej Pigulski

Astronomical Institute of the University of Wroclaw

We present the results of a joint photometric and spectroscopic analysis of two southern eclipsing binary systems: HD101794 and HD167003. Both targets are known to be early B-type stars showing short-period, low amplitude variability consistent with β Cephei-type pulsations. The UBVRI light curves of targets are analysed in conjunction with radial velocities obtained from high-resolution optical spectroscopy. The attempts at deriving the masses and radii of individual components of both systems are discussed, and initial results are presented.

15. Observing bright stars using a partial-field neutral density filter

Waldemar Ogłoza, **Marek Dróżdż**,
Greg Stachowski, Bartłomiej Zakrzewski

Mt. Suhora Astronomical Observatory

We have developed a method of observing very bright stars, such as those planned as targets of the BRITE satellite constellation, by masking part of the CCD chip with a uniform neutral-density filter, which reduces the signal from the bright star by several magnitudes without affecting its photometric properties. This allows much fainter nearby stars in the same field (not masked by the filter) to be used for differential photometry while also maintaining good pixel sampling of the star images. Here we present initial results from observations of a number of bright variable stars of various types, demonstrating the feasibility of the method. Once the method is refined we plan to use it for ground-based support and follow-up for the the BRITE mission.

16. Strömgren photometry and medium-resolution spectroscopy of some delta Scuti and gamma Doradus in the Kepler field

Lester Fox-Machado

Insituto de Astronomia-UNAM, UNAM, México

As part of the ground-based observational efforts to support the Kepler space data undertaken by the WG4 and WG10 KASC subGroups, we have obtained Strömgren $uvby - H_\beta$ photoelectric photometry and medium-resolution spectroscopy of a number of δ Scuti and γ Doradus in the Kepler field. The observations were performed at the Observatorio Astronómico Nacional-San Pedro Mártir (OAN-SPM) in Baja California, Mexico. The 1.5-m telescope with the

six-channel Strömgren spectrophotometer and the 2.12-m telescope with the Boller & Chivens spectrograph were used. In this poster we present the standard Strömgren indices of the stars as well as the physical parameters derived from spectroscopic and spectrophotometric observations.

17. Characterizing the variability of Cl Melotte 111 Av 1224: a new variable star in the Coma Berenecis open cluster

L. Fox-Machado, R. Michel, M. Alvarez

Insituto de Astronomia - UNAM

A search for new pulsating stars in the Coma Berenices open cluster was carried out at the 0.84-m telescope of the San Pedro Martir observatory in Mexico. As a result of this search the cluster member Cl Melotte 111 Av 1224 presented clear indications of photometric variability with a dominant period of ~ 4.2 h. In order to determine its physical parameters accurately Strömgren standard indices and low-resolution spectra were acquired for this target. In this poster we discuss the nature of the variability of Cl Melotte 111 Av 1224.

18. Asteroseismology from Dome A, Antarctica

Jianning Fu, Weikai Zong, Yi Yang, Zhihua Huang, et al.

Department of Astronomy, Beijing Normal University, Beijing, China

Observations in polar sites open a new window for long, uninterrupted and consecutive time-series photometry/spectroscopy for pulsating variable stars which is a powerful tool for asteroseismology. In the past years, some facilities including Gattini, CSTAR and AST3 have been installed at Dome A, Antarctica which provides time-series photometric data for a large number of pulsating variable stars. The poster will summarize the study for variable stars with those data and predict the scientific potential of observations from Dome A, Antarctica for asteroseismology.

19. An interferometric view on binarity and circumstellar envelopes of Cepheids

Alexandre Gallenne

Universidad de Concepcion

Optical interferometry is the only technique giving access to milliarcsecond resolution at infrared wavelengths. For Cepheids, this is a powerful and unique tool to detect the orbiting companions and the circumstellar envelopes (CSE). Most of the companions are located too close to the Cepheid to be observed

with a single dish telescope. We are engaged in a long-term observing program, that aims at detecting and characterizing the companions of nearby Cepheids. Our main objectives are the determination of accurate masses and geometric distances from high precision orbitography. The derived empirical masses will be very valuable constraints to model the pulsation and evolution of intermediate-mass stars. The presence of CSE around Cepheids was recently discovered by interferometry. The characterization of these envelopes is particularly important as they give access to the present mass loss rate of Cepheids. These CSEs were probably formed through past or ongoing mass loss, possibly generated by shock waves in the pulsating atmosphere of the Cepheid. Due to their small angular extension, interferometric observations are required to estimate their size, and they provide clues of their composition. I will present our recent results on the binary Cepheid V1334 Cyg using the 6-telescopes beam combiner CHARA/MIRC, and CSE observations from the 2-beam combiner VLTI/MIDI.

20. Multidimensional interaction of radial pulsation and convection

Chris Geroux[1], Robert Deupree[2]

[1] *University of Exeter, Saint Mary's University,* [2] *Saint Mary's University*

We have previously calculated a number of 2D hydrodynamic simulations of convection and pulsation to full amplitude. These revealed a significantly better fit to the observed light curves near the red edge of the instability strip in M3 than did previous 1D mixing length models. Here we compare those 2D results with our new 3D hydrodynamic simulations calculated with the same code. As expected, the horizontal spatial behavior of convection in 2D and 3D is quite different, but the time dependence of the convective flux on pulsation phase is quite similar. The difference in pulsation growth rate is only about 0.1 % per period, with the 3D models having more damping at each of the five effective temperatures considered. Full amplitude pulsation light curves in 2D and 3D are compared.

21. The lack of connectivity in asteroseismic time series

Javier Pascual Granado, Rafael Garrido Haba

Instituto de Astrofisica de Andalucia - CSIC

Thanks to the ultra-high accurate photometry of asteroseismology missions like CoRoT and Kepler we can now study properties of the observables that were impossible to study with ground-based data. In this work, we reveal a striking feature appearing to be ubiquitous in all kind of data coming from sufficiently accurate space observations: the lack of connectivity of the samples. This means that probably the data are generated from a disconnected manifold that cannot

be described with a circular transformation.

As a consequence of this property time series here considered do not satisfy the necessary conditions to be represented in the form of a sum of harmonic components and Fourier expansion is not an adequate aproximation.

22. Nonlinear hydrodynamics simulations of radial pulsations in massive stars

Catherine Lovekin, **Joyce A. Guzik**

Los Alamos National Laboratory, Los Alamos, NM

We investigate the radial pulsation properties of massive main sequence stars using both linear and non-linear calculations. Using envelope models of 20, 40, 60 and 85 solar mass models evolved by Meynet et al. (1994), we calculate nonlinear hydrodynamic models including the effects of time-dependent convection. Many of these models are massive enough to lose a significant amount of mass as they evolve, which also reveals more helium-rich layers. This allows us to investigate the dependence of pulsation on mass, metallicity and surface helium abundance. We find that as a model loses mass, the periods become longer relative to the period predicted by the period-mean density relation (period x sqrt(mean density) is proportional to a constant, Q) for the initial model. Increased surface helium abundance causes a dramatic decrease in the period relative to that expected from Q, while changing the metallicity had no significant impact on the periods.

