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Conference Information & Presentations

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Content

Stars and their Variability, Observed from Space (Stars and Space 2019)

1. FLASHLIGHTS as INTRODUCTION

1i01 - The space photometry revolution

Kerschbaum, Franz (Institut für Astrophysik, Wien, AUT)

We look back to more than half a century of photometric measurements from space. They provided us with access to the full electromagnetic spectrum, atmospherically undisturbed spatial resolution and photometric quality as well as uninterrupted, high cadence measurements. By this our picture of the universe as a whole and its constituents changed drastically. This success story was not without setbacks – some remain.

1i02 - The demystification of classical Be stars through space photometry

Baade, Dietrich (ESO, Garching bei München, GER)

None of the space photometers capable of monitoring bright stars has missed out on attacking the century-old mystery of the origin and timing of star-tocircumstellar disk mass-transfer events of Be stars.
Each satellite has highlighted new aspects:
-- MOST established multi-periodicity, i.e. nonradial pulsation.
-- CoRoT discovered dramatic changes of the power spectrum during an outburst.
-- SMEI demonstrated the longevity of pulsation frequencies.
-- Kepler detected complex couplings of amplitudes and rich groups of sum and difference frequencies.
-- BRITE revealed that difference frequencies can clock repetitive outbursts.

In conclusion, multiply nested pulsation clockworks seem to control the valves of the (probably rotationpowered) mass-loss process of Be stars.

Thanks to the much increased number of objects, TESS will be able to further assess the role of pulsations in the mass loss from Be stars by comparing pulsation properties of Be and other rapidly rotating B stars without decretion disk. TESS may also search for different pulsation signatures of Be stars of different evolutionary paths (if any; e.g., single and binary).

1i03 - Listening to the Heartbeat: Tidal Asteroseismology in Action

Guo, Zhao (Pennsylvania State University, University Park, USA)

The effect of tides on stellar oscillations have been theorized for many decades. Thanks to accurate and continuous measurements from space missions, we are now able to study directly the tidally excited oscillations (TEOs) in a class of eccentric binary system, the 'Heartbeat Stars'. The systems that have been studied in detail include A, F-type stars and red giants observed by Kepler, O-B stars and very massive Luminous Blue Variables observed by BRITE. I will discuss the challenges that heartbeat stars posed on our understanding of linear and non-linear tides.

1i04 - From no-go to highlights: Red Giants

Kallinger, Thomas (IfA, Vienna, AUT)

When I started with my PhD studies, seismic observations of red giant stars were a rarity and their information content was questioned in general. Some 15 years and a few satellites later, asteroseismology of RG’s is driving new developments in stellar evolution theory, thanks to availability of space-photometry. Red giants cover a rare phase in stellar evolution where we can seismically probe the entire internal structure of a star. This has led to various developments, from using global oscillation parameters to measure stellar fundamental parameters, over using dipole mode patterns to disentangle different evolutionary phases, to trace the angular momentum transfer during stellar evolution.

1i05 - An innovative distance determination technique: ripples of light

Kervella, Pierre (Observatoire de Paris, Meudon, FRA)

The long-period Cepheid RS Pup is one of the most luminous Cepheids in the Milky Way, and is surrounded by a large circumstellar dusty nebula reflecting its light. Due to the changing luminosity of the central source, spectacular light echoes propagate into the nebula which yield a reliable geometric distance to RS Pup. The 3D structure of the scattering dust has to be known for this new distance-determination technique.

1i06 - Nova Carinae 2018 - a first in many respects

Aydi, Elias (Michigan State University, East Lansing, USA)

Catching a nova eruption in real time has always been a surreal idea giving the transient nature of these events, but thanks to BRITE, this wishful thinking has became a reality. While monitoring the red giant star HD 92063 in the constellation Carinae, a nova eruption took off, resulting in an unprecedented light-curve covering with an immaculate resolution the different phases of the eruption. The event, namely ASASSN-18fv, triggered a multiwavlength campaign which revealed remarkable features in the different wave bands, making this nova a first in many respects.

2. PARAMETER SPACE & PATTERN

2k01 - GAIA's revolution in stellar variability

Eyer, Laurent (Observatoire de Genève, Versoix, CHE)

The description of stellar variability is reaching a new level with the ESA Gaia mission, which enables to locate many variable stars in the Hertzsprung-Russell Diagram. Furthermore, this mission also allows to detect, characterise and classify many millions of new variable stars thanks to its very unique nearly simultaneous multi-epoch survey with different instruments (photometry, spectro-photometry, radial velocity spectrometer). Follow-up or combination of data of some Gaia sources with other observations from ground or space will enhance further the understanding of stellar variability. A summary of the HR diagram will be presented with some future prospects.

2k02 - What we can learn from constant stars, and what means constant?

Paunzen, Ernst (Institut für Astrophysik, Vienna, AUT)

Variable stars can be found almost all over the Hertzsprung-Russell diagram (HRD). Over the past 150 years countless papers have been dedicated to the detection of new variable stars, because of their astrophysical significance, and the detection limit depends primarily on the instrumentation. Nowadays, we know of hundreds of thousands of variable stars especially due to large photometric surveys and it is difficult to find publications on really stable (constant) stars. But do we need such stars? Non-variable stars are urgently needed for calibrations of observations and models, in order to define, e.g., flux standards or boundary conditions for stellar models. It is therefore important to know the distribution of non-variable stars across the HRD. Surprisingly, the characteristics of non-variable stars and their statistical occurrence compared to the variable stars of similar effective temperature, luminosity, [dereddened] colour, absolute magnitude are not really known. One exception, for example, is the paper by Adelman (2001, A&A, 367, 297) who investigated time series from the Hipparcos mission. He found many objects reported as variable, but which turned out to be constant and vice versa. The study "Gaia Data Release 2 -- Variable stars in the colour--absolute magnitude diagram" (Gaia Collaboration, 2019, A&A, 623, A110) hopefully initiates future investigations. Here we present our efforts using CoRoT and Kepler data in order to establish a sample of non-variable stars with a given upper limit of variability in a certain wavelength range for a given time base and frequency domain, and discuss the influence of instrumental effects and apparent outliers.

2o01 - Obscured Long Period Variables from the NIR VMC survey

Groenewegen, Martin (Koninklijke Sterrenwacht van Belgie, Brussels, BEL)

The VISTA Magellanic Cloud (VMC) survey covers 180 sq. degrees of the Magellanic System (SMC, LMC, and parts of the Bridge and Stream). The observations are carried out in the Y, J and K filters. In K a minimum of 12 epochs of data are taken typically over 6 months. However for many object there is more data available (from observing blocks that were stopped because of changes in seeing for example) over a longer timespan. When combined with earlier data from e.g. DENIS, 2MASS, 2MASS6X and the IRSF an even longer timespan is covered and a period analysis of the K-band data is feasible.

The time coverage (10 years) and cadence (an observation every few days) of the OGLE survey is superior in finding variables, including Long Period Variables (LPVs), but OGLE is limited to about $I \sim 21$. The reddest asymptotic giant branch (AGB) stars with the heaviest mass-loss rates are very red and become faint to invisible in I. These stars are bright in the near-infrared.

In the present study we present the time-series analysis of a photometrically selected sample of about 1400 AGB/LPV candidates, with known OGLE LPVs with periods below 500 days already excluded. Based on the analysis of about 200 known OGLE LPVs with periods longer than 500 days in the sample, a final list of 400 (potentially new) long-period LPVs is presented. Some periods are well over a 1000 days.

This is the status end-March and an update of this work will be presented in August.

2o02 - A zoology of high-mass pulsators with the TESS and K2 space missions.

Burssens, Siemen (Institute of Astronomy, KU Leuven, Leuven, BEL); Bowman, Dominic (Institute of Astronomy, Leuven, BEL); Aerts, Conny (Institute of Astronomy, KU Leuven, Leuven, BEL); Simón-Díaz, Sergio (Instituto de Astrofisica de Canarias, La Laguna, Tenerife, ESP)

The parameter space of pulsating stars in the high-mass regime is still sparsely populated. Theoretical advancements -- i.e. for core structure, mixing descriptions, magnetic/rotational influences -- are therefore profoundly lacking observational calibration in stellar evolution models. The K2 and TESS space missions are observing many O and B-type stars and are populating the upper main sequence. An important result is that a significant fraction of the OB stars observed with K2 and TESS display variability, providing a direct diagnostic to their structure. In the K2 sample alone, several new high-mass pulsators -- including classical Beta Cephei, SPB

and Be type variables -- are discovered. With TESS, we are rediscovering bright massive stars that exhibit previously unknown multiperiodic variability. By introducing high-resolution spectroscopy, we find this zoo of variables covering a large range on the sHRD, perfect for systematic qualitative and quantitative comparison with theory.

2p01 - Pre-TESS observations of pulsating white dwarf stars at Konkoly Observatory

Bognár, Zsófia (Konkoly Observatory, MTA CSFK, Sopron, HUN); Kalup, Csilla (Konkoly Observatory, MTA CSFK, Sopron, HUN); Sódor, Ádám (Konkoly Observatory, MTA CSFK, Sopron, HUN)

The TESS (Transiting Exoplanet Survey Satellite) all-sky survey space mission provides an unique opportunity to study the pulsations of white dwarf variables, even with the currently available 120-second cadence mode. We performed survey observations at the Piszkéstető mountain station of Konkoly Observatory, Hungary, to find new bright white dwarf pulsators which could be potentially interesting targets for TESS observations, too. We successfully identified two new pulsators, namely PM J22299+3024 and WD 1310+583, a variable candidate (EGGR 120), and derived detection limits for possible pulsations for 18 objects. We also performed extended observations of another proposed TESS targets, LP 119-10 and HS 1625+1231, respectively. With the practically one-season long measurements of PM J22299+3024, WD 1310+583, LP 119-10, and HS 1625+1231, we determined a set of eigenmodes for all targets for the purpose of astreroseismic investigations. With the TESS observations, we expect to be able to complement these lists of eigenmodes which provides more constraints for the asteroseismic fittings. We present here our survey measurements with the results of the preliminary asteroseismic investigations of the observed variables.

2p02 - Comparison of the results obtained from the stars observing separately by Kepler Satellite and Ground Based Telescopes

Yoldas, Ezgi (Ege University, Izmir, TUR); Dal, Hasan Ali (University of Ege, Izmir, TUR)

In this study, the results obtained from the Kepler observations continued on twelve eclipsing binaries are presented. Examining the model parameters of distributions of the flare equivalent durations in the logarithmic scale versus flare total durations, it is found that the highest flare equivalent durations occurring on the stars (Plateau values) are found to be varying with the B-V color indexes in agreement with the variations of both the magnetic field strength (B) of the magnetic loop and especially the electron density of its plasma (n_e). The same variation is seen in the other model parameters such as the half-life and maximum flare total time values. For the first time in the literature, the distributions of flare cumulative frequencies were derived by using the flare equivalent durations, instead of the flare energy. The most impressive result obtained in the distributions is that there is a secondary variation, which can be just modelled with opposite two Damping Sine Waves, behind the main exponential variation of the flare cumulative frequency. The models indicate that this secondary variation in the flare cumulative frequency distributions is in the same shape with the periodic or quasi periodic pulsations detected in the light curves of the stellar and solar flares. This caused to ask new questions about the flare mechanism working on stellar atmospheres.

2p03 - A pre-main sequence variability classifier for TESS photometry

Zwintz, Konstanze (Universität Innsbruck, Innsbruck, AUT); Müllner, Marco (University Innsbruck, Innsbruck, AUT)

NASA's TESS space telescope will provide observations of 20 million objects. In collaboration with the T'DA group and TASOC collaboration, we propose a new classifier, that searches for pre main sequence stars in the objects observed by TESS. For this, we consider an array of different input parameters, including GAIA parallaxes and proper motions. We also apply machine learning to find characteristic structures in the light curves of young stars. Additionally, we also provide a new method to find T-Tauri stars, considering their semi-regular and regular variability.

2p04 - Clumpiness: Time-domain classification of Kepler red giant evolutionary states

Kuszlewicz, James (Max-Planck-Institut für Sonnensystemforschung, Göttingen, GER); Bell, Keaton (Max-Planck-Institut für Sonnensystemforschung, Göttingen, GER); Hekker, Saskia (Max-Planck-Institut für Sonnensystemforschung, Göttingen, GER)

The eras of TESS and PLATO will provide new challenges for evolutionary state classification of red-giant stars (i.e. red-giant branch vs. core helium burning) given the large number of stars being observed and the short datasets. We propose a new method based upon a supervised classification scheme that uses only "summary statistics" of the timeseries to predict the evolutionary state. Applying this to red giants in the APOKASC catalogue, we obtain a classification accuracy of ~93% for the full 4 years of *Kepler* data. The method also generalises to shorter datasets; it achieves an accuracy greater than 92% for subsets of the *Kepler* data with durations that mimic CoRoT (180 days), K2 (80 days) and TESS data (27 days). This work helps to pave the way towards fast, reliable classification of vast amounts of data with a few, well-engineered features. We also show how these features can be applied beyond solar-like oscillators and used in more general stellar classification tasks.

2p05 - Classification of variable stars

Tarczay-Nehéz, Dóra (Hungarian Academy of Sciences Research Centre for Astronomy and Earth Sciences, Sopron, HUN); Szabó, Róbert (Konkoly Observatory, MTA CSFK, Budapest, HUN); Szeleczky, Zoltán (Wigner Datacenter, Budapest, HUN)

The most recent telescopes (e.g. Kepler, K2, Gaia, TESS) and sky surveys (e.g. SSDS, and the forthcoming LSST) provide huge amont of data, that leads to the challenge of data processing. This huge amount of data need to be analyzed with fast and effective automated computer programming techniques. Therefore, machine learning algorithms become popular in astronomy, as they can play a key role in automatic classification of variable stars. In this work, we present our machine learning algorithm for searching variable stars, based on the statistical data of light curves, that represent the brightness variability of the stars in the Kepler field.

2p06 - LAMOST-II Medium-Resolution Spectroscopic Survey: The stellar parameter pipeline

Zuo, Fang (National Astronomical Observatories,Chinese Academy of Sciences, Beijing, CHN)

LAMOST (the Large Sky Area Multi-object Fiber Spectroscopic Telescope) is a large reflective Schmidt telescope independently developed in China. It has 16 spectrographs, each connected with 250 optical fibers, and can observe 4000 objects at the same time, making it the highest efficient telescope in the world. At present, LAMOST has entered the second phase of the sky survey project, in which the resolution R = 7500 spectral data will be obtained. The blue and red bands are 4910-5385 and 6300-6700, respectively. In the experimental observation phase of 2018, the number of spectra with signal-to-noise ratio greater than 10 is about 70W, and the stellar parameters of about 50W spectra are published. The improvement of resolution provides us with more information for further analysis of spectra. Abundant information makes it possible to give not only more accurate basic parameters of stars (effective temperature, surface gravity, metal abundance, apparent velocity), but also rotational velocity (vsini). Obtaining this information has important scientific value for many research subjects.

3. PULSATION

3k01 - Potential and challenges of pre-main sequence asteroseismology

Zwintz, Konstanze (Universität Innsbruck, Institut für Astro- und Teilchenphysik, Innsbruck, AUT)

The earliest phases in the lives of stars determine their whole future fate until their final stages. But although we have a general concept on how stars are formed and evolve through their youths, our knowledge of these phases is quite limited and contains major shortcomings. Asteroseismology of pre-main sequence stars has the potential to contribute to a better understanding of the input physics for theoretical models and to answer some of the open issues in early stellar evolution. But at the same time, when studying the pulsational properties of the youngest stars, we are faced with particular challenges. Examples are that pre-main sequence objects mostly show high levels of activity that perturb oscillation signals at millimagnitude levels and below, and the observational identification of the pre-main sequence evolutionary stage of a given star is not straight forward. An overview of the power of pre-main sequence asteroseismology for our theory of stellar structure and evolution and the connected challenges will be presented.

3k02 - Observations of internal structures of low-mass main-sequence stars and red giants

Hekker, Saskia (Max Planck Institute for Solar system research, Göttingen, GER)

Over the past years asteroseismic observations have been able to probe the internal structures of stars. Stellar structure inversions of low-mass main-sequence stars provide now observational information of the deep stellar interior. Additionally, the mixed modes in subgiant and red-giant stars are now exploit to obtain measures of the internal structure. Results and challenges of these internal structure measures will be discussed.

3k03 - The inner structure of intermediate-mass stars revealed

Ouazzani, Rhita-Maria (LESIA - Paris Observatory, Meudon, FRA)

The Kepler mission has allowed the exploration of a new area of the HR diagram: the main sequence of intermediate-mass stars. Applying asteroseismic analyses to dozens of stars of intermediate-mass, revealed their inner structure for the first time. Stellar rotation introduces a number of phenomena that considerably complicate the modelling of these stars and the interpretation of their pulsations. It induces dynamical processes such as meridional circulation, shear and baroclinic instabilities, and modifies the dynamics of pulsation modes, eventually giving rise to new classes of pulsation modes. With data of exquisite quality, we are finally able to study such pulsations in depth, and use them for asteroseismic analyses. I will focus on low frequency pulsations. After introducing these new classes of modes and their physics, their seismic potential will be demonstrated.

3k04 - Some thorny problems in pre-main sequence models: accretion, convection, rotation, and lithium

Constantino, Thomas (University of Exeter, Exeter, GBR)

The correctness of pre-main sequence models is not only important for studying stellar evolution, it is vital for understanding circumstellar disks and the formation of planetary systems. Standard models of pre-main sequence stars fail to pass some critical observational tests: they imply an age spread of around 10 Myr in young clusters, contradicting arguments that the age spread should be less than disk lifetimes, and do not simultaneously predict the observed colour-magnitude diagram and patterns of lithium depletion. These deficiencies have been partly attributed to inadequate accounting for factors such as accretion history, magnetic activity, rotation, and the properties of convection. In this talk I discuss our recent efforts to address some of these short-comings. We do this using the compressible hydrodynamical Multidimensional Stellar Implicit Code (MUSIC), which is a versatile tool for studying 3D phenomena in stellar physics. Inspired by simulations of hot and cold accretion, we developed a new boundary condition for accreting stellar models. We have also characterized the properties of convection in a pre-main sequence star as well as the impact of rotation on convection. Finally, we propose a rotation-dependent parametrisation of mixing due to convective overshooting that better explains the age-mass-rotation dependence of lithium abundances in open clusters.

3k05 - Asteroseismology of hot subdwarf and white dwarf stars

Van Grootel, Valerie (Université de Liège, 4000, BEL); Fontaine, Gilles (Université de Montréal, Montreal, CAN); Brassard, Pierre (Université de Montréal, Montréal, CAN); Charpinet, Stéphane (IRAP Toulouse, Toulouse, FRA); Giammichele, Noemi (IRAP Toulouse, Toulouse, FRA); Dupret, Marc-Antoine (Université de Liège, Liège, BEL)

I will review the progress made on asteroseismology of hot subdwarf and white dwarf stars in the space era. Indeed, compact stars are a showcase of asteroseismology since decades, but huge progress has been made since the advent of CoRoT, Kepler/K2, and more recently TESS space missions. This includes obtaining accurate stellar parameters, internal structure and chemical profiles thanks to quantitative (adiabatic) asteroseis-mology, as well as gaining a more in-depth understanding of the driving and damping of pulsation modes in these stars through nonadiabatic asteroseismology.