23. The diverse pulsational behaviour of beta Cephei stars: lessons learned from long-term monitoring

Gerald Handler

Nicolaus Copernicus Astronomical Center Warsaw, Poland

We have obtained several seasons of ground based time-resolved photometry of four bright Beta Cephei stars. The pulsational behaviour of these objects shows many previously unknown subtleties. Whereas the oscillations of Gamma Peg appear to be extremely stable over time, allowing the detection of modes with amplitudes in the sub-millimag domain, 15 CMa shows some mild amplitude variability. The latter is also observed for Nu Eri, which exhibits period changes incompatible with evolutionary effects in addition, and even reveals apparent evidence for a temporally increasing rotation rate near the stellar core. Periodic pulsational phase variations of 12 Lac indicate that it is the primary component of a 6.5-yr binary system, but its pulsation amplitudes are variable as well, allowing to reconstruct its full mode spectrum over time, and allowing identifications of the s pherical degree of several previously undetected oscillation modes.

24. Pysca: A tool for automated frequency extraction from photometric time series

Kolja Glogowski, **Wiebke Herzberg**

Kiepenheuer-Institut für Sonnenphysik

Pysca is a software tool that allows automated extraction of frequencies, amplitudes and phases from non-equally sampled time series containing gaps. The extraction is done by identifying the highest peaks in the Lomb-Scargle periodogram and fitting the time series with a sum of harmonic functions of the corresponding frequencies. This is implemented using an iterative algorithm where the time series is progressively prewhitened up to an user defined termination condition. The signal-to-noise ratio is calculated for every frequency as a statistical measure of significance.

25. Asteroseismology with SuperWASP - Rapidly Varying A-type Stars

Daniel Holdsworth, Barry Smalley

Keele University

The searches for transiting exoplanets have produced a vast amount of time-resolved photometric data of many millions of stars. One of the leading ground-based surveys is the SuperWASP project. We present the results of a survey of over 1.5 million A-type stars in the search for high frequency pulsations using SuperWASP photometry. We are able to detect pulsations down to the 0.5 mmag level in the broad-band photometry. This has enabled the discovery of several rapidly oscillating Ap stars and over 200 δ Scuti stars with frequencies above 50 d^{-1}. Such a large number of results allows us to statistically study the frequency overlap between roAp and δ Scuti stars.

26. Pulsations in extremely low-mass helium stars

Simon Jeffery[1], Hideyuki Saio[2]

[1]*Armagh Observatory,* [2]*University of Tohoku*

We have explored the radial (p-mode) stability of extremely low-mass stars across a range of composition, effective temperature, and luminosity. We have identified the instability boundaries associated with low- to high-order radial oscillations ($0 \leq n \leq 13$) and show that these are a strong function of both composition and radial order (n). The blue edge shifts to higher effective temperature and luminosity with decreasing hydrogen abundance. In addition, high-order modes are more easily excited, and small islands of high radial-order instability develop, some of which may correspond with real stars. The excitation mechanism is discussed with reference to these instability islands. In particular, these

models are applied to a recent discovery of pulsations in an extremely low-mass helium star.

27. Ground-based Photometry for 42 Kepler-Field RR Lyrae Stars

Jeon, Young-Beom[1], Ngeow, Chow-Choong[2], Nemec, James M.[3]

[1]*Korea Astronomy and Space Science Institute (KASI), Daejeon 305-348, Korea,* [2]*Graduate Institution of Astronomy, National Central University, Taiwan,* [3]*Department of Physics & Astronomy, Camosun College, Victoria, British Columbia, Canada*

Follow-up $BVRI$ photometric observations have been made for 42 RR Lyrae stars in the Kepler field. The new magnitude and color information will greatly complement the available extensive high-precision Kepler photometry and recent spectroscopic results. The photometric observations were made with the 1m and 41cm telescopes of Lulin Observatory in Taiwan, and the 81-cm telescope of Tenagra Observatory in Arizona, USA. Each target was observed from 210 to 390 times from 2010 to 2011. Independent $(U)BVRI$ photometry was carried out using the 1.8-m and 15-cm telescopes at the Bohyunsan Optical Astronomy Observatory (BOAO) in Korea, using the 61-cm telescope at the Sobaeksan Optical Astronomy Observatory (SOAO) in Korea, and using the 1-m telescope at the Mt. Lemmon Optical Astronomy Observatory (LOAO) in Arizona, USA. Preliminary results of the Korean observations were presented at the 5th KASC workshop in Hungary, and now we include the 2012 and 2013 observations. Fully covered light curves and some physical parameters will be shown, and our plan for additional standard photometric observations will be described.

28. The mean density and the surface gravity of the primary component of mu Eridani

Mikołaj Jerzykiewicz

Instytut Astronomiczny Uniwersytetu Wrocławskiego, Poland

Precision asteroseismology uses the observed effective temperature and luminosity or surface gravity in order to select evolutionary models for analysis. In the case of the primary component of μ Eri, an SPB variable, these parameters can be supplemented with the star's mean density and surface gravity derived for an assumed mass from the parameters of the SB1 eclipsing system, viz., the half-range of the radial-velocity curve, the eccentricity, the inclination of the orbit, and the star's relative radius. We examine how the mean density and the surface gravity so derived restrict the range of the evolutionary models suitable for asteroseismic analysis.

29. Comparative study of BL Her type pulsating variable stars using publicly available photometric databases

Monika Jurkovic[1], László Szabados[2]

[1]*Astronomical Observatory of Belgrade, Serbia,* [2]*Konkoly Observatory of the Hungarian Academy of Sciences, Hungary*

BL Her type pulsating variable stars are a subtype of Type II Cepheids, pulsating in the range from 1 to 4 days. The list of these object was taken from the General Catalogue of Variable Stars (http://www.sai.msu.su/gcvs/gcvs/). The list contains 71 object. For each star a search for data-sets was preformed, using the publicly available photometric databases: AAVSO, ASAS, Catalina Sky Survey, INTEGRAL OMC, LINEAR, NSVS, SuperWASP. For 6 stars there were no data. Since, the databases used different methods for collecting their photometric data-sets (e.g. with or without filter(s)), the analysis was done separately for each data-set. Here we present our first results.

30. KIC 10486425 : A Kepler Eclipsing Binary System with a Pulsating Component

Filiz Kahraman, E. Soydugan

Canakkale Onsekiz Mart University

We present first light curve and frequency analysis of the KIC 10486425 eclipsing binary system observed by Kepler satellite. In order to make a reliable frequency analysis of the pulsational component, the proximity and eclipse effects were removed from light curve of the system. Each observational points subtracted from light curves modeled with Wilson-Devinney program. From the frequecy analysis, we have detected about 90 frequencies, which are above the significant limit. Some of these frequency values are each other's harmonics. The dominant frequency value was found 1.32 d^{1}.

31. High-precision photometry of variables in globular cluster cores

Noé Kains

European Southern Observatory

I present an overview of a new large-scale project to study variability in the cores of globular clusters with unprecedented precision from the ground. I will describe our observations with the Lucky Imaging camera on the Danish 1.54m telescope in La Silla, and will discuss the advantages of using lucky imaging in crowded fields in conjunction with difference image analysis to obtain high-precision photometry. Such a survey represents the next step towards obtaining a complete census of variables in globular clusters, down to s everal magnitudes

below the horizontal branch. I will also present some preliminary results of variable detections in globular clusters, and discuss the aims and potential of our observational campaign, which is expected to overhaul our knowledge of variable star populations in globular cluster cores.

32. Global Astrophysical Telescope System - first results from telescope nr 2

Krzysztof Kamiński, Wojciech Dimitrow, Monika Fagas, Magdalena Poliańska

Astronomical Observatory Institute, Faculty of Physics, A.Mickiewicz University

The Global Astrophysical Telescope System (GATS) is a project intended to operate a pair of astronomical spectroscopic telescopes located at two different geographic longitudes. The first telescope (PST1), installed in Borowiec near Poznań (Poland) is operational since 2007. The second telescope (PST2) is currently being tested in Poznań and will be transported to Winer Observatory in Arizona (USA) and operated in fully robotic mode. Together they will constitute a unique network, which, thanks to a time difference, will be able to perform nearly continuous (up to 21 h/day) astronomical observations. Each telescope is equipped with a high-resolution (R$\sim$40000) echelle spectrograph that is able to record spectra from roughly 400 to 750 nm and measure stellar radial velocity with a precision of about 40 m/s (depending on spectral type). Such a combination of resolution, precision and high duty-cycle will allow to perform radial velocity measurements and line profile variations of pulsating stars, characterizing their frequency spectrum with much cleaner spectral window and even detecting new extrasolar planets around them. We report the principles of the second telescope design and present first results of test observations from our second telescope just before its transportation to target location.

33. Wide-field variability survey of the globular cluster NGC4833

Grzegorz Kopacki

Instyut Astronomiczny U.Wr.

We will present preliminary results of the search for variable stars in the southern globular cluster NGC4833. The survey covers 26×39 arcmin^2 field centered on the cluster core.

34. The Rich Frequency Spectrum of the Triple-Mode Variable AC And

Geza Kovacs[1], Gaspar A. Bakos[2], Joel D. Hartman[2]

[1]*Konkoly Observatory, Budapest, University of North Dakota, Department of Physicsand Astrophysics, Grand Forks* [2]*Princeton University, Department of Astrophysical Sciences, Princeton*

AC And is the first variable star classified as triple-mode radial pulsator. Because of the observed range of periods and the lack of reliable mass estimate, there is a controversy on the nature of this object. Possible models allow both RR Lyrae- and low-mass Cepheid-type pulsations. From linear pulsation models and the then available observed rates of period change Kovacs & Buchler (1994) concluded that a fast evolving post-main sequence δ Scuti model was preferred over an RR Lyrae model.

By using the database of the wide-field transiting extrasolar planet search project HATNet, we analyzed this object to cast more light on its physical nature and search for possible additional components in its light curve. We found significant components (up to 50) down to 2-3 mmag. Many of these are simple low-order linear combinations of the three basic components, whereas others, in the low-amplitude (but still significant) tail can only be explained by invoking physically less attractive high-order combinations. We will discuss the relevance of this finding and the current values of the periods regarding the likelihood of the δ Scuti model advocated in our earlier work.

35. Chromospheric Activity in gamma Doradus Variables

Anthony B. Kaye[1], **Cristine A. Kristof**[1], Richard O. Gray[2]

[1]*Texas Tech University,* [2]*Appalachian State University*

Based on the most recent and precise asteroseismology results for F stars and their structure (including the modeled convective shell), we examine the role of magnetic activity based on observations of the He I D_3 λ 5876 Å triplet in a collection of γ Doradus stars. Similar observations have been used to determine chromospheric activity levels in late A- and early F-type stars instead of the more usual Ca II H&K lines (that are "washed out" at higher temperatures; see, e.g., Strassmeier & Kaye, 1998). We compare our new results with 5876 Å observations already published for the known γ Doradus variables, and discuss these results in light of the most recent hypotheses surrounding the ongoing discussion of the asteroseismology of these objects.

36. Traditional Photometry on Kepler Observations of Open Clusters NGC 6791 and NGC 6819

Charles Kuehn, Jason Drury, Dennis Stello, Tim Bedding

University of Sydney

The Kepler space telescope has proven to be a gold mine for the study of variable stars. Unfortunately, Kepler only reads out the handful of pixels surrounding each target star, meaning that there are a large number of stars in the Kepler field for which we get no information about any potential variability. The Kepler field does contain the open clusters NGC 6791 and NGC 6819 and the number of Kepler target stars in these open clusters was large enough that one can use the individual pixel files from the target stars to form complete images of the clusters. These complete cluster images can potentially be used to study additional stars in the open clusters. The similarity in properties of cluster stars makes them ideal targets for asteroseismic studies and finding additional variable stars in these clusters will help to improve our ability to test stellar evolution theories. We present preliminary results from our attempt to use traditional photometric techniques to identify and analyze additional variable stars in the open clusters from these images.

37. Modeling non-radial oscillations on components of close binaries

Olivera Latkovic, Attila Cseki

Astronomical Observatory of Belgrade

We developed an advanced binary system model that includes stellar oscillations on one or both stars, with the goal of mode identification by fitting of the photometric light curves. The oscillations are modeled as perturbations of the local surface temperature and the local gravitational potential. In the case of tidally distorted stars, it is assumed that the pulsation axis coincides with the direction connecting the centers of the components rather than with the rotation axis. The mode identification method, originally devised by B. Biro, is similar to eclipse mapping in that it utilizes the amplitude, phase and frequency modulation of oscillations during the eclipse; but the identification is achieved by grid-fitting of the observed light curve rather than by image reconstruction. The proposed model and the mode identification method have so far been tested on synthetic data with encouraging results.