3k06 - What physics is missing in theoretical models of high-mass stars: new insights from asteroseismology

Bowman, Dominic (Institute of Astronomy, Leuven, BEL)

Almost all massive stars inevitably end their lives in a violent supernova explosion and form a black hole or neutron star. The mass of the compact remnant and the supernova chemical yield depend strongly on the internal physical properties of the progenitor star, which are currently not well-constrained from observations. The large theoretical uncertainties in interior rotation, mixing and angular momentum transport in massive-star interiors accumulate throughout stellar evolution, making it difficult to accurately predict the properties of the resultant supernova. Probing of stellar interiors was severely limited due to the dearth of detected pulsations until recent space photometry missions. In this talk, I provide an overview of the advances in our understanding of high-mass stellar interiors made with asteroseismic modelling. The discovery of pulsations in massive stars, and particularly for stars in different evolutionary stages from the main sequence to the blue supergiant phase, provides a necessary first step towards a data-driven empirical calibration of theoretical evolution models for the most massive and short-lived stars in the Universe.

3k07 - Cepheids under the magnifying glass - not so simple, after all!

Anderson, Richard I. (European Southern Observatory, Garching bei München, GER)

High-precision space- and ground-based observations of type-I Cepheid variable stars calibrate the cosmic distance scale and provide crucial insights into stellar astrophysical processes. Photometric, spectroscopic, and interferometric time series data have revealed unexpected changes of periods and amplitudes that challenge our paradigm of these stars as regularly varying and well-understood standard candles. This talk summarizes the rich harvest of unexpected and currently unexplained variability issues on timescales ranging from days to decades that provide new insights into evolutionary timescales and the hydrodynamics of stellar pulsations. Second, it reviews the usefulness of Cepheids as stellar laboratories for testing the effects of rotation on stellar evolution. Finally, I present the current state-of-the-art of combining HST photometry with Gaia parallaxes to measure the Hubble constant and elucidate the nature of the much-discussed Hubble tension.

3k08 - Asteroseismology of rapidly rotating stars with acoustic modes

Reese, Daniel (LESIA, Observatoire de Paris, Meudon, FRA)

Recent observations of mixed modes in red giants has revealed the shortcomings of current theory at explaining stellar rotation and angular momentum transport. Such shortcomings become more acute in the case of rapidly rotating stars where the relevant physical processes such as baroclinicity are amplified. A series of recent stellar models based on 1D and 2D numerical approaches are starting to provide insights into these questions but require observational constraints. Stellar pulsations potentially provide the tightest constraints on internal stellar structure but need to be identified correctly. In this talk, I will focus on acoustic pulsations of rapidly rotating stars. After recalling the asymptotic behaviour of so-called island modes, the rotating counterparts to low degree modes, I will describe generalised rotational splittings and the insights they provide into the stellar rotation profile. I will then describe recent efforts at interpreting observed pulsations, in particular searches for regular frequency patterns in different stars as well as multi-colour mode identification in beta Pic using observations from various instruments including the BRITE constellation.

3o01 - The BRITE SONG of Aldebaran

Beck, Paul (Universität Graz, Graz, AUT); Kuschnig, Rainer (Graz University of Technology, Graz, AUT); Kallinger, Thomas (Institut für Astrophysik, Universität Wien, Wien, AUT); Houdek, Günter (Stellar Astrophysics Centre (SAC), Department of Physics and Astronomy, Aarhus University, Aarhus, DNK); Grundahl, Frank (Stellar Astrophysics Centre (SAC), Department of Physics and Astronomy, Aarhus University, Aarhus, DNK); Weiss, Werner W. (Institut für Astrophysik, Universität Wien, Wien, AUT)

Solar-like oscillations in red-giant stars are now commonly detected in thousands of stars with space telescopes such as NASA Kepler or TESS missions. While such satellites provide ultra-precise monochromatic photometry, typical target stars are too faint for light-demanding ground-based complementary techniques or the time base is not sufficient to resolve long-periodic variations. The large number of targets is a goldmine for understanding stellar structure and evolution. However, simultaneous multi-color photometry and/or parallel radial-velocity monitoring for a few well studied stars therefore is crucial for a better understanding of the physics governing the oscillations and their amplitudes.

The link between the oscillation amplitudes and phase shifts of relative flux and radial-velocity variations has hardly been experimentally addressed yet in giants through direct comparison due to a lack of appropriate data. While radial-velocity measurements determine the velocity fluctuations from granulation and oscillations along the line of sight and allow a direct comparison to the theoretical models, the case of photometric variations remains challenging. As the latter correspond primarily to the temperature variations of the atmosphere over the oscillation cycle but need to be translated into fractional changes of the bolometric luminosity and scaled to the photometric passband of the space telescope. The amplitude ratio between intensity and velocity variations therefore is an important diagnostic which can be used to test models of the stellar atmosphere. Furthermore, the phase shift between modes seen in the two observables is a relevant parameter for constraining pulsation eigenfunctions, test the level of adiabaticity in the outer atmosphere and eventually models for stochastic excitation.

Aldebaran (alpha Tau), the star in the bull's eye has been monitored in several observing seasons with satellites of the BRITE-Constellation network and the 1m SONG (Stellar Observations Network Group) Telescope on Tenerife in total for ~300 days, each. Furthermore, 80 days of photometry with the Kepler K2 mission and some shorter data snippets up to 30 days of MOST data exist. These observations confirm the presence of oscillations of nuMax=2.1muHz (P=5.7d). In the latest observing season of 2018/19, we orchestrated a joint observing campaign to achieve simultaneous measurements of the intensity and velocity variations of Aldebaran through two-color photometry with BRITE constellation and SONG spectroscopy, respectively.

In this talk, we first present the first complete determination of the global asteroseismic parameters and a redetermination of the suspected planetary Jupiter-like companion. At the time of the writing this abstract the data reduction is still ongoing. We will discuss the early results of the ratios of the oscillation amplitudes and on the phase shifts between the variations between the two fields. The results from this campaign give important lessons learned for similar joint observing programs with ongoing TESS and the forthcoming Plato missions.

3o02 - Complex asteroseismology of SX Phoenicis

Daszynska-Daszkiewicz, Jadwiga (University of Wroclaw, Wroclaw, POL); Pamyantykh, Alosha (Nicolaus Copernicus Astronomical Center, Warsaw, POL); Walczak, Przemyslaw (University of Wroclaw, Wroclaw, POL); Szewczuk, Wojciech (Astronomical Institute of the Wroclaw University, Wroclaw, POL)

SX Phoenicis is the high-amplitude double-mode radial pulsator located in the δ Scuti instability strip. Probably, only the two radial modes are excited as no additional frequencies have been detected from the TESS data (Antoci et al. 2019).

Already fitting the two radial modes yields very strong constraints on stellar parameters and chemical composition. Petersen \& Christensen-Dalsgaard (1996) found that the model with the mass 1.0$M_{\odot}$ and metallicity $Z=0.001$ fits best an observed value of the frequency ratio ($\nu_1/\nu_2=0.7782$).

We have further extended this seismic analysis and constructed seismic models which reproduce both the two radial-mode frequencies as well as the corresponding values of the bolometric flux amplitude (the so-called parameter f). The empirical values of f were derived from multicoulor photometric amplitudes and phases adopting NEMO models of stellar atmospheres. Such complex seismic modelling is very demanding because only few models reproduce all the observables and account for mode instability.

We computed a grid of nonadiabatic pulsational models based both on stellar envelope models as well as on full evolutionary models obtained with MESA and Warsaw-New Jersey codes. Our analysis has led to constraints on mass, effective temperature, hydrogen, metallicity as well as on the efficiency of convective transport and the amount of overshooting from convective regions. In addition, some modification of opacities was required to meet all the conditions.

3o03 - Modelling Long-Period Variables in the Gaia Era

Trabucchi, Michele (University of Padova - Department of Physics and Astronomy, Padova, ITA)

Long-period variables (LPVs) are asymptotic giant branch (AGB) and upper red giant branch (RGB) stars that exhibit variability due to stellar oscillations in one or more modes of low radial order. Owing to the strong link between pulsation and stellar properties, their observed periods and amplitudes provide a powerful tool to estimate stellar masses and radii. Being deeply entwined with highly uncertain processes such as convection, mass-loss, and dust-formation, the variability of these evolved stars represents a promising channel to better understand stellar physics. Finally, LPVs follow several distinct period-luminosity relations that hold a high potential as distance indicators.

Large-scale microlensing surveys (EROS, MACHO, OGLE) carried on during the last few decades turned the Magellanic Clouds into ideal laboratories to study the ensemble properties of LPVs. Today, the Gaia mission is providing new insight into these objects, as well as new possibilities to apply them to the characterization of stellar populations.

I will present here some of these recent results, as well as a novel approach to their interpretation based on the combination of new pulsation models with state-of-the-art synthetic stellar population models. I will cover the main shortcomings of the theory that are becoming evident from the emerging picture of LPVs in the Magellanic Clouds, as well as the constraints offered by variability observations to improve theoretical models.

3p01 - Modeling the Solar-like Radial p-mode Line Profile Asymmetries

Philidet, Jordan (LESIA, Meudon, FRA)

Solar p-modes are stochastically excited and damped harmonic oscillators featuring a Lorentzian-shaped peak in their power spectral density. However, the observed line profiles are actually skew symmetric. The origin of this asymmetry was attributed early on to the localisation of the source of excitation. It was also discovered that the observed asymmetries are very different depending on the observable used (velocity or temperature). This puzzling result was finally ascribed to the fact that a significant amount of asymmetry is due to the interference between the acoustic noise and the oscillation it generates.

In this context, we aim at quantitatively reproducing the asymmetries observed in solar-like radial p-mode line profiles. To that end, we integrate the radial acoustic wave equation over the entire stellar interior for fixed temporal frequencies. We use an equilibrium state provided by CESTAM to model the acoustic potential, and 3D simulations of the Sun atmosphere provided by CO5BOLD to realistically model the source term of the wave equation. This enables us to extract the asymmetry of radial p-mode line profiles. We model both the effect of source localisation and of correlations between the noise and the oscillation, and demonstrate that both contributions have similar impacts and must therefore be accounted for to reproduce the observed asymmetries.

3p02 - The planet-host pulsating star HR 8799 as seen by BRITE

Sódor, Ádám (Konkoly Observatory, MTA CSFK, Sopron, HUN); Bognár, Zsófia (Konkoly Observatory, MTA CSFK, Sopron, HUN)

HR 8799 is a well-known planet-host star with at least 5 planets discovered by direct imaging. HR 8799 is also a gamma Doradus pulsator, target of several previous photometric studies. BRITE observed this target in 2017 for 140 days, obtaining the most extended photometric data on this pulsator to date. We analyse these data in comparison with the results of previous space- and ground-based photometric observations. We confirm our earlier conclusion that resonances in the sparse frequency content of this pulsator might render the astreroseismic investigations rather difficult, if not impossible.

3p03 - The changing non-radial pulsation pattern of the Algol-type star RZ Cas

Lehmann, Holger (Thüringer Landessternwarte Tautenburg, Tautenburg, GER); Pertermann, Frank (Thüringer Landessternwarte Tautenburg, Tautenburg, GER)

Recent and current satellite missions like CoRoT, Kepler, BRITE, and TESS have opened new windows to exoplanet search and to the exploration of pulsating stars. In both fields, it turned out that support from ground-based spectroscopic follow-up observations is needed to characterize the planet hosting as well as the pulsating stars and asteroseismology has proven beneficial once non-radial pulsations can be observed.
Using time series of spectra, we can determine pulsation modes of low l degree from measured radial velocities whereas high-degree modes can be found from line profile variations. In the latter case, the FAMIAS program (Zima 2008) provides a useful tool by its pixel-by-pixel method. We introduce a Python-based computer program that extends the capabilities of FAMIAS to perform an automated frequency search in the case of a large number of non-radial pulsation modes as observed e.g. for Delta Scuti-type pulsators. Therefor it applies an S/N based stop criterion, similar to Breger (1993). It also determines the error estimates of the detected frequencies, which was not possible with the pixel-by-pixel method so far. We apply the program to time series of spectra obtained for the short-period Algol-type star RZ Cas in different epochs to search for changes in its pulsation pattern connected with the occurrence of active and inactive phases of mass transfer and present first results.

3p04 - Asteroseismology of Low-mass Pulsating White Dwarfs

SU, Jie (Yunnan Observatories, Chinese Academy of Sciences, Kunming, CHN)

Low-mass pulsating white dwarfs are newly discovered, which are expected to harbor helium cores. There are few related studies on them. In this presentation, I will introduce our scheme to establish models with parameterized chemical abundance profiles, which will effectively reduce the model errors caused by uncertainties in the evolution of stars. Based on the new models, we use data obtained from observations of some low-mass pulsating white dwarfs to accurately determine their essential parameters and to calibrate their chemical abundance profiles by asteroseismological methods. The aim is to reconstruct the chemical abundance profiles that match the real situation. This will deepen our understanding of the process of element diffusion. A correct understanding of the internal chemical composition and structure of low-mass white dwarfs will help us to improve the model and further improve the accuracy and reliability of the model.

3p05 - Pre-main sequence g-mode pulsators in K2 and TESS

Ketzer, Laura (Universität Innsbruck, Innsbruck, AUT); Zwintz, Konstanze (University of Innsbruck, Innsbruck, AUT)

MOST, CoRoT and BRITE have led the way for detailed asteroseismic studies of pre-main sequence (pre-MS) pulsators. In the extended Kepler mission (K2), campaigns 2, 9 and 15 pointed towards young-star forming regions, which are host to pre-MS stars. Alongside this, the all-sky survey mission TESS will provide us with more long-baseline data for this class of stars.

Currently, only a handful of pre-MS gravity (g-)mode pulsators of gamma Doradus and Slowly Pulsating B types are known. Therefore we aim to discover additional pre-MS g-mode pulsators using K2 and TESS data. g-modes are most sensitive to the conditions in the deep stellar interior. Hence, our search focuses also on detecting g-mode period spacing patterns in young stars which can then be used to constrain the near-core rotation. Increasing the sample size of pre-MS g-mode pulsators will allow us to better understand the location and extent of the instability strip and put constraints on stellar structure models and their treatment of convective energy transport.

3p06 - Asteroseismology of the ß Cen system

Lovekin, Catherine (Department of Physics, Mount Allison University, Sackville, NB, CAN)

Recently, the triple system β Centauri was observed with the BRITE-Constellation (Pigulski et al, 2016). These photometric observations detected 19 periods, of which eight are likely g modes and nine are identified as p modes. As both the Aa and Ab components of the system are identified as early B-type stars, the pulsations could belong to either or both components. Pigulski et al. (2016) attempted preliminary asteroseismic modelling of the system, but the rapid rotation meant that no final seismic model was produced. We expand on the modelling of Pigulski et al. (2016), and use a 2D stellar evolution code and a 2D pulsation code to calculate models of the Aa and Ab components of the β Cen system. The 2D nature of these codes allows us to more fully account for the effects of rotation on both the structure and pulsation frequencies of the stars. We use the known binary constraints of the system to limit the range of models calculated and further constrain our fit. We present the preliminary results of our fit, which includes our determination of which star produces the pulsation frequencies, absolute rotation rates, convective core overshoot parameters, and the absolute age of the system.

3p07 - Seismic modeling of Epsilon Persei and Epsilon Centauri based on BRITE and ground based photometry plus professional and amateur spectroscopy

Zoclonska, Elzbieta (Nicolaus Copernicus Astronomical Center, Warszawa, POL); Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warszawa, POL); Pamyatnykh, Alexey (Nicolaus Copernicus Astronomical Center, Warszawa, POL)

Epsilon Persei and Epsilon Centauri are moderately rotating Beta Cephei stars with complex patterns of pulsation. BRITE photometry was used to determine a forest of pulsation frequencies and we will describe the challenges which arose during data reduction and analysis. Additionally to space and ground based photometry we analyzed high-resolution spectroscopy from professional as well as amateur observations. Using the line profile variations we performed mode identification. We will present initial asteroseismic modeling results based on those data.

3p08 - The prototype star gamma Doradus, as viewed by TESS and ground-based telescopes

Christophe, Steven (Observatoire de Paris, Meudon Cedex, FRA)

As a bright (V=4.20) F1V star and the prototype of the eponymous pulsating variable class, gamma Doradus is one the most studied star of its class. The recently launched NASA TESS satellite observed gamma Dor for 3 Sectors (78.4 days), offering a fresh and better view at its pulsation spectrum. Benifiting from recent progress in the understanding of gamma Dor pulsations thanks to the Kepler mission and synergies between photometric, spectroscopic and astrometric data, gamma Dor is particularly suitable for detailed asteroseismic modelling.

We present a conjoint analysis of all available data in attempt to derive consistent estimates of stellar parameters, and notably the surface-to-internal rotation period ratio.

3p09 - The existence of hot gamma Doradus and A-F type hybrid stars

Kahraman Alicavus, Filiz (Nicolaus Copernicus Astronomical Center, Warsaw, POL); Poretti, Ennio (INAF Osservatorio Astronomico di Brera, Milan, ITA); Catanzaro, Gianni (National Institute of Astrophysics, Rome, ITA); Smalley, Barry (Keele University, Keele, GBR); Niemczura, Ewa (Astronomical Institute of Wroclaw University, Wroclaw, POL); Rainer, Monica (INAF - Osservatorio Astrofisico di Arcetri Largo, Firenze, ITA)

The existence of hot gamma Doradus and A-F type hybrid pulsating stars have been revealed thanks to the high-quality Kepler data. However, in these hot objects, there should not be a sufficient convective envelope to excite the gamma Doradus type oscillations. To explain the situation of these stars, some opinions were put forward such as possible incorrect atmospheric parameters, binarity, rapid rotation, and chemical peculiarities. The explanation of these opinions needs a detailed spectroscopic and photometric study. Therefore, we present the result of our detailed spectroscopic and photometric investigation of twenty-four hot gamma Doradus and A-F type hybrid star candidates. As a result, we confirm that the hot gamma Doradus and A-F hybrid stars exist. The binarity and surface chemical peculiarities don't appear to be a possible explanation for the existence of these objects. It has been suggested that hot gamma Doradus and hybrid stars might be fast rotating slowly pulsating B stars (Balona et al. 2016). The stars in our sample have high projected rotational velocity (on average 130 and 190 km/s for gamma Doradus and hybrid stars, respectively) but they don't show B type spectral lines. The result of this study provides new information to improve the understanding of the pulsation mechanism that occurs in the gamma Doradus stars.

3p11 - Delta Scuti stars in the Galactic bulge

Netzel, Henryka (Nicolaus Copernicus Astronomical Centre, Warszawa, POL)

In the Optical Gravitational Lensing Experiment there are more than nine thousand Delta Scuti stars identified in the Galactic bulge fields. This is the most numerous sample of Delta Scuti stars observed so far. We present the results of the frequency analysis of all stars in this sample. The most interesting objects are stars with two and with three radial modes excited simultaneously, which constitute 24 and 4 percent of the analyzed sample, respectively. Also, we found a few stars which likely pulsate in four radial modes. In the poster we present detailed results and properties of the analyzed Delta Scuti stars.

3p12 - Effect of the magnetic field on period spacings of gravity modes in rapidly rotating stars

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Stellar magnetic fields play a crucial role in the evolution of angular momentum of stars and in their interactions with companions or planets.
Spectropolarimetric surveys provide us with numerous observational constraints on surface magnetic fields, but we have very few direct constraints on internal magnetic fields.
Asteroseismology allows us to probe stellar interiors and is thus an excellent candidate to obtain new constraints on the magnetism of the interiors of stars.
In this context, we developed a perturbative treatment of a large-scale fossil-like mixed magnetic field (i.e. poloidal and toroidal) in the traditional approximation of rotation (which neglects the horizontal component of the rotation vector) to investigate its effect on the period spacing patterns of gravity modes in rapidly rotating stars.
We then applied it to a representative model of the SPB star HD 43317 and show how the magnetic signatures are different from those of rotation and chemical mixing.
Consequences for the seismic characterisation of the near-core boundary in intermediate-mass and massive stars are finally discussed.