38. The Large Magellanic Cloud Cepheids: effects of He content variations

Marcella Marconi[1], Roberta Carini[2], Enzo Brocato[2], Gabriella Raimondo[3]

[1]*INAF-Osservatorio Astronomico di Capodimonte,* [2]*INAF-Osservatorio Astronomico di Roma,* [3]*INAF-Osservatorio Astronomico di Teramo*

We have produced an extended set of evolutionary and pulsational models representative of Classical Cepheids in the Large Magellanic Cloud. The comparison between the standard and He enhanced theoretical predictions is analysed and the implications for our interpretation of current observations and for the Cepheid based distance scale are discussed.

39. Corotation resonances for gravity waves and their impact on angular momentum transport in stellar interiors

Stephane Mathis[1], Lucie Alvan[1], Thibaut Decressin[2]

[1]*Laboratoire AIM Paris-Saclay CEA/DSM/IRFU/SAp,* [2]*Observatoire de Genéve*

Gravity waves, which propagate in radiation zones, can extract or deposit angular momentum by radiative/viscous damping. Another process, poorly explored in stellar physics, concerns their direct interaction with the differential rotation and the related turbulence. In this work, we thus study their corotation resonances, also called critical layers, that occur where the Doppler-shifted frequency of the wave approaches zero. First, we study the adiabatic and non-adiabatic propagation of gravity waves near critical layers. Next, we derive the induced transport of angular momentum. Finally, we use the dynamical stellar evolution code STAREVOL to apply the results to the case of a solar-like star. The result depends on the value of the Richardson number at the critical layer. In the first stable case, the wave is damped. In the other unstable and turbulent case, the wave can be reflected/transmitted by the critical layer with a coefficient larger than one. The critical layer acts as a secondary source of gravity waves. These new results can have a strong impact on our understanding of angular momentum transport processes in stellar interiors.

40. Variable Stars in Young Open Cluster NGC 2244

Gabriela Michalska

Instytut Astronomiczny, Uniwersytet Wrocławski

We present results of the search for variable stars in the young open cluster NGC 2244. As a result we have found many eclipsing systems and pulsating stars, some of them are multiperiodic. Here we show only a few examples.

41. Modeling oscillations in fast-rotating stars: the example of Ras Alhague

Giovanni Mirouh

IRAP, France

Rotation has become over the last ten years a key ingredient of stellar models, and many early-type stars have been measured with high angular velocities. In such stars, mode identification is difficult as the effects of differential rotation and modal properties are not well known. We aim at improving fast-rotating stars models by identifying oscillation frequencies from such stars.

Using fundamental parameters measured by interferometry, we use the ESTER structure code and the TOP oscillation code, which both take centrifugal flattening, differential rotation and heat diffusion into account, to predict the oscillation spectrum. By matching the computed frequencies with the measured ones, we can give new constraints on the interior of the star. We present a first investigation of the 57 oscillation frequencies of the fast rotating star Ras Alhague (alpha Ophiuchi) recently observed by the MOST satellite.

42. LAMOST observations in the Kepler field

P. De Cat[1], G. Catanzaro[2], C.J. Corbally[3], A. Frasca[2], J.N. Fu[4], R.O. Gray[5], A.L. Luo[6], **J. Molenda-Żakowicz**[7], J.R. Shi[6], X. Yang[4], H.T. Zhang[6],

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The uninterrupted time-series of high-precision Kepler photometry of thousands of stars of every pulsational type and flavor are a precious resource for asteroseismic studies. However, the Kepler data do not provide information on the physical parameters, such as the effective temperature, surface gravity, metallicity, and projected rotational velocity, that are key ingredients for many astrophysical problems. To exploit the Kepler data best, additional ground-based data are mandatory. The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) is new instrument with 4000 optical fibers attachted to a 4-m telescope at the Xinglong observatory in China. We requested to observe 14 fields to cover the full field-of-view of the Kepler mission during the commissioning phase to gather the spectra needed to classify and characterize the Kepler targets in a homogeneous way and to provide input parameters for seismic modeling. Our full target list consists of 250 "standard targets" (MK secondary standard stars), 7,000 "KASC targets" (targets of the Kepler Asteroseismic Science Consortium) and 150,000 "planet targets" (targets from the planet search group). The remaining fibers were filled with other objects

from the KIC10 catalogue or field stars of $V < 20$. In 2011 and 2012, one and three of the fields has been observed, respectively. In this presentation, we show representative examples of LAMOST spectra and give a brief overview of the methods used and progress made in their analysis within the Chinese, European and American team.

43. Kepler RR Lyrae stars: beyond period doubling

László Molnár, József Benkő, Róbert Szabó

Konkoly Observatory

Recent investigations revealed that modulated RR Lyrae stars exhibit various phenomena: additional modes, period doubling and states of near-resonances between modes. We examined the complete short cadence sample of Kepler RR Lyrae stars to find more examples of these effects. Here we present the findings on four stars. In three cases (RR Lyr, V360 Lyr, KIC 7257008), the additional modes that may correspond to the first or second overtone, dominate over the period doubling either temporarily or permanently. In the case of V450 Lyr, no period doubling is observed: it may be a non-classical double-mode RR Lyrae star pulsating in the fundamental mode and the second overtone. Since the period ratios are close to resonant values, we observe a quasi-repetiting pattern of 3, 6 or 8 pulsation cycles in the stars. These findings point towards the possibility that modulated RRab stars are in fact multimode pulsators and therefore support the mode-resonance explanations of the Blazhko effect.

44. Revision of the Fourier Coefficient-Metallicity Relationship for c-type RR Lyrae Variables

Siobahn M. Morgan

University of Northern Iowa

The relationship derived by Morgan, Wahl and Wieckhorst (2007) for type-c RR Lyrae variables (RRc) between values of [Fe/H]-ϕ_{31}-Period has been revised and expanded. New relationships are based upon Fourier coefficients of 163 RRc variables in 19 galactic globular clusters using the metallicity scales of Harris (1996), Zinn & West (1984) and Carretta et al. (2010). This larger data base includes more low-metallicity cluster ([Fe/H]< -2.0), and the best fitting relations are found to depend upon values of $\log P$ rather than P. The new relations are compared to various populations of RRc including those found in LMC globular clusters and ω Cen.

45. Long-term polarization observations of Mira variable stars suggest asymmetric structures

Hilding Neilson, Richard Ignace, Gary D. Henson

East Tennessee State University

Mira and semi regular variable stars have been studied for centuries but continue to be enigmatic. One unsolved mystery is the presence of polarization from these stars. In particular, we present 40 years of polarization measurements for the prototype *o* Ceti and V CVn and find very different phenomena for each star. The polarization fraction and position angle for Mira is found to be small and highly variable. On the other hand, the polarization fraction for V CVn is large and variable, from 2 - 7 %, and its position angle is approximately constant, suggesting a long-term asymmetric structure. We suggest a number of potential scenarios to explain these observations.

46. Making a Be star disk: the role of rotation and pulsations

C. Neiner

LESIA, Paris-Meudon Observatory

The Be phenomenon, i.e. the ejection of matter from Be stars into a circumstellar disk, has been a long lasting mystery. In the last few years, the CoRoT satellite brought clear evidences that Be outbursts are directly correlated to pulsations and rapid rotation. In particular the stochastic excitation of gravito-inertial modes, such as those detected by CoRoT in the hot Be star HD51452, is enhanced thanks to rapid rotation. These waves increase the transport of angular momentum and help to bring the already rapid stellar rotation to its critical value at the surface, allowing the star to eject material. I will present the CoRoT observations and modelling of several Be stars and describe the new picture of the Be phenomenon which arose from these results.

47. Spectroscopic survey of Kepler stars: high-resolution observations of B, A and F stars

Ewa Niemczura[1], Giovanni Catanzaro[2], Simon Murphy[3], Katrien Uytterhoeven[4]

[1]*Astronomical Institute, University of Wrocław,* [2]*INAF-Osservatorio Astrofisico di Catania,* [3]*Jeremiah Horrocks Institute, University of Central Lancashire,* [4]*Instituto de Astrofsica de Canarias*

We present the detailed analysis of high-resolution spectra of B, A and F-type stars in the Kepler field-of-view. Observations were obtained with HERMES/Mercator, FIES/NOT, SOPHIE/1.92m OHP and ESPaDOnS/CHFT instruments. We applied LTE methods to analyse the spectra of F, A and late

B- type stars. The nonLTE approach was used to obtain the atmospheric parameters and chemical abundances of hot B-type stars. In our sample of about 200 objects we discovered chemically peculiar stars (e.g. Am, HgMn, 3He-4He stars), spectroscopic binaries of SB2 type and Be stars.

48. Effects of rotation on mixed modes in sub-giants and red giant stars

Rhita-Maria Ouazzani[1], Marie-Jo Goupil[2], Marc-Antoine Dupret[3],

[1]*IAS - Orsay France,* [2]*LESIA Observatoire de Paris - France,* [3]*Université de Liége - Belgium*

The space missions CoRoT and Kepler provide high quality data that allow us to test the transport of angular momentum in stars by the seismic determination of the internal rotation profile. Our aim is to test the validity of the seismic diagnostics for sub-giants and red giants rotation that are based on a perturbative method and to investigate the oscillation spectra when the validity does not hold. We use a non-perturbative approach implemented in the ACOR code (Ouazzani et al. 2012) that accounts for the effect of rotation on pulsations, and solves the pulsation eigenproblem directly for dipolar oscillation modes.

49. Analysis of pulsations of cool ZZ Ceti star PG 2303+243 according 2012 observations

Erika Pakstiene

Vilnius University, Institute of Theoretical Physics and Astronomy, Lithuania

PG 2303+243 is a cool DA variable (also called ZZ Ceti) star having a rich pulsation spectrum and variable amplitudes. In this presentation we present analysis of observed photometric data of PG 2303+243 during mini campaign performed in 2012 during one week with three telescopes (165 cm in Moletai AO (Lithuania), 180 cm VATT (Arizona) and 60 cm telescope in Horten astronomical observatory (Norway)). Results are compared with observations from 2004 and 2005. Fourier transform (FT) spectra of PG 2303+243 got in 2004, 2005 (Pakstiene et al. 2011, Pakstiene 2013) and 2012 are clearly different. Only few peaks can be found at about the same frequency, but their amplitudes differ strongly. Combining frequencies obtained from different years we did l=1 and l=2 modes identification. We compared observed periods with Romero et al. (2012) models for DAV stars and estimated physical parameters of PG2303+243.

50. Variable stars in open clusters

Ernst Paunzen

Department of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic

Based on our new catalogue (Zejda et al. 2012, A&A 548, A97), I will give an overview of all types of variable stars in cluster fields. I will discuss the implication and importance of the accuracy of cluster and stellar parameters. I will also give an overview of the ungoing survey to find new variables in star clusters and the input for the Gaia satellite mission.

51. On the interchange of alternating-amplitude pulsation cycles: Comparison of RV Tauri and RR Lyrae stars

Emese Plachy, Laszlo Molnar, Zoltan Kollath

Konkoly Observatory

The main characteristic feature of RV Tauri light curves is the alternation of primary and secondary minima. However, the sequence often shows irregularities in the form of occasional reversals. Similar interchange was recently discovered in the order of period doubling cycles in RR Lyrae stars. We present a comparative analysis on the time scales of the interchange in these different types of variable stars.

52. Global Astrophysical Telescope System - GATS

Polińska Magdalena, Kamiński Krzysztof, Dimitrov Wojciech, Fagas Monika, Borczyk Wojciech, Kwiatkowski Tomasz, Baranowski Roman, Bartczak Przemysław, Schwarzenberg-Czerny Aleksander

Astronomical Observatory Institute, Faculty of Physics, A. Mickiewicz University

We would like to present the Global Astrophysical Telescope System project which consists of telescopes: PST 1 and PST 2 (Poznań Spectroscopic Telescope), the project is managed by Institute Astronomical Observatory, of Adam Mickiewicz University and it is mainly dedicated for stellar medium-high resolution spectroscopy. The GATS project is purposed to research topics such as: eclipsing binary stars, asteroseismology of hybrid pulsating stars, stellar rotation and dynamical evolution in binary, eclipsing stars, stellar activity cycles. The first PST 1 telescope is already operating and is located in Poland at Borowiec Astrogeodynamic Observatory near Poznań. The PST 1 consists of binary 2 x 0.5 m Newtonian telescope, fibre-fed echelle spectrograph of resolution around 35000 and low noise back-illuminated 2k x 2k Andor DZ 436 CCD camera. Thanks to two mirros the telescope can be used in different modes (for example

simultaneous spectroscopic and photometric mode). The second PST 2 telescope it is a modified version of PST1 and will be placed in USA at the end of 2013 year. The PST 2 consists of Planewave CDK700 0.7 m telescope, fibre-fed echelle spectrograph of resolution around 40000 and other equipments.

53. Mode identification from spectroscopy of g-mode pulsators

Karen Pollard, Emily Brunsden, Peter Cottrell

University of Canterbury

I outline the observational programme we are undertaking at the Mt John University Observatory in New Zealand to obtain long time-base high-resolution spectra of selected γ Doradus, and related, stars. We have investigated various methods to successfully analyse these observations to obtain reliable mode-identifications in order to constrain the theoretical models of γ Dor stars. In particular we are looking at the way that g-modes differ from p-mode pulsations in the mode identification methods and the effects of rotation in these stars.