3p13 - Astrophysics of Cepheids: Physical properties and evolutionary status of Cepheids in eclipsing binary systems.

Pilecki, Bogumil (Nicolaus Copernicus Astronomical Center, Warsaw, POL)

Cepheids are important distance indicators in the local Universe and key objects for testing the predictions of stellar evolution and stellar pulsation theories. A presence of Cepheids in eclipsing binary systems give us an opportunity to measure and study their physical parameters, including the mass. The analysis of such systems is very challenging and new methods had to be developed to take full advantage of this configuration. In total, we have studied ten Cepheids in nine eclipsing binary systems and found firm relations between such observed parameters as period mass and radius. The results based on evolution and pulsation models can be now compared with observations and challenged. The study resulted in finding evidence for binary interactions during the evolution and a non-pulsating object inside the instability strip. Our measurements provide strong constraints for solving the famous Cepheid mass discrepancy problem. We have also measured the first dynamical mass and determined the evolutionary status of a type II Cepheid. A presence of complex ringed disk structures was also detected around the companions to type II Cepheids.

3p14 - Wondering about red supergiants

Messineo, Maria (University of Science and Technology of China, Hefei, CHN)

Massive stars are key ingredients of spiral galaxies, they trace the spiral arms, and chemically enrich the interstellar medium by losing mass at high rates and exploding as supernovae. Galactic massive stars are often found in massive clusters and in the proximity of giant HII regions. RSGs are the brightest stars in the Disk seen at infrared wavelengths, being young and cold objects with typical luminosity above 10,000 that of our Sun. Due to our position on the Disk, dust obscuration, and poor distances, their identification is difficult and their census highly incomplete, with about five hundred RSGs currently reported in the literature. Multi-wavelength photometric data of the Galactic plane (e.g. from 2MASS, CIO, MSX, WISE, GLIMPSE, MIPSIGAL) allow us to characterize bright late-type stars, while Gaia provides their parallaxes. We have prepared an infrared catalog of 889 Class I stars with spectral types reported in the catalog of Skiff (2016), and with good-quality parallaxes from Gaia DR2. We confirm that a fraction of 60% of those stars are brighter that the tip of red giant stars, and we derive average magnitudes per spectral types. On a very large scale, such Galactic massive stars are useful as calibrators of resolved stars that future telescopes will observe in far distant spiral galaxies.

3p15 - The pulsation spectrum of the mass-accreting component of AS Eri.

Mkrtichian, David (National Astronomical Research Institute of Thailand, Chiang Mai, THA); Gunsriwiwat, K. (AUT); Engelbrecht, C. (AUT); Lampens, P. (AUT); Lehmann, H. (AUT)

We will present the pulsational analysis of MOST (2013) and TESS (2018) light curves of an A3V primary component of semidetached Algol-type system AS Eri. Space observations have been supported by two follow-up ground-based photometric campaigns of AS Eri carried out in 2014 (68 nights) and in 2018 (30 nights) using the PROMPT and the TRT robotic telescope networks. High- and medium-resolution time series of echelle-spectroscopy of AS Eri have been collected using 10m SALT and 2.4m Thai National Telescopes. One set of SALT time-series observations
has been obtained simultaneously with TESS telescope. The analysis of photometry and spectroscopy revealed the rich spectrum of low- and high degree non-radial modes. We found a strong pulsational line profile variations in the spectrum of a mass-accreting gainer caused by high-degree non-radial modes. We will present the spectroscopic indicators of the interaction of gas-stream with the atmosphere of a pulsating gainer showing the existence of a hot turbulent zone in an upper atmosphere The orbital variability of He I lines is in good agreement with the expectation of position of hot zone found from our 3-D hydrodynamic simulations of mass-transfer.

3p16 - Cepheids near and far

Tarczay-Nehéz, Dóra (Hungarian Academy of Sciences Research Centre for Astronomy and Earth Sciences, Sopron, HUN); Dencs, Zoltan (Hungarian Academy of Sciences Research Centre for Astronomy and Earth Sciences, Budapest, HUN); Szabados, Laszlo (Konkoly Observatory, Budapest, HUN)

Cepheid variable stars play a fundamental role in astronomy because they are standard candles in calibrating the cosmic distance scale via the period-luminosity relationship. As of early 2019, Cepheids have been discovered in 97 galaxies beyond the Milky Way. The total number of known Cepheid variable stars exceeds 20000 (not counting the newly discovered ones announced in Gaia DR2). In this work, we present our online data base maintained at the web site of the Konkoly Observatory (https://cepheids.konkoly.hu).

3p17 - TESS Discovers Tidally Trapped Pulsations in HD 74423

Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warsaw, POL)

We report the discovery of tidally trapped pulsations in the ellipsoidal variable HD 74423. The oscillations are shown to have much larger amplitude in the hemisphere that faces the (so far undetected) secondary star. We interpret this as a dipole oscillation whose pulsational axis has been tilted into the orbital plane and pointing to the secondary star. This is the first time such a phenomenon has been observed. We provide attempts to model the tidal focusing of oscillation modes, and also model the system in general. The primary star is close to filling its Roche Lobe and mass transfer is soon to set on.

3p18 - Multicolor Photometry of Peculiar Cepheid Stars Observed in the Konkoly Observatory

Cseh, Borbála (Konkoly Observatory, MTA CSFK, Sopron, HUN); Szabados, László (Konkoly Observatory, Budapest, HUN); Molnár, László (Konkoly Observatory, Budapest, HUN); Plachy, Emese (Konkoly Observatory, Budapest, HUN); Szegedi-Elek, Elza (Konkoly Observatory, Budapest, AUT); Klagyivik, Péter (Instituto de Astrofiísica de Canarias, La Laguna, Tenerife, ESP); Marschalkó, Gábor (Baja Astronomical Observatory of Szeged University, Baja, HUN); Moór, Attila (Konkoly Observatory, Budapest, HUN); Szing, Attila (Baja Astronomical Observatory of Szeged University, Baja, HUN); Vida, Krisztián (Konkoly Observatory, Budapest, HUN)

We present preliminary light curves of ten Cepheid stars of the northern sky. Four classical Cepheids: BY Cas, CE Cas, CF Cas, S Vul, two Type II Cepheids: AU Peg and IX Cas and four Anomalous Cepheids: BL Boo, BW Com, DT Gem, SDSS J145659.89+164008.2. The data were collected between 2011 and 2015 with the 60/90 cm Schmidt telescope of the Konkoly Obervatory in BVRI filters. Some of the program stars show strong period change or even cycle to cycle variations that our observations clearly confirm.

3p19 - Science with BRITE-Constellation at the University of Innsbruck

Zwintz, Konstanze (Universität Innsbruck, Institut für Astro- und Teilchenphysik, Innsbruck, AUT)

At the University of Innsbruck, BRITE-Constellation data of several types of variable stars are analyzed together with students in bachelor theses and as course work during lectures. An overview of our recent (team) work including gamma Doradus and delta Scuti stars as well as some stars showing variability caused by spots will be presented.

3p20 - Long-term BRITE and SMEI space photometry of gamma Cas (B0.5 IVe)

Borre, Camilla (Stellar Astrophysics Centre, Aarhus University, Aarhus C, DNK); Baade, Dietrich (European Organisation for Astronomical Research in the Southern Hemisphere (ESO), Garching, GER); Rivinius, Thomas (European Organisation for Astronomical Research in the Southern Hemisphere (ESO), Santiago 19, CHL); Weiss, Achim (Max-Planck-Institut für Astrophysik, Garching, GER); Bright Target Explorer, BRITE (N/A, N/A, AUT)

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Gamma Cas was the first classical Be star discovered (Secchi 1866). It is the prototype of a ~1% subset of X-ray-defined Be stars. Almost all of them have spectral types between B0.5 and B1.5; but later subtypes are beginning to be reported. The X-ray radiation is thermal, harder and more continuous than that of Be X-ray binaries (BeXRBs) with accreting compact companions, and exhibits flux levels intermediate between BeXRBs and shocked radiative winds (Smith, Lopes de Oliveira& Motch 2016). In the late 1930's / early 1940's, gamma Cas underwent two spectacular outbursts (mass-transfer events to the circumstellar disk). The star is a binary with an unseen companion in a circular 203.5-day orbit (Nemravová et al. 2012), the signature of which was not detected by both BRITE (Bright Target Explorer) and SMEI (Solar Mass Ejection Imager).

The SMEI photometry from 2003 to 2012 confirmed the 0.82-c/d frequency found in 13 years of ground-based photometry (1997-2011; Henry & Smith 2012) and attributed by Smith and co-workers to critical rotation but without physical model for the light modulation. In four consecutive seasons of BRITE observations (2015-2018) not overlapping in time with the other two datasets, the 0.82-c/d was not detected at the mmag level. However, a new 2.48-c/d frequency was present at all times and in observations with all BRITE satellites. The ratio of the two frequencies is very close to but different from 3.0. They are discussed in the framework of nonradial pulsations that are ubiquitous in classical Be stars and probably responsible for most of their mass-loss events. BRITE detected no such event >0.03 mag. The disappearance of the 0.82-c/d frequency as proposed rotational modulation casts doubts on the notion (Smith, Lopes de Oliveira& Motch 2016) of two undetectable but interacting small-scale magnetic fields.

4. VARIABILITY OTHER THAN PULSATION

4k01 - Early-type magnetic stars: the rotation challenge

Mathys, Gautier (ESO, Santiago, CHL)

Large-scale organised magnetic fields of kG order are present in 5-10% of the upper main-sequence stars. The rotation periods of these stars span up to 5 or 6 orders of magnitude, with no evidence for evolution besides conservation of the angular momentum during their main-sequence lifetime. Explaining how period differentiation over such a wide range is achieved in stars that are essentially at the same evolutionary stage represents a major challenge. To address it, improved knowledge of the distribution of the rotation periods is a pre-requisite. Space missions have already enabled considerable progress to be achieved in the study of the periods of days to months, and they will continue to do so in the coming years. Ground-based observations lend themselves better to the monitoring of the longer periods. The most extreme among the latter, which may reach decades to centuries, are of particular interest, but constraining them is also the most challenging endeavor. Recent progress in this area will be reviewed, and future prospects and concerns will be discussed.

4k02 - Be star variability as seen from ground-based and space photometry

Carciofi, Alex (Universidade de São Paulo, São Paulo, BRA); Labadie-Bartz, Jonathan (Universidade de São Paulo, São Paulo, BRA)

Be stars are rapidly rotating B-type main sequence stars. Owing to an yet undetermined phenomenon acting in addition to the stellar rapid rotation, mass is ejected from the star, forming a Keplerian gaseous disk. These objects have been known to vary in virtually all timescales, and variability arises both from the photosphere proper (pulsations, mass ejections) and the disk (density waves, viscous processes, etc.). In this joint talk, we begin reviewing the most relevant aspects of Be star research, with an emphasis on how lightcurve modeling is challenging our view about the structure (and possibly evolution) of these fast spinning stars. We have analyzed hundreds of lightcurves of Be stars (some of them spanning more than 17 years of observation) using hydrodynamical disk models to determine several fundamental disk quantities, such as the kinematic viscosity and the angular momentum loss rate. Comparison of the later quantity with model predictions indicates large discrepancies between the two, whose impact and consequences on the theories of the structure and evolution of fast-spinning stars must still be understood. The second part of the talk describes recent TESS observations of several hundred Be stars made with a 2-minute cadence. The pulsational properties of this sample are studied at a precision that has not yet been possible. We present an overview of the TESS results, that reveals that some of the studied systems are variable in ways that have never before been observed.

4k03 - BRITEness variations of the BRITEst hot stars

Moffat, Anthony (Univ. de Montreal, Westmount, QC, CAN)

Our massive-star team has been using BRITE since the beginning to observe some of the intrinsically and apparently brightest hot stars in the sky. This includes O, LBV and WR stars, which share the feature of driving strong winds and ending in a supernova explosion yielding a NS, BH or no remnant at all. As such, O/LBV/WR stars are tied to GRBs and GW sources, in addition to the first stars to form in the Universe, being predominantly very massive. We present some key cases observed by BRITE with their implications for stellar winds and internal stellar structure. In particular, contrary to expectations, hot luminous stars (especially the most extreme among them) tend to show frequent hydrostatic-surface, semi-stable bright spots that betray the stellar rotation and drive the universal spiral pattern wind features known as co-rotating interaction regions (CIRs), seen in virtually all O-star and some WR-star winds. Such spots are likely the direct result of a distinct layer of subsurface convection, as proposed recently by Cantiello et al. (2009). This layer may also be the ultimate source of shorter-lived stochastic bright spots in the photosphere, which lead to wind clumping, seen in all hot-star winds.

4o01 - Shine BRITE: shedding light on the variability of stars through

Fabbian, Damian (Institut für Astrophysik Göttingen (IAG), Georg-August-Universität Göttingen, Göttingen, GER); Kupka, Friedrich (MPI for Solar System Research, Göttingen, GER); Krueger, Daniel (Institut für Astrophysik Universität Göttingen, Göttingen, GER); Kostogryz, Nadiia (MPI for Solar System Research, Göttingen, GER)

The correct interpretation of the large amount of complex data from the next-generation (in particular, space-based) observational facilities, requires that a very strong theoretical underpinning be in place. In the near future, the use of three-dimensional (3-D) magneto-radiation-hydrodynamics (MRHD) stellar atmospheric models coupled with advanced radiative transfer treatment including non-local thermodynamic equilibrium (non-LTE) effects and polarisation will become the norm.

We present some ideas, results, problems, with a view to generate some lively and open discussion on the needed and expected advances.

4p01 - Stellar rotational variability and starspot diagnostics

Khodachenko, Maxim (Space Research Institute, Austrian Academy of Sciences, Graz, AUT); Arkhypov, Oleksyi (IWF ÖAW, Graz, AUT); Lammer, Helmut (IWF ÖAW, Graz, AUT); Güdel, Manuel (Institute of Astronomy, Uni. Wien, Wien, AUT); Lueftinger, Theresa (Institute of Astronomy, Uni. Wien, Wien, AUT)

The evolution of starspot activity pattern is controlled by hitherto unresolved mixture of drivers from near-subsurface small-scale plasma flows up to giant turbulence in stellar deeps. To shed more light on the related mechanisms, the changing starspot distribution over the global scales was studied in the rotational light-curve (spot-modulated) variability of ~2000 main-sequence stars with periods $0.5 < P < 30$ days and effective temperatures $3227 \leq T \leq 7171$ K, observed by Kepler mission. It is found that in cool and fast rotators the large-scale activity patterns are much more stable than the smaller ones, whereas for hotter and/or slower rotating stars such difference is less pronounced. This effect is explained in terms of two mechanisms: (1) the diffusive decay of long-living spots in activity complexes of stars with a saturated magnetic dynamo, and (2) the spots emergence, modulated by turbulent gigantic convection flows in stars with a weaker magnetism. The realistic values of the diffusivity of the magnetic elements in the photosphere were obtained in the broad interval of stellar effective temperatures from 3300 to 6600 K. Moreover, the effect of sub-diffusion in stellar photospheres, characterized by the nonlinear dependence of the squared displacement (typical scale) of magnetic element on time, was revealed from observations. The elaborated approach opens a way for investigation of stellar surface flows as well as deep convection, inaccessible for astroseismology. A diagnostic diagram was proposed that differentiates stars in the (P-T) parameter space with respect to a dominating mechanism of their spot variability quantified in terms of gradient function $\beta_{12} = [\log(\tau_2) - \log(\tau_1)]/\log(2)$, where τ_2 and τ_1 are the time-scales of variability of the squared amplitudes of first and second rotational harmonics (A_{12}, A_{22}) of the stellar light-curve. The values of $\beta_{12} = -2/3$, -2, <-2, and -1 correspond to the domination of Kolmogorov's turbulence, magnetic diffusion, sub-diffusion, and differential rotation, respectively. This diagram enables further selection of particular objects for further more detailed study.

4p02 - Short-term periodicities in activity of solar-type stars

Gurgenashvili, Eka (Ilia State University, University of Goettingen, Tbilisi, GEO); Kukhianidze, Vasil (Ilia State University, Tbilisi, GEO); Reiners, Ansgar (University of Goettingen, Goettingen, GER); Reinhold, Timo (Max Planck Institute for Solar System Research, Goettingen, GER); Zaqarashvili, Teimuraz (University of Graz, Graz, AUT)

Rieger type periodicity occurs in many indices of solar magnetic activity such as: sunspots, solar flares, CME-s, etc. Our recent analysis of long-term sunspot data showed that observed Rieger-type periods correlate with solar cycle strength so that the stronger cycles show shorter periods. This finding allowed us to estimate the magnetic field strength in the solar dynamo layer. Some solar-type stars show short-term variations in magnetic activity, which might correspond to the solar Rieger-type periodicity. We study Kepler light curves to search the periodicities on solar like stars at different evolutionary stages and to use them for estimation of stellar dynamo magnetic field. We will present preliminary results of the study.

4p03 - Measurement of short-period activity cycles of fast rotating stars observed by Kepler mission

Khodachenko, Maxim (Space Research Institute, Austrian Academy of Sciences, Graz, AUT); Arkhypov, Oleksyi (Space Research Institute, Austrian Academy of Sciences, Graz, AUT); Guedel, Manuel (Institute of Astronomy, University of Vienna, Vienna, AUT); Lueftinger, Theresa (Institute of Astronomy, University of Vienna, Vienna, AUT)

We study a short-periodic component of stellar activity with a cycle period of $P_c < 1000$ days, using the Kepler mission photometry of 462 fast-rotating ($1 < P < 4$ days) stars with spectra of M4V to F3V. The direct Fourier analysis and two non-spectral methods are applied in combination to the time sequence of varying spectral power A_1^2 of the first rotational harmonic of the stellar light curves. The latter has been shown to be a measure of stellar surface activity and its useful index. The obtained results are in accordance with previous measurements of other research teams, using different methodologies and essentially smaller number of stars. With a dedicated modelling, we show that the measured short-period activity cycles of objects in the analysed sample are not strongly affected by differential rotation of spots and related beating effect. The measured P_c values cluster in the $(1/P_c)$ vs. $(1/Ro)$ diagram by Saar & Brandenburg (1999) within a specific branch which connects the branch of inactive stars with the area populated by super-active objects. The formation of the discovered branch is due to the α-quenching effect, which saturates the stellar magnetic dynamo and increases the cycle periods with the increase of inverted Rossby number Ro.

4p04 - Superfast spectral variations of OBA stars

Batrakov, Alexander (Saint Petersburg State University, Saint Petersburg, RUS); Kholtygin, Alexander (Saint Petersburg State University, Saint Petersburg, RUS); Hubrig, Swetlana (Leibniz-Institut für Astrophysik Potsdam, Potsdam, GER); Fabrika, Sergei (Special Astrophysical Observatory RAS, Nizhnij Arkhyz, RUS); Valeev, Azamat (Special Astrophysical Observatory RAS, Nizhnij Arkhyz, RUS); Alexander, Kostenkov (Saint Petersburg State University, Saint Petersburg, RUS)

We present results of our search for fast line profile variations (LPVs) in spectra of selected OBA stars. The regular variations of the line profiles with periods ranging from several hours to days in spectra of all OBA stars are well known. Recent observations of the A0 supergiant HD 92207 using FOcal reducer low dispersion spectrographs FORS 2 in spectropolarimetric mode mounted on the 8-m telescopes of the VLT showed moderate line profile variations of various lines on a time-scale of minutes or maybe even of a fraction of a minute. Such short time-scale LPVs we also detected in our spectral time series of HD 93521 (O9.5III), rho Leo

(B1Iab), and α^2~CVn obtained with the multi-mode focal reducer SCORPIO at the 6-meter telescope (Northern Caucasus, Russia). Both regular LPVs with periods from 2 to 90 minutes and non-regular LPVs with amplitudes of 1-2\% of the continuum level are detected. The presence of the short-term spectral variability in massive OBA stars, which are suggestec to be the progenitors of Type II supernova, was not studied systematically in the past and can be critical for the current theoretical understanding of the supernova physics and for modeling the stellar evolution.