54. Pulsating variable stars in the VMC survey

V. Ripepi et al.

INAF-Osservatorio Astronomico di Capodimonte

The VISTA near-infrared YJ$K_{\rm s}$ survey of the Magellanic System (VMC, PI M.-R. L. Cioni) is collecting deep $K_{\rm s}$–band time–series photometry of the pulsating variable stars hosted in the system formed by the two Magellanic Clouds (MCs) and the Bridge connecting them. In this talk I will present new results on the pulsating variables RR Lyrae, Classical Cepheids, Anomalous Cepheids and type II Cepheids on the basis of 6 and 2 "tiles" (i.e. about 9 and 3 squared deg.) already completed in the LMC and SMC, respectively. In particular, our results include new Period-Luminosity, Period-Luminosity-Color and Period-Wesenheit relations for the quoted pulsators, as well as preliminary results concerning the geometry of the LMC/SMC system.

55. Theoretical instability strip of M dwarfs and their potential to show solar-like oscillations

Rodríguez-López C.[1], MacDonald J.[2], Moya A.[3], Dermott M.[2], Amado P.J.[1]

[1]*Instituto de Astrofisica de Andalucia (IAA-CSIC), Spain,* [2]*University of Delaware, USA,* [3]*Centro de Astrobiologia (INTA-CSIC), Spain*

The overstability of the fundamental radial mode in M dwarf models was theoretically predicted by Rodríguez-López , MacDonald & Moya (2012) for periods

in the range ∼20-40 min and ∼4-8 h, depending on the age of the star's model and the excitation mechanism. We have extended our initial M dwarf model grid in metallicity, mixing length parameter and to include Phoenix NextGen atmospheres. We have found the instability of non-radial, non-fundamental modes. In addition, we find theoretical evidence of the potential of solar-like oscillations in M dwarfs.

56. Pulsating B-stars in the open cluster NGC 884: frequencies, mode identification and asteroseismology

Sophie Saesen

Geneva Observatory, University of Geneva, Switzerland

Recent progress in the seismic interpretation of field β Cep stars has resulted in improvements of the physics in the stellar structure and evolution models of massive stars. Further asteroseismic constraints can be obtained from studying ensembles of stars in a young open cluster, which all have similar age, distance and chemical composition. We present an observational asteroseismology study based on the discovery of numerous multi-periodic and mono-periodic B-stars in the open cluster NGC 884. We have analysed the pulsation properties of all B-type stars thoroughly by deriving all significant frequencies and performing a mode identification based on the photometric amplitudes. Relations between pulsation and basic stellar parameters were investigated. Imposing the identified degrees and measured frequencies of the radial, dipole and quadrupole modes of five β Cep stars led to a seismic cluster age estimate of $\log(\text{age/yr}) = 7.12 - 7.28$ from a comparison with stellar models. Our study is a proof-of-concept for and illustrates the current status of ensemble asteroseismology of a young open cluster.

57. Using B-type pulsators as a constraint on the opacity

Sebastien Salmon

Université de Liége

β Cephei and Slowly Pulsating B stars (SPBs) are main sequence B stars, presenting low-order acoustic and gravity modes, and high-order gravity modes, respectively. Their pulsations are driven by the κ mechanism activated thanks to a peak of opacity due to iron group elements. Recently, ground- and space-based observations increased significantly the number of hybrid B-type pulsators, which exhibit both SPB and β Cephei modes. To interpret these rich frequency spectra, we need to ensure that we are dealing with adequate physics input in theoretical stellar models. Opacity and the abundances of iron group elements are concerned in particular. Indeed, current opacity data from OPAL or OP,

combined with the most recent solar chemical mixture do not allow to reproduce what is observed in the hybrid pulsators. Thus we investigate how opacity and the chemical mixture affect the instability of B stars. Firstly, we investigate the role of the chemical mixture by considering the recently discovered B-type pulsators in the Magellanic Clouds, that are known for their low metallicity. Secondly, we proceed to ad hoc and local changes of iron-group opacities, showing that Ni opacity plays an important role and might be underestimated in opacity tables.

58. Spectroscopic mode identification of 4 CVn, a delta Scuti pulsator in a binary system

Valentina S. Schmid[1], Nathalie Themessl[2], Michel Breger[3], Conny Aerts[1], Paul G. Beck[1], Steven Bloemen[1],

[1] *University of Leuven,* [2] *University of Vienna,* [3] *University of Texas at Austin*

The evolved star 4 CVn, one of the most thoroughly studied δ Scuti stars, shows an intriguing pulsation spectrum. More than 40 years of ground-based photometry revealed 30+ independent pulsation modes with variations in both amplitude and frequency. The star exhibits radial and non-radial modes, most of them with a low spherical degree of $\ell \leq 2$.

We obtained more than 2000 spectra at McDonald Observatory in Texas, USA, in 2008, 2010 and 2011. The observed line-profile variations allowed us to constrain the spherical degree ℓ and azimuthal order m of some of the pulsation modes that were detected in the photometric observations. Also, since line-profile variations are less prone to partial cancellation effects, we could discover modes not seen in photometry.

We present the final results of our analysis of the combined dataset and discuss the agreement between the photometric and spectroscopic mode-identification techniques. Moreover, we discovered that 4 CVn is part of a binary system with an eccentric orbit of 124 d, based on the radial velocity curve extracted from the first moment of the absorption-line profiles.

Our study proves once more the value of adding high-precision spectroscopy to long-term photometric monitoring to get a correct physical description of a multi-periodically pulsating star.

59. On the Information Content of Stellar Spectra

Jesper Schou

Max Planck Institute for Solar System Research

With the increasing quality of seismic observations and investments made to obtain them, it is becoming increasingly important that we minimize both the random and systematic errors in our mode parameter estimates. To that

end I will look at what is needed to make an accurate model of spectra, in the presence of modes, various forms of convection and instrumental effects. Among the effects considered are center-to-limb visibility effects, such as those caused by opacity and non-adiabatic effects, horizontal displacements, center-to-limb phase shifts, visibility of convective and magnetic features and finite instrument resolution, all as a function of wavelength, formation height of lines and position within the lines. It is the hope that such an accurate model will help us obtain more modes, see less random and systematic errors and optimize the observing and analysis techniques.

60. Delta Scuti Type Pulsation in the Hot Component of Algol Type Binary System BG Pegasi

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In this study, 23 Algol type binary systems were selected as candidate binaries with pulsating components and their observations were carried out at the cCanakkale Onsekiz Mart University Observatory. Delta Scuti type light variations were determined in the hotter component of BG Peg for the first time during the observations. We present results derived from multicolor photometric observations of Algol type binary system BG Peg. After modeling light curves, the eclipse and proximity effects were removed from their light curves in B and V filters for performing the frequency analysis. According to frequency analysis results carried out PERIOD 04 program, the massive component of the BG Peg represents the multi-mode pulsation at periods of 0.039 and 0.047 days. Spherical harmonic degrees (l) could be corresponds to non-radial ($l = 2$) modes for these two frequency values.