4p05 - Results of Light Curves Analysis of Eclipsing Dwarf Nova EX Dra

Voloshina, Irina (Sternberg Astronomical Institute, Moscow State university, Moscow, RUS); Tatiana, Demidova (Pulkovo Observatory, Saint-Petersburg, RUS)

Photometric observations of the eclipsing variable star EX Dra acquired in the course of a program of studies of cataclysmic variables and their parameters recently carried out at the Sternberg Astronomical Institute (SAI) are presented. The star was observed with the 50-cm

and 60-cm telescopes of the SAI Crimean Astronomical Station and a CCD photometer (~10500 images in the V and Rc filters, 24 observational nights) during the variable's outburst and in a period of quiescence in 2014-2016. The orbital period was derived by the new numerous data in good agreement with the previous one. The light curves of EX Dra were plotted with this new value. Parameters of the system components (white and red dwarfs, accretion disk with hot spot and gaseous stream) were derived from 80 % of light curves using a “composite” model that takes into account the presence of a hot spot on the lateral surface of the geometrically thick disk and of a region of enhanced energy release near the disk edge, at the base of the gas flow (the so-called “hot line”). We also considered the variations of these parameters with the system transition from one stage of activity to another one. Six light curves of EX Dra were also used together with a “composite” model that additionally takes into account the presence of dark spots on the secondary component surface. The parameters of these dark spots on the red dwarf were determined. Two models were proposed to explain outbursts in dwarf novae: MTIM –mass transfer instability model and DIM – the termal-viscous disk instability model. Our data evidence that outbursts in EX Dra dwarf nova are due to the increase in the rate of accretion (MTIM model).

4p06 - X-ray variability of Single and Binary Hot Stars

Pollock, Andy (University of Sheffield, Sheffield, GBR)

Observations of the hottest stars from orbiting high-energy telescopes reveals the unexpected but ubiquitous presence of slow, stochastic variations of up to 10% or more in X-ray emission that originates in supersonic stellar winds. Although CIRs are sometimes thought to be responsible, the location, amplitude and incoherence of the variations might suggest other possibilities. Binary systems show more regularities but still present modelling challenges.

4p07 - Astronomical Potential of Satellite Star-Tracker Data

Pollock, Andy (University of Sheffield, Sheffield, GBR)

Spacecraft pointing systems employ star trackers that deliver rapidly-sampled photometry of a changing handful of relatively bright stars continuously over hours and sometimes days. While the Chandra X-ray Observatory pioneered the use of such data for astronomical purposes, data from other satellite projects remain obscure. Although operational and calibration issues still need to be considered, inspection of star-tracker measurements from the XMM-Newton X-ray Observatory reveals a remarkable treasure trove of stellar variability that constitute a unique astronomical resource including otherwise exceedingly rare simultaneous multi-frequency variability measurements.

4p08 - EM Cep - an Interesting Be Star

Kochiashvili, Nino (Abastumani Observatory, Ilia University, Adigeni, GEO)

On the basis of UBVR photometric data, obtained in the Abastumani Observatory during 1991-1999, a very interesting and unusual flare of the Be star EM Cep has been revealed - increasing of stellar brightness in R pass-band was observed together with the simultaneously decreasing of brightness in U band. Duration of the flare was over two hours. We estimated the percentage of brightness increase during the flare and brightness decrease of the corresponding anti flare and the minimum amount of the mass lost during this event. The different explanations for the nature of the star were investigated, from a binary companion to a pulsating star to a magnetic reconnection event. The present data point to the star being likely a single magnetic Be star, however to finally settle the question on the EM Cep nature, new observations are required.

4p09 - Old and New observational Data of P Cygni.

Beradze, Sopia (Abastumani Astrophysical Observatory, Ilia State University, Tbilisi, GEO); Vardosanidze, Manana (Ilia State University, Tbilisi, GEO)

We are going to present results of the old and new photometric observations of P Cygni. Old 1951-1983 years photometric observations were made by E. Kharadze and N. Magalashvili in the Abastumani Astrophysical Observatory, Georgia, which we found, recalculated and made conclusion that the star should undergone the next great eruption in some 100 years. New observations were obtained in 2014, 2017 and 2018 using the 48 cm Cassegrain telescope of the Abastumani Observatory. Some interesting behaviors of the light curves were revealed

4p10 - The first Ap star in an eclipsing binary system

Skarka, Marek (Department of Theoretical Physics and Astrophysics, Masaryk University, Brno, CZE)

Based on the photometric Kepler K2 data and original spectroscopic observations gathered with the 2m Perek Telescope in Ondrejov, Czech Republic, and other telescopes, we found that HD 99458 is a chemically peculiar star which is bound in a binary system. The secondary component is a low-mass red dwarf star that causes transit-like eclipses. As such, HD 99458 is the first eclipsing binary system known to contain an Ap star. In addition, the primary Ap component shows pulsations of delta Scuti type. We discuss the parameters of this unique system and the new observations confirming the Ap status of the primary component.

4p11 - Measuring Rotational Evolution With Space Photometry

Shultz, Matthew (University of Delaware, Newark, USA)

Magnetic braking predicts that hot magnetic stars should shed angular momentum throughout their lives, with the spindown rate increasing with surface magnetic field strength and spindown rate. This is borne out by the generally lower vsini of magnetic vs. non-magnetic hot stars, and by the longer rotation periods of magnetic O-type stars vs. magnetic B- and A-type stars. Rotational period change has been directly measured for 5 stars, only 2 of which are spinning down; the other 3 exhibit rotational acceleration. This suggests that the surface rotation of magnetic hot stars is not affected by magnetic braking alone. Magnetic AB stars almost universally exhibit strictly periodic photometric modulation arising from surface abundance inhomogeneities. The era of space photometry, combined with ground-based robotic survey telescopes, promises to greatly extend the number of magnetic hot stars for which we possess multi-decadal photometric datasets with high precision and high-cadence sampling. This makes it possible to measure the rotational evolution of a much larger fraction of magnetic hot stars. We present early results of our analyses of a selection of magnetic AB stars, and discuss the implications for our understanding of the rotational evolution of magnetic chemically peculiar stars, and what this might tell us about both specific stars, as well as the population in general.

4p12 - Varaible stars in the ASAS-SN and APOGEE surveys

Pawlak, Michal (Charles University in Prague, Praha 2, CZE)

I would like to present the results of a search for periodic variable stars among the targets observed by the Apache Point Observatory Galactic Evolution Experiment (APOGEE) using photometry from the All-Sky Automated Survey for Supernovae (ASAS-SN). The catalog consists of 1925 periodic variables selected from more than 258000 APOGEE targets. The sample is homogeneously classified into 430 eclipsing and ellipsoidal binaries, 140 classical pulsators (Cepheids, RR Lyrae and delta Scuti), 720 long period variables (pulsating red giants) and 635 rotational variables. The search was performed using both visual inspection and machine learning techniques. The light curves were also modeled with the damped random walk stochastic process. The median [Fe/H] of variable objects is lower by 0.3 dex than that of the whole APOGEE sample. The median of eclipsing binaries and ellipsoidal variables is shifted to the lower [Fe/H] by 0.2 dex. Eclipsing binaries and rotational variables exhibit significantly broader spectral lines than the rest of the sample.

4p13 - The strange case of HD 65987, a magnetic Bp star in the open cluster NGC 2516

Landstreet, John (Department of Physics & Astronomy, University of Western Ontario, London, Ontario, CAN); Neiner, Coralie (Observatoire de Paris, Meudon Cedex, FRA); David-Uraz, Alexandre (University of Delaware, Newark, USA); Kochekhov, Oleg (Uppsala University, Uppsala, SWE); Nelson, Patrick (University of Western Ontario, Ontario, CAN); Wade, Gregg (RMC, Kingston, CAN)

HD 65987 is a late B star in the open cluster NGC 2516 that has been variously classified as an eclipsing binary of Algol type, a member of a long period binary system, and a chemically peculiar star. The star has a magnetic field of a few hundred G that reverses sign. It is a light variable with a period of 1.45 d.

The magnetic field of HD 65987 was recently measured from seven new polarised spectra. The new data confirm the amplitude and reversal of sign foundin older data.

Light variability of this star was detected by TESS. Several groups have confirmed that the light of this star varies with a small amplitude and a period of 1.4 to 1.45 d, and that the variations are what would be expected for rotational variability of a magnetic Bp star.

However, when the magnetic observations are plotted on the period provided by photometry, the <Bz> data simply form a scatter plot. The magnetic observations do phase reasonably with a period of about 6.90 d (in much better accord with the small v sin i of about 20 km/s), or with the 1/day alias of this period at 1.15 d. Thus the magnetic and light variations appear to occur with different periods. Which is the rotation period of the star?

This poster will discuss possible solutions to the strange case of HD 65987.

4p14 - Multi-Instrument Analysis of Gaia, Kepler, ASAS-SN, and ASAS Observations for Long-Period Variables.

Hartig, Erich (University of Vienna, Astrophysics, Bromberg, AUT); Hinkle, Kenneth H. (National Optical Astronomy Observatories, Tucson, USA); Lebzelter, Thomas (University of Vienna, Department of Astrophysics, Vienna, AUT)

The Gaia Data Release 2 (**Gaia DR 2**) provided details about 550.737 stars based on 22 months of observations from 2014-07-25 to 2016-05-23, 151 761 of them are long-period variables (LPV) and published in Mowlavi et al. 2018 [4)]. The All-Sky LPV Catalogue from the All-Sky Automated Survey for Supernovae (**ASAS-SN**) V-band survey (Jayasinghe et al. 2018 [5)] analyzed ~421.000 variable stars of the VSX Catalog. **The *Kepler* K2 SFF** data provided high quality details but are restricted by the relatively short time span covered of roughly 90 days. The three data sets have been obtained with some overlap in time, and thus offer a direct comparison of the light curves obtained by the different missions/projects. We selected a set of LPVs from our own *Kepler* K2 program for this study. **ASAS** observations starting from 1997 were included to explore any long-time trends.

In this poster we discuss a selection of adjustment methods for the zero points of the various data sets and the problems encountered when looking for the most appropriate solution. We test the influence of the zero point settings on the calculated periods of the combined datasets, exploring also the case of multiple periods. First results for a few showcases are presented.

Ref.:
1) N. Mowlavi, I. Lecoeur-Taibi, T. Lebzelter, et al. Gaia Data Release 2: The first Gaia catalog of long-period variable candidates, A&A, Volume 618, id. A58, pp.
2) T. Jayasinghe, K. Z., Stanek, C. S., Kochanek, et al. 2018, All-sky LPV catalog from the All-Sky Automated Survey for Supernovae (ASAS_SN) survey, ArXiv e-print
3) E. Hartig, K. Hinkle, T. Lebzelter, 2017, *Kepler*-K2: A Search for Very Red Variables, Seismology of the Sun and the Distant Stars - TASC2 & KASC9 Workshop, EPJ Web of Conferences, Volume 160, id.01008
4) E. Hartig, J. Cash, K. Hinkle, T. Lebzelter, et al. 2014: *Kepler* and the Long Period Variables, AJ, 148, 6, 123, 15pp

4p15 - Superflares on GKM stars

Nogami, Daisaku (Kyoto University, Kyoto, JPN)

Flares have been observed on many kinds of stars, especially M-type stars, very young stars, RS CVn-type binaries, and, of course, the Sun. It was, however, recognized as quite difficult to detect flares in solar-type stars. The Kepler spacecraft changed this situation with its great performance and strategy including its quite high precision of photometry and long term monitoring. Since we published our first paper (Maehara et al. 2012, Nature 485, 478) of the discovery of superflares on solar-type stars, namely, flares with more than ten times larger energies (> 10^33 erg) than that of the largest solar flares, on the basisof the public data by the Kepler spacecraft, we have continued research on superflares in GKM stars from many kinds of viewpoints, such as statistics of superflares, stellar properties of superflare stars, starspots, mechanisms of superflares, influence on (exo)planets, and so on. This poster reviews the recent progress of our research.

4p16 - A new window into massive star variability: 2-min cadence TESS data

Labadie-Bartz, Jonathan (Universidade de São Paulo, São Paulo, BRA); Carciofi, Alex (Universidade de São Paulo, São Paulo, BRA)

We are using data from the TESS satellite to characterize the variability of massive stars, in particular the highly variable Be stars. To date a relatively small number of massive stars have been observed with space photometry, and the all-sky viewing strategy of TESS results in large numbers of OB stars being visited. Approximately 600 Be stars have been observed with 2-minute cadence in the Southern hemisphere, with another 700 to be observed in the Northern hemisphere. Analysis of these data reveal rapid variability on the timescale of 10s of minutes, and many events that are likely associated with mechanical mass ejection. The pulsational properties of this sample are studied at a precision that has not yet been possible. Over 99% of these systems are variable, some in ways that have never before been observed. To better characterize and understand this variability, we are observing selected targets in high resolution time-series spectroscopy simultaneously with TESS observations. Many years of archival ground-based observations for these targets give important context to the TESS photometry, allowing us to examine links between their pulsational properties (as determined with TESS) and behavior on much longer timescales. In this poster we present individual systems of interest and summarize our analysis of the first year of TESS data for the full sample.

4p17 - STEREO Observations of Be stars

Ozuyar, Dogus (Ankara University, Ankara, TUR); Balona, Luis (South African Astronomical Observatory, Cape Town, ZAF)

The classical Be stars are dwarf and giant B stars whose Balmer lines (particularly Hα) show, or have at some time, emission in the core of the line (Slettebak 1979;Porter & Rivinius 2003). Stars in which the emission is a result of binary interaction are excluded from the definition. The emission is thought to be a result of mass loss from the star which is greatly assisted by the rapid rotation. It is generally believed that non-radial pulsation (NRP) acts as the trigger for mass-loss outbursts which occur from time to time (Rivinius 2013). Because the additional velocity provided by NRP is relatively small, this mechanism requires the star to be rotating in excess of about 90 percent of the critical rotational velocity at the equator. However, it has been shown that the angular rotation rate relative to critical rotation is less than this value, which would not allow NRP to act as a trigger for mass-loss outbursts.

The evidence for NRP in Be stars comes mostly from ground-based spectroscopic observations in which the line profiles vary in a way which is characteristic of NRP. These variations, which are also visible in the light curve, have periods close to one day. This poses considerable difficulties in distinguishing between the true pulsation frequencies and their 1 d^{-1} aliases due to the inevitable daily gaps in ground-based data. Fortunately, photometry from space has provided virtually continuous data sets which have resolved this problem. The three Be stars in the Kepler field have been analyzed by Rivinius et al. (2016b). The photometric behavior of each star is very different and may be interpreted in different ways. More recently, the BRITE satellites have been an important source of space-based photometry for Be stars. These observations, however, are only continuous for 5 – 20 min during the orbital period of about 100 min. Furthermore, the light curves need to be corrected for the many instrumental signatures. BRITE observations for several well-known classical Be stars have been presented by Baade et al. (2016, 2018b) and Baade et al. (2018a).

A study of 48 Lib using STEREO data (Ozuyar et al. 2018) fails to show the coherent frequencies expected from NRP. Instead, the photometric behavior seems more simply understood as transient variations which could easily be interpreted as NRP if observed over a time interval of a few days. The overall light curve shape is, however, consistent with a rotating star in which an obscuration (spot) is present. From this point of view, the aim of this study is to present further observations of Be stars observed by the STEREO satellite which may assist in clarifying the physical processes in the photosphere of Be stars.

4p18 - Variability in Wolf-Rayet Stars

Lenoir-Craig, Guillaume (Université de Montréal, Montreal, CAN)

Wolf-Rayet stars are known to be very variable stars. BRITE photometry enabled us to have the longest continuous observations of multiple WR systems, on which Gabor, wavelet and gaussian analysis were performed to extract signals. Results will be presented. WR22's atmospheric eclipse modeling will also be presented.

4p19 - Simultaneous photometric and spectral analysis of the new outburst of V1686 Cyg

Andreasyan, Hasmik (Byurakan Astrophysical Observatory, Yerevan, ARM); Magakian, T.Yu. (Byurakan Observatory NAS Armenia, Byurakan, ARM); Movsessian, M.H. (Byurakan Observatory NAS Armenia, Byurakan, ARM); Gevorgyan, M.H. (Byurakan Observatory NAS Armenia, Byurakan, ARM)

We present an analysis of the optical observations of Herbig AeBe star V1686 Cyg, which is associated with a small isolated star-forming region around HAeBe star BD+40◦4124. V1686 Cyg demonstrating photometric variability up to 3 magnitudes. In this work we presented results of its photometric and spectroscopic observations in optical range. Observation of this star was a part of our project of young eruptive stars investigation. Observations were held on 2.6m telescope of Byurakan Observatory from 2015 to 2017. For this period we obtained its direct images as well as 14 medium- and low-resolution spectra. In the course of observations we noticed that this star underwent new outburst. After data reduction we found that full rise and decline of V1686 Cyg brightness for almost 3 magnitudes lasted about 2 months. We were able to trace the changes of the stellar spectrum during the outburst.

4p20 - Five new magnetic stars tipped from their Kepler photometry

<u>Romanyuk, Iosif (Special Astrophysical Observatory, Nizhny Arkhyz, RUS)</u>; Mikulasek, Zdenek (Masaryk University, Brno, CZE); Yakunin, Ilya (Special Astrophysical Observatory of RAS, Karachaevo-Cherkessia Repblik, RUS); Moiseeva, Anastasia (Special Astrophysical Observatory of RAS, Karachaevo-Cherkesia republik, AUT); Hummerich, Stefan (BAV, Berlin, GER); Janik, Jan (Masaryk University, Brno, CZE); Bernhardt, Klaus (BAV, Berlin, GER); Krticka, Jiri (Masaryk University, Brno, CZE); Paunzen, Ernst (Masaryk University, Brno, CZE); Zejda, Miloslav (Masaryk University, Brno, CZE); Prvak, Milan (Masaryk University, Brno, CZE)

Using a spectropolarimeter of the 6-meter SAO reflector in Russia, a global magnetic field was searched for several upper main sequence candidates suspected of being magnetic chemically peculiar stars. The selection of candidates was based mainly on preceding analyses of their ultra-precision Kepler data and spectrograms of various origins. Five of these candidates, namely: KIC 4180396, KIC 5264818, KIC 5473826, KIC 6065699, and KIC 8324268, have been proved to have a strong magnetic field by our prediction. Research continues.

4p21 - NUV Variability in the Kepler Field

<u>Bertone, Emanuele (INAOE, San Andres Cholula, MEX)</u>; Sachkov, Mikhail (Russian Academy of Sciences, Moscow, RUS); Olmedo, Daniel (INAOE, Tonantzintla, MEX); Olmedo, Manuel (INAOE, Tonantzintla, MEX); Chavez, Miguel (INAOE, Tonantzintla, MEX)

We present a large database of space near-UV light curves of point-like sources in the Kepler field. The Multi-visit GALEX-CAUSE-Kepler (MGCK) catalog includes almost 400,000 sources, with a mean number of visits of 17 and a limiting AB magnitude of NUV~21.5. The observations of the whole Kepler field, possibly the most studied field for variable stars, were carried out by the UV space telescope GALEX during 46 days in August-September 2012, overlapping with Quarter 14 of the Kepler telescope program. About 60% of the objects in the MGCK database are in the Kepler Input Catalog and more than 100,000 form a sample of stellar Kepler targets. The MGCK database represents an important tool for multiwavelength studies of variable stars and will be publicly available.