61. BLASGALF database

Marek Skarka

DTPA, Masaryk University, Brno

BlaSGalF is an acronym of Blazhko Stars of Galactic Field database, which is regularly updated online list of known RR Lyraes exhibitting the Blazhko effect. The list contains about 270 stars (the number is continuously changing) and it gives basic informations about positions, brightnesses, pulsation and modulation periods based on VSX catalogue and more than sixty papers. We would like to introduce present form of the list and discuss the future plan with this databse.

62. Chaotic Blazhko Effect in BL Her Models

R. Smolec, P. Moskalik

N. Copernicus Astronomical Center, PAS

We present the hydrodynamic models of BL Her stars with chaotic modulation of pulsation. Within the domain of chaotic behaviour we identify a few stability domains with stable period-k cycles for both even and odd k. As control parameter (effective temperature) is varied these solutions undergo a series of period doubling bifurcations en route to chaos. This behaviour is not observed in BL Her stars, but was recently reported in RR Lyrae star showing the Blazhko modulation. In particular period-six variation was reported in the Kepler data for RR Lyr. The models may help to understand the still mysterious mechanism behind the Blazhko modulation.

63. Extensive spectroscopic and photometric study of HD 25558, a long orbital-period binary with two SPB components

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We present the extensive photometric and spectroscopic investigation of the SPB binary, HD 25558. The $\tilde{2}000$ spectra obtained at 13 observatories during 4 observing seasons, the ground-based multi-colour light curves and the photometric data from the MOST stellite revealed that this object is a double-lined spectroscopic binary with a very long orbital period of about 9 years. We determined the physical parameters of the components individually, and have found that both lie within the SPB instability strip. Accordingly, both components show line-profile variations consistent with stellar pulsations. Altogether, 11 independent frequencies were identified in the data. The observational data do

not allow the inference of a reliable orbital solution, thus, disentangling cannot be performed on the spectra. Since the lines of the two components are never completely separated, the analysis is very complicated. Nevertheless, pixel-by-pixel variability analysis of the cross-correlated line profiles was succesful, and we were able to attribute all the frequencies to the primary or secondary component. Spectroscopic and photometric mode-identification was also performed for several of these frequencies of both binary components. Comparison of the mode-identification results on the two components suggests some properties of a mode-selection mechanism in action.

64. Analysis of strange mode instability with the time-dependent convection theory

Takafumi Sonoi, Hiromoto Shibahashi

University of Tokyo

Strange mode instability has been theoretically found in stellar models with $L/M \sim 10^4 L_\odot/M_\odot$; e.g., massive main-sequence, evolved stars, and helium stars. This instability is much stronger than instability of ordinary p and g modes. The growth timescale is as short as oscillation period, and can be influential on stellar evolution. Most of the nonadiabatic analyses of this instability have so far been carried out with the frozen-in convection approximation. But the excitation occurs in convective layers, and we cannot definitively conclude that convection never affects stability of strange modes.

We carried out nonadiabatic analysis including the time-dependent convection theory, and found that stability of some strange modes can be affected by convection. Influence of convection on the stability depends on contribution of convective luminosity to total luminosity. Strange modes excited in convective layers with negligible contribution of convective luminosity show almost the same results both with and without time-dependent convection. On the other hand, those excited in convective layers with 10 % contribution of convective luminosity become less unstable with time-dependent convection than with the frozen-in convection approximation.

65. Variable stars in the field of the young open cluster Roslund 2

Paulina Sowicka[1], Gerald Handler[2], Ruth Taubner[3], Magdalena Brunner[3], Vera-Maria Passegger[3], Florian Bauer[3], Ernst Paunzen[4], Andrzej Pigulski[5]

[1]*Astronomical Observatory, Jagiellonian University, Poland,* [2]*Nicolaus Copernicus Astronomical Center, Poland,* [3]*Institut für Astronomie, Universität Wien, Austria,* [4]*Department of Theoretical Physics and Astrophysics, Masaryk University, Czech Republic,* [5]*Instytut Astronomiczny, Uniwersytet Wrocławski, Poland*

The study of variable stars in open clusters via asteroseismology is a powerful tool in study of stellar evolution and stars in general. That is because we believe that stars in clusters originate from the same interstellar cloud, so they share similar properties such as age and overall metallicity. We performed a search for variable stars in the field of the young open star cluster Roslund 2. We used 56 hours of CCD photometry in filter V carried out with the 0.8-m Vienna little telescope at the Institute of Astronomy of the University of Vienna. The data reduction was done using IRAF package, for photometry we used program for image subtraction - DIAPL2 and DAOPHOT/ALLSTAR package. Additionally we analyzed 42 hours of observation in the Strömgren uvy filters acquired at the 0.75-m Automatic Photoelectric Telescope (APT) T6 at Fairborn Observatory in Arizona. Within the resulting light curves we have found 12 variable stars. Our measurements confirm three previously known variables.

66. Analysis of rosette modes of oscillations in rotating stars

Masao Takata[1], Hideyuki Saio[2]

[1] *University of Tokyo* [2] *Tohoku University*

We present a theoretical analysis of a new class of eigenmodes in rotating stars, which was discovered numerically by Ballot et al. (2012). The frequency of the modes is located in the range of low-order g modes, but still in the outside of the inertial domain. The modes start to appear when the rotation rate is only a few tens of percent of the critical (break-up) rate. The modes are named rosette modes because their distribution of kinetic-energy density on a meridional plane forms characteristic rosette patterns. We argue that rosette modes are generated by the interaction among (non-rotating) eigenmodes with almost the same frequency and successive spherical degrees with the same parity. The interaction is induced by the effect of the Coriolis force. We demonstrate that this process can be described by the quasi-degenerate perturbation theory, by regarding the effect of the Coriolis force as a small perturbation. We also pin down the process of the formation of the rosette patterns based on the JWKB analysis.

67. The fast rotating delta Scuti pulsator V376 Per: Frequency analysis and mode identification

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The δ Scuti star V376 Per (= HR 1170) was first revealed to be variable by Breger (1969). In the following years, several observing attempts have been carried out, which report consolidated findings regarding its multiple frequencies

and existing radial and non-radial modes.