5. MODELLING

5k01 - Stellar convection and pulsation mode physics

Houdek, Günter (Department of Physics and Astronomy - Aarhus University, Aarhus, DNK)

The NASA spacecraft Kepler provided asteroseismic data of unprecedented quality of several types of star. Additional to the oscillation frequencies, information of pulsation linewidths and amplitudes were collected, which allow the study of the still ill-understood surface physics of stars. Understanding better the surface layers of stars improves the diagnostic potential of asteroseismic data, including measurements from future space missions such as the planned ESA mission PLATO. In this presentation I shall provide an overview of our current understanding of modelling the energy exchange between stellar convection and oscillations in stars supporting solar-type oscillations. Stellar calculations, adopting a 1D time-dependent convection model and calibrated with 3D simulation results, are tested against data of Kepler main-sequence stars, thereby providing insight into the physical processes that determine pulsation damping rates and contribute to the so-called surface effects of pulsation frequencies.

5k02 - 3D Hydrodynamical Simulations of Stellar Convection for Helio- and Asteroseismology

Kupka, Friedrich (MPI for Solar System Research, Göttingen, GER)

Hydrodynamical simulations of stellar convection are an essential theoretical tool to gain insight into the physics of mixing and heat transport by convection as well as into the interaction of convection with pulsation. They are particularly useful for an accurate description of the structure of the superadiabatic layer which is important to explain the observed frequencies of p-modes in solar-like oscillating stars. The simulations can also be used to probe analytical models of excitation and damping of modes and thus explain their amplitudes and in the end the physical completeness of such models. In this presentation I discuss general challenges of such 3D hydrodynamical simulations developed for helio- and asteroseismology and summarize some recent results in this field for the Sun and other stars of the lower main sequence.

5k03 - Low-mass stars: where observations and theoretical modeling don't agree

Thoul, Anne (FNRS, University of Liège, 4000, BEL)

I will review some of the open questions in the structure and evolution of low mass stars, emphasizing where observations and theoretical modeling don't agree. I will in particular review the importance of element diffusion in the evolution and surface abundances of low-mass stars. I will talk about the importance of the position of the convective boundaries (proper positioning of the boundaries, overshooting, semiconvection,...) during the main sequence and core helium burning stages of evolution. I will also briefly present the problems encountered on the Red Giant Branch (role of thermohaline mixing, location of the bump).

5k04 - Challenges to modelling from groundbreaking new data of present/future space and ground facilities

Clementini, Gisella (INAF Osservatorio di Astrofisica e Scienza dello Spazio, Bologna, ITA)

Cepheids and RR Lyrae stars are powerful tools to measure distances and trace different stellar generations in galaxies. Their pulsation characteristics can be determined with great precision, are unaffected by distance and reddening, and are directly linked to intrinsic parameters such as stellar mass, effective temperature and chemical composition, thus allowing these quantities to be inferred directly from pulsation. The Cepheid period-luminosity (PL) relation, along with optical luminosity-metallicity and infrared PL-(metallicity) relation of RR Lyrae stars are at the basis of their use as stellar standard candles. I will focus on the challenges posed to stellar evolution and pulsation models by the huge amount of high-accuracy data (multi-band photometry, spectroscopy, astrometry) and seismic information for Cepheids and RR Lyrae stars, that past, on-going and future space missions like Kepler, Gaia (and its possible extension to the infrared: GaiaNIR), PLATO, TESS, JWHT and ground-based facilities like MOONS, WEAVE and the LSST are to provide within the next decade.

5k05 - Open problems in high-mass stellar evolution

Ekström, Sylvia (University of Geneva, Versoix, CHE); Georgy, Cyril (Department of astronomy, Geneva University, Versoix, CHE); Meynet, Georges (Department of astronomy, Geneva University, Versoix, CHE); Hirschi, Raphael (Astrophysics Group, Keele University, Keele, GBR); Groh, José (School of Physics, Trinity College Dublin, Dublin)

Massive stars can roughly be divided into two categories: the one that will become RSG at (or shortly before) the end of their life, and those that will become WR stars. RSG stars are dominated by convection, and experience a very strong mass loss; WR stars also undergo a strong mass loss, though through another process than RSGs. Both convection and mass loss doesn't arise naturally in 1D stellar evolution code, so we rely on prescriptions. On top of that, most massive stars live in multiple systems, which increases even more the complexity of the picture. I will review the current status of massive star modeling, the problems we meet and some solutions that could come, either from 3D modeling, or from surveys

5k06 - Stellar magnetic fields: internal magnetic fields

Fuller, Jim (California Institute of Technology, Pasadena, USA)

Very little is known about magnetic fields in stellar interiors, and how these fields coevolve with their stars. Theoretically, magnetic fields are expected to be common in stellar interiors, but observational constraints on such fields are difficult to obtain. Fortunately, asteroseismology of red giant stars allows us to constrian the magnetic field strength in their radiative cores. Similar constraints may also be achieved for various types of gravity mode pulsators. I will review these observational constraints and discuss their implications for internal magnetic evolution of stars. discuss the impact of internal magnetic fields on the rotational evolution of stars, and their possible relationship with magnetic fields in compact objects.

5k07 - Search for quiet stellar-mass black holes by asteroseismology from space

Shibahashi, Hiromoto (Univesity of Tokyo, Tokyo, JPN)

Stellar evolution theory tells us that stars with the initial mass more than ~ 30 solar masses become ultimately black holes, and then the stellar-mass black holes should be ubiquitous. Nevertheless, only around 20 stellar-mass black holes have been found to date, and they have all been found through their X-ray emission and high energy physics, as either High Mass X-Ray Binaries (HMXB) whose optical counterparts are early type stars which are blowing gas to black holes emitting X-rays, or soft X-ray transients among Low Mass X-Ray Binaries (LMXB) whose optical counterparts are late type stars filling the Roche lobes to overflow to black holes. On the other hand, it is natural to expect stellar-mass quiet black holes without X-ray emission in binary systems with large separation. The discovery of black holes in the optical through their gravitational interactions would be a major scientific breakthrough. Recent space-based photometry has made it possible to measure the orbital phase variation or the frequency modulation of pulsating stars in binary systems with extremely high precision over long time spans. The lower limit for the mass of the binary companion is obtained by analysis of phase variation or frequency modulation of the pulsating star. If the companions are non-luminous and if the masses of the companions exceed the mass limit for neutron stars (~ 3 solar masses), the companions should be black holes. We review the methodology, and analyses of some encouraging cases are demonstrated.

5o01 - Accretion Simulations of Eta Carinae and Implications to Evolution of Massive Binaries

Kashi, Amit (Ariel University, Ariel, ISR)

Mass loss and mass accretion in the context of stellar evolution of massive stars is a subject that did not get enough attention and its implications to the fate of stars are not yet recognized and not yet incorporated in stellar evolution codes. We present high resolution numerical simulations of the colliding wind system Eta Carinae, showing accretion onto the secondary star close to periastron passage. This question was unanswered for more than a decade and our new high resolutin simulations were able to finally provide an answer.We find that the smooth stellar winds collide and develop instabilities, mainly the non-linear thin shell instability, and form filaments and clumps. We find that a few days before periastron passage the dense filaments and clumps flow towards the secondary as a result of its gravitational attraction, and reach the zone where we inject the secondary wind. We run our simulations for the conventional stellar masses, M1=120 Msun and M2=30 Msun, and for a high mass model, M1=170 Msun and M2=80 Msun, that was proposed to better fit the history of giant eruptions in the nineteenth century. As expected, the simulations results show that the accretion processes is more pronounced for a more massive secondary star. We obtain orbital parameters of the binary system from the simulation results, and learn about the recovery of Eta Carinae from its giant eruptions. As accretion occurs now, it surely occurred during the giant eruptions. This leads us to the conclusion that the presence of a binary companions can have a huge influence on the evolution of massive star, especially at later stages where it may undergo giant episodes of mass loss and mass transfer.

5o02 - From the Sun to solar-like stars: how does the solar modelling problem affect our studies of solar-like oscillators?

Buldgen, Gaël (Observatoire de Genève, Versoix, CHE)

Since the first observations of solar oscillations in 1962, helioseismology has probably beenone of the most successful fields of astrophysics. Data of unprecedented quality were obtainedthrough the implementation of networks of ground-based observatories such as the GONG projector the BiSON network, coupled with space-based telescopes such as SOHO, Solar Orbiter andSDO missions. Besides the improvement of observational data, solar seismologists developedsophisticated techniques to infer the internal structure of the Sun.Back in 1990s these comparisons showed a very high agreement between solar models and the Sun. However, the downward revision of the CNO surface abundances in the Sun in 2005, confirmed in 2009, induced a drastic reduction of this agreement leading to the so-called solarmodelling problem. More than ten years later, in the era of the space-based photometry missionswhich have established asteroseismology of solar-like stars as a standard approach to obtaintheir masses, radii and ages, the solar modelling problem still awaits a solution. In this talk, I will briefly present the results of new helioseismic

inversions, discuss the current uncertainties of solar models and possible solutions to the solar modelling problem. I will also discusshow the solar problem can have significant implications for asteroseismology as a whole by discussing the modelling of the 16Cyg binary system and the exoplanet-host star Kepler-444, thus impacting the fields requiring precise and accurate knowledge of stellar masses, radii and ages, such as Galactic archaeology and exoplanetology.

5o03 - Asteroseismic Binaries as non-Solar Mixing Length Calibrators

Joyce, Meridith (Australian National University, Weston Creek, AUS)

Asteroseismic binaries, especially those systems comprising solar analogs, are ideal laboratories in which to test our stellar modeling formalisms. One such formalism under recent scrutiny is the ad hoc adoption of a solar-calibrated value of the one-dimensional convective mixing length parameter, α_{MLT}, in models of highly non-solar stars.

The recent work of Joyce and Chaboyer has demonstrated that the assumption of solar-calibrated α_{MLT} no longer constitutes a reliable method in 1-D stellar evolution modeling. This calls into question the use of current stellar evolution databases, all of which assume solar-calibrated mixing lengths in their isochrones.

These calibrations, however, require tight constraints and thus rely on high precision observations in many arenas: classical brightness measurements, interferometry, spectroscopy, and asteroseismology.

In light of unprecedented observational scope and precision---thanks to Gaia, TESS, and stable, high resolution spectroscopy---the number of candidates for non-solar calibration is increasing.

Among recent, successful candidates for empirical mixing length calibrations are metal-poor subgiant HD 140283 and Alpha Centauri A and B. In this talk, I will discuss the methods used to perform these calibrations, the necessary observational constraints, and the feasibility of extending this analysis to future TESS targets and known, doubly oscillating or eclipsing binary systems such as 16 Cyg, Procyon, HD 176465, KIC 8410637, KIC 5640750, and KIC 9540226.

An understanding of the relationships between α_{MLT} and other fundamental stellar parameters, grounded by direct observational data, will contribute to the development of more sophisticated stellar tracks and isochrones. Such science is necessary to maintain the utility of 1-D stellar structure and evolution models in the current observational landscape.

5o04 - Unbiased seismic model fitting

Kallinger, Thomas (Institut für Astrophysik, AUT)

Seismic model fitting, i.e. the search for a match between some observed and model frequencies in order to identify a representative stellar model, is an important piece in the big puzzle of stellar astrophysics. It allows us to determine otherwise unknown stellar properties, to evaluate our stellar models, and even to test the underlying physics itself. However, there are know deficiencies in the stellar models that cause unpredictable shifts of the model frequencies and therefore hamper a direct comparison with the observations. This so-called surface effect is commonly treated by corrections calibrated to the Sun. Even though it is meanwhile expected that this might be insufficient, especially for stars very different from the Sun, it is still widely in use. In this talk, I present a new approach that uses probabilistic methods to marginalise the influence of the surface effect and therefore allows for an unbiased search for a best-fit model by using only the observed frequencies. The approach was tested with Kepler data of red giants in eclipsing binary systems and more than 50 members of two open clusters in the Kepler field. It thereby gives accurate results that are consistent with independent measurements. As a byproduct the method returns the actual model frequency shifts, which are quite different from what is presently expected. This at least questions many results based on commonly used surface effect corrections.

5o05 - The relevance of partial ionization in the outer layers of F-stars

Brito, Ana (CENTRA- center for astrophysics and gravitation, Lisbon)

The present-day quality of asteroseismic data allows us to probe the complex outer layers of sun-like stars. F-stars are particularly interesting given their diversity of magnetic and rotational behaviors. Using a seismic diagnostic based on the phase shift of the acoustic waves, we found a trend, in the form of a power-law dependence, that correlates the ionization processes occurring in these external layers with the rotation period of the stars.
Additionally, we have studied the internal structure of the outer layers of 10 main-sequence F-stars, and we found that the rotational characteristics of these stars can be distinguished by the relative location of the partial ionization region of heavy elements and the base of the convective zone. Since the region near the base of the convective zone (the tachocline) is know to have strong influence in the expected dynamo-driven mechanism, these results might be important to better and further understand the relations between magnetism and rotation in these stars.

5o06 - KIC 11971405 - the SPB star with the four asymptotic sequences of g modes

Szewczuk, Wojciech (Astronomical Institute of the Wroclaw University, Wroclaw, POL); Walczak, Przemyslaw (Astronomical Institute of the Wroclaw University, Wroclaw, POL); Daszynska-Daszkiewicz, Jadwiga (Astronomical Institute of the Wroclaw University, Wroclaw, POL)

KIC 11971405 is the fast rotating B-type pulsator that was observed by the Kepler satellite. Papics et al. (2017) found three quasi-equidistant in period sequences of g modes. Our previous modelling showed that the two sequences can be associated with prograde sectoral dipole and quadrupole modes, whereas the third sequence is most probably accidental. Recently, we re-analysed Kepler observations and found two more independent sequences. Our seismic modelling implies that these new sequences are associated with prograde sectoral g modes of $\ell=3$ and 4. Fitting the four g-mode sequences simultaneously gives a unique opportunity to obtain stringent constraints on the internal rotation and internal processes described by the free parameters, e.g., convective overshooting and rotation-induced mixing. This is the main goal of our seismic modelling and we present what information we were able to extract.

5o07 - An entropy-based calibration of the mixing-length parameter using 3D numerical simuations of convection

Spada, Federico (Max-Planck-Institut fuer Sonnensystemforschung, Goettingen, GER)

Solar-like stars (M < 1.5 Msun) have convective envelopes which significantly affect their overall structure and global parameters. Their radii, in particular, are sensitive to the details of the inefficient convective regime that is realized in their outermost layers. The standard treatment of convection in stellar evolution models, based on the mixing-length theory (MLT), provides only a very approximate description of the inefficient convective regime. Moreover, it contains a free parameter whose standard calibration, based on the Sun, is routinely applied to other stars, thus ignoring their different surface conditions (e.g., effective temperature, gravity, chemical composition) and previous evolutionary history. We present an alternative calibration of the MLT parameter that is based on 3D radiation hydro-dynamics (RHD) simulations of convection. In this approach, the value of the MLT parameter is adjusted to match the specific entropy in the deep, adiabatic layers of the convective envelope obtained from the 3D RHD simulations. When applied to the Sun, this method yields a present-day solar model that matches the available empirical constraints. This entropy-calibrated solar model, however, predicts a different evolution of the radius, effective temperature, and depth of the convection zone with respect to the standard solar models, leading, for instance, to enhanced light elements depletion during the pre-main sequence. The implications of these results for other solar-like stars, and further testing and refinement of the entropy-calibration against well-characterized stars (e.g., the alpha Centauri system) will be discussed.

5o08 - The slowly pulsating B-star 18 Peg: A testbed for upper main sequence stellar evolution

Irrgang, Andreas (Dr. Karl Remeis-Observatory, Bamberg, GER); De Cat, Peter (Royal Observatory Belgium, Brussels, BEL); Pigulski, Andrzej (Instytut Astronomiczny, Uniwersytet Wroclawski, Wroclaw, POL); Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warszawa, POL); Tkachenko, Andrew (Institute of Astronomy, KU Leuven, Leuven, BEL); the BRITE team (AUT)

The predicted width of the upper main sequence in stellar evolution models depends on the empirical calibration of the convective overshooting parameter. Despite decades of discussions, its precise value is still unknown and further observational constraints are required to gauge it. In 2016 (A&A, 591, L6), we discovered that the mid B-type giant 18 Peg is one of the most evolved members of the rare class of slowly pulsating B-stars and, thus, bears tremendous potential to derive a tight lower limit for the width of the upper main sequence. In this contribution, we report on our photometric and spectroscopic analyses of follow-up observations obtained with the BRITE-Heweliusz satellite as well as with the HERMES spectrograph (covering 46 epochs to determine atmospheric parameters and to study the line-profile variations), which led to significantly improved results about the star's nature and its potential as a benchmark object for stellar evolution theory.

5o09 - Determination of precise stellar parameters of Kepler LEGACY targets using the WhoSGlAd method

Farnir, Martin (Université de Liège, Liège, BEL); Dupret, Marc-Antoine (Université de Liège, 4000, BEL); Salmon, Sébastien (Université de Liège, 4000, BEL); Noels, Arlette (Université de Liège, 4000, BEL); Buldgen, Gaël (Université de Genève, Genf, CHE); Reese, Daniel (Observatoire de Paris, Meudon, FRA)

The increasing number of spaceborne missions provides us with a wealth of exquisite data. Such data combined we the new techniques that are developed then provide us with a deeper understanding of stellar structure and evolution but also shed light on the uncertainties of the current stellar models (e.g. angular momentum transport mechanisms, extent of mixed regions, chemical composition,...). Asteroseimology is one of those techniques. It links stellar pulsation frequencies to the stellar structure and allows the probing of stellar interiors. In particular, the observation of acoustic glitches, which consist in oscillating features in spectra and are caused by sharp variations of the stellar structure, provides very stringent information. Namely, they inform us on the localisation of the transition between a radiative and a convective region or the envelope helium abundance. Thus, the analysis of the glitches signal allows us to provide constraints on several model uncertainties.

We present here a new method to analyse the oscillation spectra of solar-like pulsators as a whole, i.e. both the acoustic glitches and the slowly varying trend (smooth component) are treated simultaneously. The method, WhoSGlAd (Farnir et al. 2019), takes advantage of linear algebra to compute seismic indicators that are as uncorrelated as possible. Namely, the glitches indicators are completely independent of those of the smooth component. Moreover, the indicators we build are more precise than the 'usual' ones which are defined as a function of the radial order. Therefore, it allows to put more stringent constraints on the stellar structure. As an example, we may retrieve an estimation of the surface helium abundance (inaccessible by other means) or obtain constrains on the necessary amount of core overshooting to reproduce observations. Those are more accurate than what we may derive from 'classical' means. Such precise measurements are necessary to lift model uncertainties (such as the mass – helium degeneracy observed by Lebreton & Goupil 2014). After showing the advantages and necessity of the method, we will present the application of the method to most stars of the Kepler LEGACY sample (Lund et al. 2017) via the use of the AIMS algorithm. This will enable us to draw trends in the surface helium abundance as well as necessary amount of core overshooting for solar-like pulsators.

5o10 - Improving stellar evolution models with atomic diffusion from asteroseismology of intermediate-mass stars

Mombarg, Joey (Institute of Astronomy, Leuven, BEL); Dotter, Aaron (Harvard-Smithsonian Center for Astrophysics, Boston, USA); Thoul, Anne (FNRS, University of Liège, 4000, BEL); Aerts, Conny (Institute of Astronomy, Leuven, BEL)

One of the biggest enigmas of stellar evolution concerns the transport of chemical elements. As this process is already ill-constrained during the core-hydrogen burning phase, the uncertainties that are introduced propagate into models of more evolved stars. The current state-of-the-art models are not able to predict the observed oscillation frequencies in intermediate-mass stars with their uncertainties. In this talk, we discuss the effect of atomic diffusion (including radiative levitation) on the frequencies of gravity modes and its implications for forward seismic modelling of intermediate-mass stars. Our results show significant differences in frequencies when including atomic diffusion, resulting in different derived masses, ages and metallicities. We will present our findings of our improved forward modelling scheme applied to a slowly rotating pulsator.