In this work, we represent the complementary study of ground-based photometry and spectroscopy of V376 Per. This analysis allows us to investigate the stellar structure and properties in great detail, which in turn provides essential improvements of common state-of-the-art models. We derive the individual frequencies from 82 nights of two-color photometry using the Period04 software package and identify the corresponding pulsation modes. Additionally, we extract the excited frequencies in the pixels across the line using 769 stellar spectra, that were obtained with the 2.1m Otto Struve telescope at McDonald Observatory in Texas. Due to the high rotational velocity of V376 Per we use the Fourier Parameter Fit method embedded in the FAMIAS software package to obtain reliable estimates of the line profile and pulsation mode parameters of the observed p modes. On the basis of our analysis, we believe that the star has already left the main-sequence and that its contraction phase has been completed by now.

68. Detection of a large sample of gamma Doradus stars from Kepler space photometry and high-resolution ground-based spectroscopy

Andrew Tkachenko

Institute of Astronomy, KU Leuven

Our ultimate goal is a detection and analysis of an extended sample of GD-type pulsating stars with the aim to search for observational evidence of non-uniform period spacings and rotational splittings of gravity modes in main-sequence stars typically twice as massive as the Sun. This kind of diagnostic can be used to deduce the internal rotation law and to estimate the amount of rotational mixing in the near core regions. We applied an automated supervised photometric classification method to select a sample of 69 GD candidate stars. For 36 of the stars, we obtained high-resolution spectroscopy with the HERMES spectrograph installed at the Mercator telescope. The spectroscopic data are analysed to determine the fundamental parameters like Teff, logg, vsini, and [M/H]. We find that all stars for which spectroscopic estimates of Teff and logg are available fall into the region of the HR diagram where the GD and DSct instability strips overlap. The stars cluster in a 700 K window in effective temperature, logg measurements suggest luminosity class IV-V, i.e. sub giant or main-sequence stars. From the Kepler photometry, we identify 45 GD-type pulsators, 14 GD/DSct hybrids, and 10 stars which are classified as "possibly GD/DSct hybrid pulsators". We find a clear correlation between the spectroscopically derived vsini and the frequencies of independent pulsation modes. We show that our photometric classification based on the light curve morphology and colour information is very robust. The results of spectroscopic classification are in perfect agreement with the photometric classification. We show that

the detected correlation between vsini and frequencies has nothing to do with rotational modulation of the stars but is related to their stellar pulsations.

69. Pulsations in the late-type B supergiant star HD 202850

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HD 202850 is late B-type supergiant. It is known that photospheric lines of such stars vary. Due to macroturbulence the lines are much wider than expected. Macroturbulence has been linked to the stellar pulsations. It has been reported that there are several B supergiants that undergo pulsations. The origin of these pulsations is not clear, since B supergiants fall out of any instability period calculated so far. In our previous work we confirmed 1.59 hours period pulsation in this object from data taken with Ondrejov 2m telescope. We continued to investigate this object and we took several time series with DAO 1.2m telescope. From our new data we were able to extract few more periods with different amplitudes varying from hours to days or longer. We will present our new results in this poster.

70. GYRE: A New Open-Source Oscillation Code

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[1] *University of Wisconsin-Madison,* [2] *University of California-Santa Barbara*

We introduce GYRE, a new open-source oscillation code which solves the adiabatic/non-adiabatic pulsation equations using a novel Magnus Multiple Shooting (MMS) numerical scheme. The code has a global error scaling of up to 6th order in the grid spacing, and is therefore very accurate. It is moreover robust and efficiently makes use of multiple processor cores and/or nodes. We present a selection of example calculations using GYRE, before discussing ongoing work to integrate GYRE into the asteroseismic optimization infrastructure of the MESA stellar evolution code.

71. Search for Pulsations in Eclipsing Binary Systems V1241 Tau and GQ Dra

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We present new photometric observations of eclipsing binary systems V1241 Tau and GQ Dra. These systems are claimed to possess pulsating components

and therefore we investigated for a potential pulsating signal on their light curves. We use the following methodology: Initially, WD code is applied to the light curves, in order to determine the geometric and absolute physical parameters of the system. Then the residuals are analyzed using Fourier Trasformation techniques. The results show that one frequency can be attributed to the residual light variation of the system V1241 Tau, while there is no evidence of pulsation on the light curve of GQ Dra.

72. Kepler and Ground-based observations of gamma Dor star KIC 6462033

C. Ulusoy[1], B. Ulas, M. Damasso, A. Carbognani, D. Cenadelli,

[1]*Izmir Institute of Technology,*

Recent space-based instruments offer us a unique opportunity to probe inner stellar structure by helio and asteroseismology. γ Dor variables, which exhibit in g-modes pulsations, are promising asteroseismic targets to understand their rich complexity of pulsational characteristics in detail. In order to achieve this goal, intensive and numerous multicolour and spectroscopic observations are also required, to complete space-based data aimed at the determination of physical parameters. We present the first preliminary results on the analysis of the time–series of Kepler and ground-based multicolour observations of the γ Dor star KIC 6462033. The frequency analysis yielded three main frequency in the range from 0.9 to 3.4 d^{-1}. We expect that future work using high-resolution spectroscopy will clarify our results on mode identification which is a signature of the physical mechanism of deep stellar interior.

73. Antarctica Photometric Survey using PDM 13

Cyrus Zalian, Merieme Chadid

Université Nice Sophia-Antipolis, Observatoire de la Cote d'Azur

PDM 13 is a new graphic interfaced program dedicated to frequency domain analysis based on the Phase Dispersion Minimization technique (PDM, Stellingwerf 1978). In this paper, we will present the different algorithms running in PDM 13, including the Auto-Segmentation, the Gauss-Newton and the PDM algorithms. Their aim is to offer a simple and powerful mean to extract frequency. Amongst the numerous improvements offered by the program we will particularly focus on the reduction of aliases and the ability to look directly for the double-period phenomenon and the Blazhko effect. After what, we will focus on a complex case study involving poor time coverage data and gaps using our program. Finally, we will show the first results from PDM 13 using the Antarctica photometric survey.

74. Review of the very high time resolution photo-polarimeters based on the SPADs

Agnieszka Słowikowska et al.

Kepler Institute of Astronomy, University of Zielona Gra, Poland

We are going to review photo-polarimeters that are based on the Single Photon Avalanche Diodes (SPADs) and were designed, built, developed, and extensively used for the high time resolution studies of astrophysical sources. Examples of such detectors are OPTIMA, GASP, AqeEYE, and IquEYE that can measure the time of arrival of single optical photons with the accuracy of down to 10 picoseconds. We will describe the most exciting results obtained with the SPADs detectors starting from the best existing optical polarimetric measurements of the Crab pulsar, discovery of the first optical magnetar and its quasi-periodic oscillation, as well as verification of the exoplantes around eclipsing cataclysmic variables. Additionally, we will discuss possible use of such detectors for astroseismology.