5o11 - Interactions of waves with convection

Schou, Jesper (Max Planck Institute for Solar System Research, Göttingen, GER); Birch, Aaron (Max Planck Institute for Solar System Research, Göttingen, GER)

Some of the most significant problems with our understanding of solar and stellar oscillations appear to be related to interactions with the convection. One problem is the
so-called surface term, another is the center-to-limb effect seen in helioseismic measurements. Here we will briefly describe these problems.
We will then show results of analyzing waves in large-scale hydrocode simulations. We show that the eigenfunctions are well described by the classic differential equations away from the near-surface layers. Near the surface significant deviations are present, we show how these can be analyzed in a simple theoretical framework and how several of them relate to known physical effects.

5o12 - Is it time to retire the Sun as the reference star for determining red giant stellar parameters

Themeßl, Nathalie (Max Planck Institute for Solar System Research, Göttingen, GER)

Red giants showing solar-like oscillations in open clusters and eclipsing binary systems are key objects for testing the asteroseismic scaling relations. Through asteroseismology we can derive their mean densities, surface gravities, masses, and radii. At the same time these parameters can be independently determined from orbital analyses (in the case of binaries) or stellar isochrones (clusters). We analyze three red-giant stars in eclipsing binary systems and about 60 red giants in two open clusters that were observed by the *Kepler* mission. When using an empirically derived Delta-v reference value we are able to obtain asteroseismic mass and radius estimates that are in agreement with the independent results from binary analyses and cluster isochrones. We also discuss which parameters (e.g. metallicity, mass loss, ...) affect these empirical values.

5o13 - Can gravity modes unravel near-core mixing profiles inside stars?

Michielsen, Mathias (KU Leuven, Leuven, BEL); Pedersen, May Gade (KU Leuven, Leuven, BEL); Augustson, Kyle (CEA, Gif-sur-Yvette Cedex, FRA); Mathis, Stéphane (CEA, Gif-sur-Yvette Cedex, FRA); Aerts, Conny (KU Leuven, Leuven, BEL)

The mass of the He core at the end of the main sequence is a key quantity in determining the later stages of evolution. Asteroseismology based on gravity modes allows to calibrate this core mass, since these modes are sensitive to the near-core region. These waves hence allows us to probe the convective core properties and the core-boundary layer of massive stars, whose properties depend on the unknown near-core mixing. We compare the predicted gravity-mode frequencies of stellar models with different mixing profiles and thermal structures in the near-core region. Furthermore, we assess if gravity modes observed with the Kepler space mission are capable to distinguish between these descriptions of near-core mixing.

5o14 - The rotation profile of gamma Dor stars: inference from Rossby modes
Christophe, Steven (Observatoire de Paris, Meudon Cedex, FRA)

Thanks to the unprecedented quality and long baseline of Kepler photometry, it is now possible to measure the near-core rotation rates of gamma Dor stars from their gravity-mode pulsations. A first comparison of these measurements with stellar models including rotationnally induced angular momentum (AM) transport indicates that, as for red giant stars, a missing transport mechanism is extracting AM from the core of these stars.

Recently highlighted in moderate to fast rotating gamma Dors, Rossby modes potentially bring new constraints on the rotation profile of these stars and so, on the missing AM transport process. We studied the probing power of Rossby modes on rotation and how it differs from that of gravito-inertial modes. To this end, we relate complete calculations of low frequency oscillation modes in gamma Dor models with stars observed by Kepler. We report on a variety of situations with some stars exhibiting signature of differential rotation while others do not.

5o15 - A Novel Modeling of Magneto-Rotating Stellar Evolution
Takahashi, Koh (Albert-Einstein-Institut, Potsdam, GER)

About 10% of massive and intermediate-mass main-sequence stars posses strong surface magnetic fields, and the magnetic massive stars may be progenitors of strongly magnetized neutron stars known as magnetors. However, the evolution of magnetic fields in stellar interiors remains a big open question for the stellar evolution theory. We are developing a new stellar evolution code which is capable to follow a long-timescale evolution of stellar magnetism. Because of the far different timescales between the MHD and the evolutionary times, high degree of simplification in the modeling is inevitable. First, we assume that the configuration of the stellar magnetic field can be approximated by axially symmetric toroidal + poloidal components, which explicitly has only a radial dependence. Then the evolution of the two component magnetic field is described by the mean-field dynamo equation. The new formalism self-consistently includes the effects of omega-dynamo, which results from large scale shear in the rotation flow, magnetic dissipation, and angular momentum transfer due to magnetic stress. We will present our preliminary results and discuss how the model can be verified by observations.

5p01 - New fully evolutionary models for asteroseismology of ultra-massive white dwarf stars
Córsico, Alejandro Hugo (University of La Plata, La Plata, ARG)

Ultra-massive hydrogen-rich (DA spectral type) white dwarf (WD) stars (M_{WD} > 1 M_{sun}) are expected to harbour oxygen and neon cores resulting from semi-degenerate carbon burning when the progenitor star evolves through the super asymptotic giant branch (SAGB) phase. These stars are expected to be crystallised by the time they reach the ZZ Ceti instability strip. Theoretical models predict that crystallisation leads to a phase separation of oxygen and neon in the core of ultra-massive WDs, which substantially impacts their pulsational properties, in particular, the period spacing. This property offers a unique opportunity to study the processes of crystallisation and to infer the core chemical composition in WD stars. In this work, we present a new grid of stellar models representative of ultra-massive DA WDs with a range of thicknesses of the H envelope. This grid of models is suited for asteroseismological studies of ultra-massive ZZ Ceti stars observed from the ground and also from space missions like Kepler and TESS. We present preliminary results of astroseismic determinations for several known ultra-massive ZZ Ceti stars.

5p02 - 2D modelling of Altair
Bouchaud, Kevin (LESIA, Paris observatory, MEUDON, FRA)

Fast rotation in stars is responsible for important changes in their overall structure, their evolution, and the way we see them. New two-dimensional models have made it possible to obtain a better representation of the effects of rotation on stars (differential rotation, meridional flows of matter and momentum, etc.), which enables an improved comprehension of recent, increasingly accurate observations from the latest facilities. The goal of my work is to determine the physical parameters of fast rotators, such as mass, flattening (which requires both the polar and equatorial radii), metallicity, and evolutionary stage. For that I will describe our method for comparing 2D ESTER models, coupled with PHOENIX model atmospheres, with both interferometric data (which allow us to study the visible effects rotation has on the stellar surface, namely gravity darkening and flattening) and spectroscopic data. I will specify the strategy used to determine each parameter (using different runs of an MCMC method for model-fitting), and the results obtained for Altair, our test star.

5p03 - Shallow water MHD waves in dynamo layers of solar-type stars
Zaqarashvili, Teimuraz (Ilia State University, Tbilisi, GEO)

Magnetic activity and variations of solar-type stars are governed by dynamo layers below or inside convection zone. This layer is supposed to be much shorter compared to the stellar radius, therefore shallow water approximation is valid for large-scale dynamics. We present recent analysis of shallow water magnetohydrodynamic waves in solar dynamo layer (called as tachocline) and their possible connection with observed variations of solar magnetic activity. Results could be generalised for solar-type stars with different rotation periods i. e. at different stages of evolution. Connection of theoretical oscillation spectrum with expected observational periods in stellar magnetic activity is discussed.

5p04 - Determining the size of helium cores for two red giant stars by asteroseismic analysis of the individual mixed modes

zhang, xinyi (Yunnan Observatories, Chinese Academy of Sciences, Kunming, CHN); Li, Yan (Yunnan Observatories, Chinese Academy of Sciences, Kunming, CHN)

In red giant stage, $l = 1$ modes are all mixed modes which carry the information of both center core and envelope. It is not easy to fit the individual mixed modes with $l = 1$ well in the previous work. We introduce a new method--frequency identification to fit the individual mixed modes and derive the precise size of the helium core. Our main method is to divide the observed frequencies with $l = 1$ modes in a large frequency separation into the most p-dominated mixed mode and g-dominated mixed modes. Then, the calculated mixed mode with the minimal mode inertia is matched with the observed mode of the most p-dominated. According to this way, the helium cores of two red giant stars KIC 9145955 and KIC 9970396 are determined to be $M_{\rm He}$ = 0.210 $\pm$ 0.002 $M_{\odot}$, $R_{\rm He}$ = 0.0307 $\pm$ 0.0002 $R_{\odot}$ and $M_{\rm He}$ = 0.229$\pm$ 0.001 $M_{\odot}$, $R_{\rm He}$ = 0.0300 $\pm$ 0.0002 $R_{\odot}$. We also present two specific methods to do the process of frequency identification: period \'{e}chelle diagram and surface effect offsets of $l = 0$ and $l = 2$ modes.

5p05 - Low-Z solar models with overshoot, accretion and mass loss consistent with helioseismic inferences

Zhang, Qian-Sheng (Yunnan Observatories, Chinese Academy of Sciences, Kunming, CHN); Li, Yan (Yunnan Observatories, Chinese Academy of Sciences, Kunming, CHN); Christensen-Dalsgaard, Joergen (Stellar Astrophysics Centre and Department of Physics and Astronomy, Aarhus University, Aarhus, DNK)

Helioseismic observations have revealed many properties of the Sun: the depth and the helium abundance of the convection zone, the sound-speed and the density profiles in the solar interior. Those restrictions have been used to judge the stellar evolution theory. With the old solar composition (e.g., GS98), the solar standard model is in reasonable agreement with the helioseismic constraints. However, a solar model with revised composition (e.g., AGSS09) with low abundance Z of heavy elements cannot be consistent with those restrictions. This is the so-called ``solar abundance problem", standing for more than ten years even with the recent upward revised Ne abundance. Many mechanisms have been proposed to mitigate the problem. However, there is still not a low-Z solar model satisfying all helioseismic restrictions. Here we report a possible solution to the solar abundance problem. With some extra physical processes that are not included in the standard model, solar models can be significantly improved. Our new solar models with convective overshoot, the solar wind, and an early mass accretion show consistency with helioseismic restrictions, the solar Li abundance, and observations of solar neutrino fluxes.</< SPAN>

5p06 - The Age of Zero Age Main Sequence Stars as an Analytic Function of Mass

Steindl, Thomas (University Innsbruck, Insbruck, AUT); Zwintz, Konstanze (Universität Innsbruck, Institut für Astro- und Teilchenphysik, Innsbruck, AUT)

We present an analytic function for the zero age main sequence (ZAMS) age of stars in the range 0.5 to 6 solar masses. This fitted function relies on a new definition of the ZAMS, where we use the hydrogen abundance troughout the star to determine the most probable ZAMS model for the MESA evolution of pre-main sequence stars. The corresponding ages are then fitted with a piecewise power law function.

5p07 - Study of convection in one and multi-dimensional pulsating models

Kovács, Gábor (Konkoly Observatory, Budapest, HUN); Szabó, Róbert (Konkoly Observatory, Budapest, HUN); Nuspl, János (Konkoly Observatory, Budapest, HUN)

The modeling of classical pulsators has a long history, but it still struggles with challenges even at present days. The handling of convection is one of these open questions in numeric models. Because the convection is a genuine multi-dimensional phenomenon, hence the one-dimensional simulations can only approximately and inadequately describe its complexity and effects. Here we investigate the accuracy of these approximations by the multi-dimensional code SPHERLS.

5p08 - convective overshooting in low-mass stars

guo, fei (Yunnan Observatories, Chinese Academy of Sciences, kunming, CHN)

The mixing of convective overshooting is very uncertain in low-mass stars.

To calculate the convective regions and the overshooting regions of the low-mass stars,
we use the k-$\omega model, which is proposed by Li. It contains not only convective region but also overshooting region. We

can get the distance of the overshooting region for the mass range of 1.0$M_{\odot}$-1.8$M_{\odot}$ stars using the k-$\omega model. We also find that the semi-convection in low-mass stars can be removed using the k-$\omega model . Furthermore, we calibrate the $f_{\rm ov}$, which is a parameter for classical overshooting, using the k-$\omega model. We get a result that the suitable value of the $f_{\rm ov}$ is about 0.008 for the mass range of 1.0$M_{\odot}$-1.8$M_{\odot}$ stars .

5p09 - Probing of stellar deep mixing with Kepler photometry

Khodachenko, Maxim (Space Research Institute, Austrian Academy of Sciences, Graz, AUT); Arkhypov, Oleksyi (Space Research Institute, Austrian Academy of Sciences, Graz, AUT); Johnstone, Colin (Institute of Astronomy, University of Vienna, Vienna, AUT); Guedel, Manuel (Institute of Astronomy, University of Vienna, Vienna, AUT); Lueftinger, Theresa (Institute of Astronomy, University of Vienna, Vienna, AUT)

The current knowledge on plasma convective mixing in stellar interiors is based on theoretical modelling, which calibrates the empirical relations between the mixing and observable stellar parameters. A model-independent approach to study the mixing process is still a challenge. Application of a dedicated spectral-correlation analysis algorithms to the light curves of ~2000 main sequence stars with periods $0.5 < P < 30$ days and effective temperatures $3227 \le T \le 7171$ K, observed by Kepler mission revealed that the pattern of stellar surface activity, manifested in the light curves, can be used as a “display” of internal motions, which are still inaccessible to asteroseismology methods. In particular, the clear manifestations of global-scale turbulence, associated with deepest convective layers, were found in the power spectra of rotational variability of spotted stars. The timescales τ1 and τ2 of the stochastic change in the spectral power of stellar rotational variability were measured for the first and second rotational harmonics. Both, the spectral power amplitudes and the timescales τ1 and τ2 of the rotational variability harmonics’ demonstrate features, typical for the Kolmogorov’s turbulence dependencies on the size of turbulent eddies (i.e. harmonic number). It has been also shown that the timescale of deep mixing, known as the turnover time in the standard mixing length theory, can be obtained by the extension of the measured timescales of the first and second harmonics of the turbulent cascade to the scale of laminar convection. This connection opens the way to determine the model-independent turnover time, whereas the proximity between the turnover time of a standardized convection cell and its measured analogue, can be interpreted as an indirect detection of gigantic convection cells in stellar interiors, which are predicted in theory but not yet observed.

5p10 - Carbon and nitrogen abundances as probes of material mixing in stars

Tautvaisiene, Grazina (Vilnius University, Vilnius, LTU)

Carbon and its isotopes as well as nitrogen give a comprehensive information on thermohaline-, rotation-, or magnetically-induced material mixing during stellar evolution, especially for intermediate- and low-mass stars. I will present the ongoing work on CNO abundances in Galactic open cluster and field stars in the context of newest stellar evolution models and exo-planetary space missions.

5p11 - Stellar convection: Convective Penetration and Gravito-inertial wave excitation

Augustson, Kyle (CEA Paris-Saclay DRF/IRFU/DAp, Gif-sur-Yvette Cedex, FRA)

A monomodal model for stellar and planetary convection is derived for the magnitude of the rms velocity, degree of superadiabaticity, and characteristic length scale as a function of rotation rate as well as with thermal and viscous diffusivities. The convection model is used as a boundary condition for a linearization of the equations of motion in the transition region between convectively unstable and stably-stratified regions, yielding the depth to which convection penetrates into the stable region and establishing a relationship between that depth and the local convective Rossby number, diffusivity, and pressure scale height of those flows. Upward and downward penetrative convection have a similar scaling with rotation rate and diffusivities, but they depend differently upon the pressure scale height due to the differing energetic processes occurring in convective cores of early-type stars versus convective envelopes of late-type stars. Gravito-inertial waves can be excited at the interface of convective and radiative regions and by the Reynolds stresses in the bulk of the convection zone. The wave energy flux will therefore vary with the properties of the convection. With the convection model, three models for assessing the wave energy flux are considered: an interfacial model and two models of the Reynolds-stress excitation, one with waves weakly influenced by rotation and another with an arbitrary rotation rate. Parameter regimes are found where the sub-inertial waves may carry a significant energy flux that depend upon the convective Rossby number, the interface stiffness, and the wave frequency.

5p12 - The s process in rotating low-mass AGB stars: nucleosynthesis calculations in models matching asteroseismic constraints

den Hartogh, Jacqueline (Konkoly Observatory, MTA CFSK, Budapest, HUN)

We investigate the s-process during the AGB phase of stellar models whose cores rotate at rates consistent with asteroseismology observations of their progenitors and successors. We calculate $2M_{\odot}$, Z=0.01 models, rotating at 0, 125, and 250 km/s at the ZAMS. An artificial, additional viscosity is added to enhance the transport of angular momentum in order to reduce the core rotation rates to be in agreement with aster- oseismology observations. For the first time, we present nucleosynthesis calculations for rotating AGB models that match the asteroseismic constraints on rotation rates of the main sequence, red giant branch, core He-burning phase and white dwarfs. In particular, we calculated one model that matches the upper limit of observed rotation rates of core He-burning stars. We also included a model that rotates one order of magnitude faster than the upper limit of the observations. The s-process production in both of these models is comparable to that of non-rotating models, which means the observed spread in s-process production cannot be accounted for by rotating models. However, there are uncertainties remaining in the treatment of rotation in stellar evolution, as well as magnetic processes. We will briefly discussed this.

5p13 - Determination of precise stellar parameters via combination of Gaia and AllWISE photometry

Perdelwitz, Volker (Hamburger Sternwarte, Hamburg, GER)

The recent second data release of *Gaia* included stellar parameters for an unprecedented number of stars. However, due to the proximity of the *Gaia* passbands, the uncertainties of these parameters are still quite large.

In order to establish a more precise estimate of effective temperature, surface gravity and metallicity, we are currently developing an algorithm which compares the absolute fluxes of all *Gaia* passbands, combined with those from the *WISE* mission, to *PHOENIX* model spectra. First tests have shown that this use of a broader wavelength range enables a much more precise determination of stellar parameters.

We present an outline of the approach, along with a comparison to the *PASTEL* catalog, a benchmark sample of spectroscopically determined stellar parameters. Furthermore, we discuss the feasibility of an all-sky catalog based on the entire crossmatch between *Gaia* and *AllWISE*, comprising of more than 300 million stars.

5p14 - Stellar Evolution in Real Time: Models Consistent with First Direct Observation of a Thermal Pulse

Molnár, László (Konkoly Observatory, MTA CSFK, Budapest, HUN); Joyce, Meridith (Research School of Astronomy and Astrophysics, ANU, Canberra, AUS); Kiss, László (Konkoly Observatory, MTA CSFK, Budapest, HUN)

Most aspects of stellar evolution proceed far too slowly to be directly observable in a single star on human timescales. One of the exceptions to this rule is the thermally pulsing asymptotic giant branch. The combination of state-of-the-art modelling techniques with data assimilated from observations collected by amateur astronomers over many decades provide, for the first time, the opportunity to identify a star occupying precisely this evolutionary stage and to constrain its physical attributes. We show that the rapid pulsation period change and associated reduction in radius in the bright, northern variable star T Ursae Minoris is caused by the recent onset of a thermal pulse.

We demonstrate that T UMi transitioned into a double-mode pulsation state, and we exploit its asteroseismic features to constrain the fundamental stellar parameters. We use the MESA and GYRE codes to track simultaneously the structural and oscillatory evolution of models with varying mass, and we apply a sophisticated iterative sampling scheme to achieve dense temporal coverage (≤ 10 years) at the onset of the relevant thermal pulses.

We report an initial mass of 1.9±0.1 M_{Sun} for T UMi—in contradiction with previous, lower mass estimates—and an age of 1.3±0.2 Gyr. The ultimate test of our evolutionary and asteroseismic models will be the continued observation of its evolution in real time. We predict that the pulsation periods in T UMi will continue shortening for a few decades before they rebound and begin to lengthen again, as the star expands in radius.

5p15 - Detection of Frequency Shifts in Evolved Kepler Stars

Kiefer, René (University of Warwick, Coventry, GBR); Broomhall, Anne-Marie (University of Warwick, AUT)

The properties of stellar oscillation eigenmodes change with the level of magnetic activity. This has been measured with data from CoRoT and Kepler, where signatures of magnetic activity have been found in the seismic properties of a few dozen main-sequence and sub-giant stars. However, as of yet, no detection of temporal variations in the oscillation frequencies of more evolved stars have been reported.

We analyse the Kepler long cadence data for the red giant sample compiled by Yu et al. (2018, ApJS 236:42) which consists of ~16,000 stars. To obtain the frequency shifts, we use a cross-correlation technique which is well suited for such a large sample of stars, as the only required input parameters are vmax and Δv. The time series are divided into segments of 250 days with an overlap of 125 days. The region of the periodograms where the oscillations are detected are cross-correlated between segments. The cross-correlation function is then fitted around the central peak. A non-zero lag indicates a shift in the frequencies from one segment to the next. The uncertainties of the frequency shifts are estimated by carrying out this procedure on resampled periodograms 1000 times (see, e.g., Régulo et al. 2016 A&A 589:A103 and Kiefer et al. 2017 A&A 598:A77). To expand the sample, we added the 415 main-sequence and sub-giant stars investigated by Serenelli et al. (APOKASC, 2017, ApJS 233:23) and the previously published frequency shifts for a sample of 87 main-sequence and sub-giant stars of Santos et al. (2018, ApJS 237:17).

We find significant frequency shifts for about 2500 stars of the red giant sample and for 90 stars of the APOKASC sample. Interestingly, stars in the helium-core-burning phase (as identified by Yu et al.) show larger shifts than stars on the red giant branch. We compare the detected frequency shifts with predictions from theoretical scaling relations and discuss implications of our findings.

5p16 - Evolution of the gravity-offset of mixed modes in RGB stars

Pinçon, Charly (Star Institute, Liège, BEL); Takata, Masao (AUT); Mosser, Benôit (Observatoire de Paris - Meudon, Meudon, FRA)

The study of mixed modes in the red giant stars observed by the satellites CoRoT and Kepler gave us stringent insights into the properties of their deep layers. Among the seismic parameters associated with mixed modes, the gravity-offset was recently measured in hundreds of red giant stars by Mosser et al. (2018). These observations showed that its value remains about constant at the beginning of the ascent of the red giant branch before rapidly dropping for the more luminous stars of the sample. In this work, we theoretically interpret the observed variations in terms of internal structure. To do so, the asymptotic analyses of mixed modes are considered and a simple analytical model is developed. The result of the investigation clearly highlights the potential of this parameter to probe the properties at the base of the convective envelope, such as for instance overshooting.

5p17 - Insights Into Stellar Magnetism With TESS: Are magnetic A-type stars far more common than previously believed?

Sikora, James (Queen's University, Kingston, CAN); David-Uraz, Alexandre (University of Delaware, Newark, USA); Chowdhury, Sowgata (Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences, Warsaw, POL); Bowman, Dominic (Institute of Astronomy, Leuven, BEL); Wade, Gregg (Royal Military College of Canada, Kingston, CAN); Khalack, Viktor (AUT); Kobzar, Oleksandr (AUT); Kochukhov, Oleg (Department of Astrophysics, University of Vienna, Austria, Uppsala, SWE); Neiner, Coralie (LESIA, Meudon, FRA); Rode-Paunzen, Monika (Institut für Sprachwissenschaft, AUT)

Along with detecting thousands of new exoplanets, the recently launched Transiting Exoplanet Survey Satellite (TESS) is yielding new and exciting insights in the field of stellar magnetism. Only a small fraction of main sequence A-type stars are known to be magnetic; however, surprisingly the all-sky high-precision and high-cadence photometric measurements provided by TESS have already revealed a large number of A-type stars that exhibit rotationally modulated light curves — a telltale sign of surface inhomogeneities, likely linked to magnetic activity. Such findings, if confirmed, would challenge our current understanding of how these objects are able to sustain magnetic fields whose influences are apparent at the stellar surface. We will present our recent search for candidate rotationally variable A-type stars based on the early TESS data releases. The identification of these objects is particularly important because, unlike the stars observed within the similarly designed Kepler mission, many of the TESS targets are bright enough to allow for follow-up high-precision magnetic and spectroscopic measurements to be obtained.

5p18 - Better Physics for Modelling Stars and their Oscillations

Trampedach, Regner (Space Science Institute, Boulder, CO, USA)

Our interpretation of stellar observations can only be as good as our stellar models and the strong constraints provided by asteroseismology demands very good models indeed. I have approached modeling improvements from three angles:
Including effects of realistic 3D convection on the structure of stellar surface layers, including non-adiabatic effects of that convection on oscillations, and finally improving and modernizing the equation of state for stellar plasmas. I will review my progress and preliminary results on all three fronts.

6. BINARIES & CLUSTERS

6k01 - Binaries as key laboratories for stellar physics

Southworth, John (Keele University, Newcastle-under-Lyme, GBR)

Eclipsing binary stars are our main source of direct mass and radius measurements for normal stars. In good cases, masses and radii can be obtained to better than 1% precision and accuracy using only photometry, spectroscopy and geometry. These measurements constitute vital empirical data against which theoretical models of stars can be checked and improved. I will summarize the present state of knowledge in this area, current challenges, and future opportunities. I will then present new results for eclipsing binary systems observed with the BRITE, Kepler/K2 and TESS space missions.

6k02 - Pulsating Stars in Binary Systems

Murphy, Simon (University of Sydney, Sydney, AUS)

Binary systems anchor many of the fundamental relations relied upon in asteroseismology. Masses and radii are rarely constrained better than when measured via orbital dynamics and eclipse depths. Pulsating binaries have much to offer. They are clocks, moving in space, that encode orbital motion in the Doppler-shifted pulsation frequencies. They offer twice the opportunity to obtain an asteroseismic age, which is then applicable to both stars. They enable comparative asteroseismology -- the study of two stars by their pulsation properties, whose only fundamental differences are the mass and rotation rates with which they were born. In eccentric binaries, oscillations can be excited tidally, informing our knowledge of tidal dissipation and resonant frequency locking. Eclipsing binaries offer benchmarks against which the asteroseismic scaling relations can be tested. We review these themes in light of both observational and theoretical developments recently made possible by space-based photometry

6o01 - R-mode oscillations in eclipsing binaries

Saio, Hideyuki (Astronomical Institute, Tohoku University, Sendai, JPN)

The presence of r mode oscillations (global modes of Rossby waves coupled with buoyancy) is recognized by dense frequency groups in a Fourier diagram. They are found in e.g., gamma Dor stars, spotted early-type stars, binary stars, and possibly accreting white dwarfs. Detecting a group of r-mode frequencies in a star, we can determine the rotation frequency fairly accurately. We frequently find the signature of r modes in Kepler light curves of eclipsing binaries. Sometimes two sets of the frequency groups are found, corresponding to the two component stars having slightly different rotation frequencies. From these detected r modes in eclipsing binaries, we discuss how close are these rotation frequencies to the orbital frequencies (i.e., synchronous rotation), depending on the binary parameters.

6o02 - Inclination Surveys in Open Clusters Using Be Stars

Sigut, Aaron (The University of Western Ontario, London, CAN)

Context: Individual stellar inclination angles (the angle between a star's rotation axis and the observer's line of sight) have been traditionally quite difficult to measure. In any population of stars, common practice has been to assume that the stellar inclinations are random and uncorrelated, leading to the prediction of the familiar sin(i) distribution for the observer. However, very recent observations using asteroseismology have demonstrated non-random inclination distributions for the stars in two Milky Way (MW) open clusters. Such correlations can provide new and important constraints on the flow angular momentum during star formation in clusters.

Method: Be stars are main sequence B stars surrounded by an equatorial, circumstellar disk. Fitting the observed H-alpha emission line formed in the disk to grids of theoretical H-alpha profiles computed with the Bedisk/Beray circumstellar disk codes allows for a robust estimate of the stellar inclination angle of the central B star. As Be stars represent about 25% of all main sequence B stars, they can form statistically significant stellar samples for young MW / LMC / SMC open clusters to observationally determine their inclination distributions.

Results: It is demonstrated that a good estimate of the inclination of a Be star can be extracted from a single observed H-alpha line profile, despite the requirement to simultaneously fit for several other parameters describing the density distribution of the disk gas. Through comparison with interferometric observations taken with the Naval Precision Optical Interferometry (NPOI) of twelve bright, nearby Be stars, a correlation-coefficient exceeding r=0.9 is found between the inclinations derived from the H-alpha line profile and those directly determined via interferometry from the resolved disk light distribution on the sky. This method is then applied to a sample of all field Be stars within 300 pc of the Sun, and several Milky Way open clusters, to observationally determine their inclination distributions.

Conclusions: Due to the high frequency of Be stars and the ease of their detection, this H-alpha method for determining Be star inclinations will allow large, direct surveys of cluster inclination distributions in MW, LMC, and SMC open clusters. Combined with polarization measurements, which constrain the projection of the stellar rotation axis on the sky (as it is perpendicular to the disk), surveys in which the full 3D stellar rotation vector is recovered become possible.

6o03 - On the amount and origin of the mass discrepancy in binary stars

Tkachenko, Andrew (Institute of Astronomy, KU Leuven, Leuven, BEL)

Detached, eclipsing, spectroscopic double-lined binary stars are for long known to be the prime source of high-precision, model-independent fundamental properties of stars, in particular their masses and radii. That said, they hold great potential for calibrating models of interior structure and evolution in a wide range of stellar masses and evolutionary stages. The discrepancy between masses measured from binary dynamics and those inferred from fitting evolutionary tracks to the stellar positions on the HR-diagram has been reported in the literature and is commonly attributed to shortcomings contained in the models. In particular, the discrepancy can often be reduced or (in some cases) completely solved by substantially increasing the amount of near-core mixing in the form of convective core overshooting. In this study, we attack the problem of the mass discrepancy in binary stars by analysing a sample of some ten systems in a wide range of stellar masses and main-sequence evolutionary stages, whose dynamic and atmospheric properties have been determined in a self-consistent and homogenous way. We quantify the mass discrepancy as a function of mass and evolutionary stage of the star and interpret our results in terms of the mass of the stellar convective core. Ultimately, we present a detailed discussion on the possible origin of the mass discrepancy problem and outline the next steps towards its solution.

6o04 - Calibrating asteroseismology for red giants with eclipsing binaries

Benbakoura, Mansour (CEA Saclay, Gif-sur-Yvette Cedex, FRA); Gaulme, Patrick (Max Planck Institut für Sonnensystemforschung, Göttingen, GER); McKeever, Jean (Yale University, New Haven, CT, USA); Sekaran, Sanjay (KU Leuven, Leuven, BEL); Beck, Paul (Universität Graz, Graz, AUT); Spada, Federico (Max Planck Institut für Sonnensystemforschung, Göttingen, GER); Jackiewicz, Jason (New Mexico State University, Las Crucess, NM, USA); Mathur, Savita (Insituto de Astrofísica de Canarias, San Cristóbal de La Laguna, ESP); Tkachencko, Andrew (KU Leuven, Leuven, BEL); García, Rafael (CEA Saclay, Gif-sur-Yvette Cedex, FRA)

With the objective of ESA's PLATO space mission to determine stellar ages with a precision of 10% through asteroseismology, it is critical to assess the accuracy of the scaling relations on which these measurements are based. Eclipsing binary systems hosting at least one star with detectable solar-like oscillations constitute ideal test objects. By combining radial-velocity measurements and photometric time series of eclipses, it is possible to determine the masses and radii of each component of a double-lined spectroscopic binary, allowing one to compare asteroseismic estimates of these quantities to independently measured values. From the analysis of a sample of 10 pulsating red giants in eclipsing binaries that had been observed by the Kepler space telescope, Gaulme et al. (2016, ApJ 832, 121) showed that the asteroseismic scaling relations systematically overestimated red-giants masses and radii, by about 15% and 5% in average, respectively. Since then, several methods have been proposed to correct this overestimation. In this talk, I will first present 15 new red giants in eclipsing binaries, among which three allow us to test the asteroseismic scaling relations. Then I will review the recently published corrections and show their results on this new sample.

6o05 - The Massive Heartbeat Project: Mapping the Upper HR Diagram

Pablo, Bert (AAVSO, Cambridge, USA)

Heartbeat stars are eccentric binary systems which remain largely constant, but produce significant variations around periastron. This signal is very sensitive to many orbital parameters, most notably inclination, allowing for well-determined masses and radii in the absence of eclipses. Another hallmark of these systems is the presence of tidally excited oscillations. The benefits of such systems for low mass stars is muted as both oscillations and eclipsing systems are rather common place. However, in the upper HR diagram this is no longer the case. There are only a handful of systems that have parameters precise enough to put constraints on stellar evolution and even fewer for which asteroseismology is applicable. This project aims to rectify this situation. Based on the stars observable with TESS and BRITE we have created a list of spectroscopic binaries which are likely to exhibit heartbeat variations. Here we will discuss initial results of this catalog along with the complimentary nature exhibited by the BRITE/TESS datasets.

6p01 - The Eclipsing delta Scuti Star EPIC 245932119

Lee, JaeWoo (Korea Astronomy and Space Science Institute, Daejeon, KOR); Hong, Kyeongsoo (Institute for Astrophysics, Chungbuk National University, Cheongju, KOR); Kristiansen, Martti H. (DTU Space, National Space Institute, Technical University of Denmark, Lyngby, DNK)

We present the physical properties of EPIC 245932119 exhibiting both eclipses and pulsations from the K_2 photometry. The binary modeling indicates that the eclipsing system is in detached or semi-detached configurations with a mass ratio of 0.283 or 0.245, respectively, and that its light-curve parameters are almost unaffected by pulsations. Multiple frequency analyses were performed for the light residuals in the outside-primary eclipsing phase after subtracting the binarity effects from the observed data. We detected 35 frequencies with signal to noise amplitude ratios larger than 4.0 in two regions of 0.62-6.28 day^{-1} and 19.36-24.07 day^{-1}. Among these, it is possible that some high signals close to the Nyquist limit f_{Ny} may be reflections of real pulsation frequencies ($2f_{Ny} - f_i$). All frequencies (f_8, f_9, f_{14}, f_{18}, f_{24}, f_{32}) in the lower frequency region are orbital harmonics, and three high frequencies (f_{19}, f_{20}, f_{20}) appear to be sidelobes split from the main frequency of f_1 = 22.77503 day^{-1}. Most of them are thought to be alias effects caused by the orbital frequency. For the 26 other frequencies, the pulsation periods and pulsation constants are in the ranges of 0.041-0.052 days and 0.013-0.016 days, respectively. These values and the position in the Hertzsprung-Russell diagram reveal that the primary component is a δ Sct pulsator. The observational properties of EPIC 245932119 are in good agreement with those for eclipsing binaries with δ Sct-type pulsating components.

6p02 - Tidal Asteroseismology: Opportunities and Challenges

Guo, Zhao (Pennsylvania State University, University Park, USA)

More than half of all stars reside in binaries and tides can have a significant effect on stellar oscillations. In the first version of the classical textbook Nonradial Oscillations of Stars by Wasaburo Unno et al. (1979), there is a whole chapter on tidally forced oscillations. However, it was removed in the second version (1989), probably owing to the notion that such oscillations are difficult to be observed in practice. Thanks to precise measurements of the space missions (Kepler, BRITE, TESS), we are now able to observe unambiguously the manifestation of (dynamical) tides: tidally excited oscillations (TEOs).

Observationally, we measure the fundamental parameters of four Kepler heartbeat binaries with TEOs by combining the Kepler light curves and Keck HIRES spectra. These accurate measurements are the prerequisite for subsequent theoretical studies.

Theoretically, we model the amplitude and phase of TEOs in the regime of linear theory. We also examine the temporal evolution of the binary orbit and the TEOs and identify the responsible dissipation mechanism. We try to explain the non-orbital-harmonic TEOs in the regime of non-linear three/multi-mode-coupling. Theoretical mode-coupling thresholds and observed parent mode amplitudes are compared.

In the end, we discuss the challenges posed by these observations in tidal asteroseismology.

6p03 - Hot Subdwarf Stars and Binary Evolution

Brown, David (Specola Vaticana, Città del Vaticano, VAT)

Hot subdwarf B stars are EHB core-helium burning stars having masses of about 0.5 $M_{s,}$ surrounded by very thin inert hydrogen envelopes of mass M_{env} < 0.02 M_s. They are thought to be formed when they lose most of the their hydrogen envelopes during the RGB phase of evolution, just before they ignite their He-cores. The mechanism by which such rapid mass loss occurs is still not fully determined, but it is suspected that binary interactions via RLOF play an important role in their formation, at least in the formation of hot subdwarf stars in the Galactic field, where most sdB stars are found in binary systems. Then again, the binary fraction of sdB stars in globular clusters is very low, and so other mechanisms, perhaps He-enhancement via AGB-star ejecta in clusters that have multiple populations, might play a role in their formation, this time from single-star progenitors. Studies done using binary population synthesis, from a theoretical point of view, following that of Han et al. (2002,2003,2007), can reveal much about the formation channels of such EHB stars, and the study described here builds on this, taking into account different chemical abundances (metalliticities). Asteroseismological studies of pulsating sdB stars have also contributed greatly to determination of sdB star parameters, especially stellar mass, which has greatly helped astronomers to understand such stars. A comparison is done using empirical observations.

6p04 - Sigma Sco: new observational insight from time-series of high-resolution spectroscopy

Tsymbal, Vadim (Institute of Astronomy RAS, Moscow, RUS)

Binary stars offer the possibility of measuring stellar fundamental properties such as masses and radii with unprecedented precision. These high-precision and accuracy model-independent parameters challenge models of interior structure and evolution, making binary stars excellent calibrators of the said models.

Existence of pulsating stars in binary systems allows for unique synergies between binarity and asteroseismology, making stellar interiors accessible through the study of oscillations of stars complemented with the unprecedented quality dynamical measurements of stellar fundamental properties.

Here, we employ the method of Least-Squares Deconvolution (LSD) generalized to binary stars with pulsating components to study a massive binary Sigma Sco which is known to consist of a radially pulsating early B-type evolved primary and a lower mass, late B-type secondary component. We separate time-series of composite SB2 spectra of the system into orbital and pulsation phase resolved spectral contributions of individual stars which are further subject to the radial velocity and line asymmetry-based analysis.

We confirm radial pulsations in the more massive primary component and present a strong evidence of the detection of radial-mode pulsations in the cooler component, consistent with its position in the HR-diagram placing it within the beta Cep instability strip.

6p05 - Eclipsing binaries with Beta Cephei variables

Kahraman Alicavus, Filiz (Nicolaus Copernicus Astronomical Center, Warsaw, POL); Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warsaw, POL)

The existence of pulsating stars in eclipsing binary systems has been known for decades. These valuable systems exhibit both pulsation and eclipse characteristics which allow us to obtain accurate fundamental stellar parameters (mass, radius) and to probe the interior structure of stars. B-type pulsating variables, in particularly Beta Cephei stars, in eclipsing binaries are useful objects to understand the evolution from the main-sequence to supergiants via their binarity nature and pressure and gravity modes. However, the known number of these variables is small. Therefore in this study, we present a search for Beta Cephei variables in eclipsing binaries to reveal new candidates and to understand the pulsational behaviour of these variables. Candidate eclipsing binary member Beta Cephei stars were selected from the most recent eclipsing binary catalog (Avvakumova et al. 2013). To obtain the final candidates, the position of the stars in the Beta Cephei instability strip was checked by calculating the luminosity using interstellar reddening and parallaxes (Gaia, Hipparcos). Available public light curves of the final candidates were retrieved and binary modelling was performed. To disclose the Beta Cephei type pulsations, the binarity effects were removed from the light curves and a frequency analysis was carried out to the residuals. As a result, we derived the orbital parameters of about 20 systems and discuss new Beta Cephei candidates in eclipsing binary systems.

6p06 - To be or not to be a binary

Themeßl, Nathalie (Max Planck Institute for Solar System Research, Göttingen, GER)

Asteroseismology has been proposed as a method to identify non-eclipsing binary systems in cases where more than one component of the system shows solar-like oscillations. Based on high-precision photometric data obtained by the *Kepler* mission, we analyze about 30 rare power density spectra of red-giant stars that show two sets of solar-like oscillations. Complementary to the asteroseismic study, we use spectroscopic effective temperatures and metallicities as well as ground-based BVI photometry and Gaia DR2 parallaxes to investigate if the pairs of stars have similar stellar properties. A mass ratio close to 1, similar ages, and distances can be an indication that the stars are physically bound in a binary system. For each pair of stars we provide probabilities for it being a binary system or rather visual double stars. This study supports the search for candidate systems that are suitable for further binary investigations.

6p07 - The results of ß Cep-type stars ensemble asteroseismology in NGC 6910 cluster

Mozdzierski, Dawid (University of Wroclaw, Wroclaw, POL)

We present results of ensemble asteroseismology of β Cep-type pulsating stars in the NGC 6910 open cluster. They were obtained using observations carried out during a multisite photometric and spectroscopic observational campaign. Ensemble asteroseismology turns out to be very useful for examination of instability strip, mode identification and testing the excitation of the modes. It also helps to constrain parameters of the cluster, its age in particular. The outcome shows the large potential of this method, especially when used with space telescopes, e.g. Kepler or TESS, that can provide precise photometry for cluster members.

6p08 - The ß Cep pulsator in the eclipsing binary V381 Car - mode identification and seismic modelling

Miszuda, Amadeusz (Astronomical Institute, University of Wroclaw, Wroclaw, POL); Daszynska-Daszkiewicz, Jadwiga (Astronomical Institute, University of Wroclaw, Wroclaw, POL); Szewczuk, Wojciech (Astronomical Institute of the Wroclaw University, Wroclaw, POL)

V381 Car (HD 92024) is a single-lined eclipsing binary in the open cluster NGC 3293. This is also one of a few massive binaries with a pulsating component of the β Cep type. The pulsating primary has a mass of about 15 $M_\odot$ whereas the secondary is a much lower-mass star (3 $M_\odot$) with the contribution to the total flux of about 2%.

We re-determined the binary orbit from multi-colour photometric and spectroscopic data of Freyhammer et al (2005). After subtracting the modelled eclipsing light curve, the Fourier analysis was performed in each Stromgren passband. We found 5 independent frequencies for which we made the mode identification from the photometric amplitudes and phases as well as from the spectroscopic IPS diagrams using the FAMIAS package.

We were able to determine that the dominant frequency is the quadrupole mode whereas for the others the higher degrees $\ell > 3$ are most probable. We constructed preliminary seismic models which fit the dominant frequency as well as account for the mode instability.

V381 Car is planned for observation as part of the TESS mission in Sector 10. Hence, there is a great hope that the binary solution will be significantly improved, and thus the seismic models will be more constrained.

6p09 - Evolutionary status of the binary system KIC 10661783 with the d Sct type component

Miszuda, Amadeusz (Astronomical Institute, University of Wroclaw, Wroclaw, POL); Szewczuk, Wojciech (Astronomical Institute of the Wroclaw University, Wroclaw, POL); Daszynska-Daszkiewicz, Jadwiga (Astronomical Institute, University of Wroclaw, Wroclaw, POL)

KIC 10661783 is a short-period eclipsing binary system with the pulsating primary of δ Scuti type. The masses of components are 2.1 $M_\odot$ and 0.19 $M_\odot$, for the primary and secondary respectively. Up to now, 55 independent pulsation frequencies were found from the *Kepler* data based on the short cadence Q2.3 and the long cadences Q0 and Q1.

We present results obtained from the analysis of all available *Kepler* data with much longer time span, i.e., Q2.3, Q6.1-Q8.3 and Q10.1-Q10.3 in the case of the short cadence and Q0-Q17 (with exception of Q3) in case of the long cadence.

The Fourier analysis of the light curve corrected for the binary effects shows far more rich oscillation spectrum. Most prominent frequency peaks are concentrated in the range of 20 - 30 d^{-1}. In addition, we found small-amplitude signals in the low-frequency range that can be manifestation of high-order g-mode pulsations.

We construct preliminary seismic models accounting for the mode instability and attempt to determine the evolutionary status of the system. In particular, we compare evolutionary and pulsational models of a single star and star in the binary system after mass transfer.

6p10 - Absolute Properties of the R CMa-type Eclipsing Binary KIC 6206751 with gamma Doradus Pulsations

Lee, JaeWoo (Korea Astronomy and Space Science Institute, Daejeon, KOR); Park, Jang-Ho (Korea Astronomy and Space Science Institute, Daejeon, KOR)

We present the absolute properties of the double-lined eclipsing binary KIC 6206751 exhibiting multiperiodic pulsations. The *Kepler* light curve of this system was simultaneously solved with the previously published radial-velocity data. The results indicate that the binary star is a short-period semi-detached system with fundamental parameters of M_1 = 1.66±0.04 $M_\odot$, M_2 = 0.215±0.006 $M_\odot$, R_1 = 1.53±0.02 $R_\odot$, R_2 = 1.33±0.02 $R_\odot$, L_1 = 5.0±0.6 $L_\odot$, and L_2 = 0.96±0.09 $L_\odot$. We applied multiple frequency analyses to the eclipse-subtracted light residuals and detected the 42 frequencies below 2.5 days-1. Among these, three independent frequencies of f_2, f_3, and f_4 can be identified as high-order (38 ≤ n ≤ 40) low-degree (l = 2) gravity-mode oscillations, whereas the other frequencies may be orbital harmonics and combination terms. The ratios between the orbital frequency and the pulsation frequencies are $f_{\rm orb}$: $f_{2\text{-}4} \simeq 2{:}3$, which implies that the γ Dor pulsations of the detached primary star may be excited by the tidal interaction of the secondary companion. The short orbital period, and the low mass ratio and M_2 demonstrate that KIC 6206751 is an R CMa-type star, which is most likely evolving into an EL CVn star. Of seven well-studied R CMa-type stars, our program target is the only eclipsing binary with a γ Dor pulsating component.

6p11 - KIC 9163796 – a benchmark binary system for the determination of stellar ages

Grossmann, Desmond H. (University of Graz, Graz, AUT); Beck, Paul G. (University of Graz, Graz, AUT); Hanslmeier, Arnold (University of Graz, Graz, AUT)

One of the parameters most difficult to derive for a star is its age. Since stellar age is not an observable, determining it requires theoretical modelling. However, since the initial conditions during the birth of the star are mostly unknown, modelling is affected by parameter degeneracies, resulting in large uncertainties in age. For two gravitationally bound stars of the same age, formed under the same initial conditions, the differences in the observed parameters are governed by the difference in mass. While the typical uncertainty of a seismically inferred mass is ~7%, the mass ratio of a binary system can be determined better than 1% from the spectroscopic orbital solution, independent of unknown inclination of the system. Therefore, studying such 'two-egg' stellar twins allows us to test for the common initial conditions, describing best both stellar components of the binary by refining the parameters in an iterative way. Such very valuable conditions of known similarities and accurately measured differences are only available in binaries. This allows us to calibrate internal mixing and investigate the relation between the otherwise degenerate initial parameters.

In this poster we discuss the ongoing analysis of KIC 9163796, constituted of two red-giant stars. The masses of the two components differ only by 1.5±0.5 %. While on the main sequence such stars would appear as virtually indistinguishable stellar twins, the increased pace of stellar evolution leads to substantial differences in their effective temperature, luminosity and lithium abundance on the low-luminosity red-giant branch. It was shown by Beck et al. (2018), that the observed systems properties are in perfect agreement with both binary components being located in the short-lived phase of the first dredge up. In our analysis, we perform a theoretical grid modelling using MESA (Modules for Experiments in Stellar Astrophysics), an open source code developed by Paxton et al. (2010), searching for the best combination of models, satisfying the observed parameters for both components.

6p12 - The spectroscopic multiplicity fraction in a sample of A/F-type (candidate) hybrid stars from the Kepler mission

Lampens, Patricia (Koninklijke Sterrenwacht van België, Brussels, BEL); Vermeylen, Lore (Koninklijke Sterrenwacht van Belgi\"e, Brussels, BEL); Lehmann, Holger (Th\"uringer Landessternwarte, Tautenburg, GER); Skarka, Marek (Astronomical Institute, Ondrejov, CZE); Bogn\'ar, Zsofia (Konkoly Observatory, Budapest, HUN); Sodor, Adam (Konkoly Observatory, Budapest, HUN); De Cat, Peter (Koninklijke Sterrenwacht van Belgi\"e, Brussels, BEL); Frémat, Yves (Observatoire royal de Belgique, Brussels, BEL)

By means of a spectroscopic study based on multi-epoch, high-resolution spectra of 83 A/F-type candidate hybrid pulsating stars from the Kepler mission collected at various observatories, we derive a lower estimate of the fraction of hybrid stars which belong to spectroscopic binary and multiple systems. In the first phase (49 hybrid stars), we derived a global spectroscopic multiplicity fraction of 27% (Lampens et al. 2018). In the second phase, we intend to obtain the same information for another 46 candidate hybrid stars. From a preliminary classification of 34 (out of 46) targets, we currently find a spectroscopic multiplicity fraction of ~30 %. Spectroscopic observations are still on-going. As a plus, we identified systems for which a combined analysis of Time Delays (TDs) with Radial Velocities (RVs) allows to derive precise orbital elements, accurate mass ratios as well as the identification of the pulsating component. Next, we analysed the low-frequency region of the periodograms based on the rich data set collected by the Kepler mission, and we will present the distribution of possible orbital and/or rotational periods for the newly detected spectroscopic systems.

6p13 - Spot or not?

Debski, Bartlomiej (Jagiellonian University, Krakow, POL)

This work is focused on the starspot migration in (near)contact binaries. With our new methods we are analysing the intrinsic variability of light curves in the long timebase photometry data. We have obtained the information on the staspot migration in more than one thousand Kepler binaries: if the spot migration is present, what is the migration rate, what is the direction of the migration and in case of selected binaries, how to pinpoint if the spot is cooler or hotter than it's host star' photosphere. All the analysis process can be automatized with a several simple tasks and applied to large databases without the need of any numerical modeling. Here we present some of the highlights of our methods, as well as the statistical results obtained for the close binaries in the Kepler mission. Out of about 1200 studied Kepler's binaries, we found only three, which present a type of activity that cannot be attributed to the spot migration. For these objects we propose a mechanism of a stationary spot evolution, i.e. strictly localised thermal pulsations.

6p14 - The variability of the B[e] supergiant binary GG Carinae

Porter, Augustus (University of Oxford, Oxford, GBR)

We present data on the enigmatic system GG Carinae (GG Car), which is believed to be a B[e] supergiant binary with a known orbital period of 31.033 days. A number of other periodicities are found in the photometric and the spectroscopic data on this system at both longer and shorter timescales than the published period. We study these signals in an attempt to determine their nature and whether they arise from intrinsic stellar variability, multiplicity interactions, or variations in the circumstellar/circumbinary environment. We compare the system to pulsating stars such as W Viriginis- and delta Scuti -type variable stars, and to binaries with precessing circumbinary disks to see if these may shed light on the signals seen in GG Car, and can give clues towards the origins of the phenomena associated with B[e] supergiants. Whether GG Car may in fact be a higher-order multiple system is investigated.

6p15 - Possible Connection Between P Cygni and Neighboring Open Clusters

Vardosanidze, Manana (Ilia State University, Tbilisi, GEO)

According to earlier investigations by Turner and co-authors, P Cygni could be a member of a hypothetical, sparsely-populated open cluster. The star lies near the east boundary of this hypothetical cluster.

There is another, but known open cluster IC 4996 on the vicinity of P Cygni. The same authors believe that above mentioned two clusters are connected to each other and they could represent a double cluster.

As P Cygni is a hypergiant and consequently has very strong and variable stellar wind, so a cluster membership can enable us to determine the age, distance, and reddening of the star relatively precisely. We used new data of different catalogues, for example, PPMXL and GAIA and tried to resolve the problem

7. OTHER & MORE CHALLENGES

7o01 - Protostellar accretion bursts and their effect on the pre-main-sequence stellar evolution

Vorobyov, Eduard (Institut für Astrophysik, Wien, AUT)

The formation process of stars is accompanied by energetic events known as FU Orionis-type eruptions (FUors), during which the stellar luminosity increases by factors from tens to hundreds. These energetic events are likely associated with an increased rate of mass accretion on the star, which is caused by various disk instabilities or external disk perturbations. I will review the current status of FUor modeling and the consequences that the accretion bursts can have on the pre-main-sequence evolution of low- and high-mass stars.

7o02 - Recent advances in numerical models that include atomic diffusion in stars

Alecian, Georges (CNRS, Observatoire de Paris, Meudon, FRA)

Atomic diffusion in stars is efficient in changing elements distribution slowly but strongly in any radiative zone. This process may produce detectable effects on time scales stretching from a few decades to star's lifetime, according to the depth of these radiative zones. The main consequences are that superficial abundances may depart from standard values, but also that internal structure and seismic diagnostics are affected due to the changes of local opacities. The main difficulty including atomic diffusion in numerical models comes from radiation force (the dominant force acting on atoms inside concerned layers), which is specific to chemical species through their atomic properties, and that makes the process strongly non-linear in usual situations (especially in atmospheres). I will present recent progress that concern modelling in atmospheres, and the improvements of a fast method for calculation of radiative accelerations in stellar interiors.

7o03 - High-resolution view of hot-star magnetic fields: current status and future challenges

Kochukhov, Oleg (Uppsala University, Uppsala, SWE)

Modern spectropolarimetric observations make it possible to reconstruct detailed maps of stellar magnetic fields with the Zeeman Doppler imaging technique. Such studies have been carried out for a number of early-type magnetic stars. This new generation of high-resolution magnetic field maps have allowed to probe deviations from the canonical oblique dipolar geometry, investigate evolutionary perspective on hot-star magnetism and study a relationship between magnetic structures and chemical abundance spots. In this talk I will present a summary of the recent progress in the surface magnetic field mapping studies and discuss directions of most promising theoretical and observational developments.

7o04 - Modelling the polarimetric signatures of magnetic massive stars with ADM

Munoz, Melissa (Queen's University, Kigston, CAN)

Magnetic O stars host strong, organized magnetic fields that channel their stellar winds, significantly confining their mass loss and enhancing the shedding of rotational angular momentum. The resultant mass-loss quenching and magnetic braking lead magnetic O stars to evolve at higher mass and slower rotation than their non-magnetic kin, making them novel laboratories for the study of high-mass stellar evolution.

At the root of the magnetic field-stellar wind interaction is the formation of a complex, co-rotating dynamical magnetosphere surrounding the star. The recently developed Analytic Dynamical Magnetosphere (ADM) model (Owocki et al. 2016) provides a straightforward description of the temperature, density, and velocity fields predicted to occur in these magnetospheres, allowing computationally efficient calculation of observable quantities needed for determination of magnetospheric physical characteristics and for testing of theoretical limitations.

In earlier papers (e.g. Munoz 2019), we have exploited the ADM model to compute photometric observables of magnetic Of?p stars, to test geometric models inferred from magnetometry (for Galactic targets) and to place constraints on as-yet-undetectable magnetic fields (for extra-Galactic targets).

In this presentation we summarize first results of ADM-based calculations of magnetospheric linear polarization, which provide an independent test of magnetospheric geometry and scattering physics, as well as independent constraints on important stellar, wind and magnetic parameters. We describe results of a first simultaneous analysis of broadband linear polarization and photometric observations of the prototypical Galactic magnetic Of?p starHD 191612, leading to an independent test of its magnetic and magnetospheric geometry, as well as a new estimate of its mass-loss rate.

7o05 - Putting Stars into Boxes

Griffin, Elizabeth (Dominion Astrophysical Observatory, Victoria, CAN)

The approaches which researchers follow can be subdivided into two simple but quite distinct categories: (A) "broad sweepers" and (B) "ultimate refiners". The first look at the wide picture and extract the kind of statistics upon which stellar physics was founded. The second look at the outliers - the ones that don't fit that wide picture, and spend a lifetime arguing.
In researching a sample of nearly 50 northern composite-spectrum binaries I have found systems that "just can't be like that". Two will be summarized: (1) a triple system containing a pair of early-A stars in a 3.8-day orbit; both are travelling at over 100 km/s and yet show no rotation at all, and (2) an SB2 system that shows no evidence of a third body or of mass loss, and yet the SB2 orbit finds that the mass of the secondary is more than twice that of the primary. These two alone challenge theories of stellar evolution, and need re-observing and re-analysing, but who will do high-dispersion spectroscopy on 6th-mag systems when the rest of the world is after 23rd? So far I not been able to frighten any theoretician sufficiently into investigating closely. The only one who was at all interested claimed that the observational data were wrong and he proceeded to alter them.
Other systems cry out for more attention too, e.g. (A) Epsilon Aurigae (V = 2.9; P = 27 years) was centre stage while it was in eclipse in 2010, it still baffled everyone, and it was left unsolved. It is obscured by something opaque – we know not what - and during egress (and only then) it emits a thin stream of gas that is rich in rare-earths. (B) The Am stars: who said that they are all members of short-period binaries? What about that 50-year system whose secondary is clearly Am?
Surveys like LSST and Gaia predict the volumes of their discoveries by extrapolation. We can extrapolate too; the four brightest stars in the northern sky (Arcturus, Vega, Sirius and Capella) are all curiously odd in some way. What does that say, then, for the rest of the stars in our Galaxy? Have the ultimate refiners been in the shadow of the broad sweepers for too long?

7p01 - FLAMing MiMeS: Extending our investigations of massive-star magnetism to nearby galaxies

Wade, Gregg (RMC, Kingston, CAN)

The past decade has witnessed remarkable advances in our understanding of the magnetic properties of massive stars, including the influence of magnetic fields on stellar mass loss and rotation (ud Doula 2002, 2008), and their ultimate impact on stellar evolution (Keszthelyi et al. 2018). Recently, examples of candidate magnetic O-type stars in the LMC and SMC have been identified (e.g. Nazé et al. 2015, Walborn et al. 2015), but first attempts to detect their magnetic fields have yielded negative results (Bagnulo et al. 2017). In this presentation we will explore the realistic potential of current and forthcoming instrumentation to build on the successes of projects such as MiMeS and VFTS to survey populations of OB stars in the Magellanic Clouds for evidence of surface magnetic fields and magnetic field-stellar wind interactions. Extending our understanding of the magnetic and magnetospheric properties of massive stars to these environments of significantly lower metallicity will provide qualitatively new constraints on models of magnetic wind confinement and insights into the origins of the magnetic fields of hot stars.

7p02 - Model Fittings of IR Spectra in Long-Period Variable Stars

Sung, Hyun-Il (Korea Astronomy and Space Science Institute, Youngcheon, KOR)

We have studied variations of physical parameters in the circumstellar envelopes of carbon-rich Mira variables at different pulsation phases. After comparing the ISO/SWS spectra of these stars with spectral energy distributions calculated from models, we could find the best-fitted parameters for the physical state of the dust envelope at each phase. The variations of the parameters effective temperature, fraction of SiC grains, mass-loss rates, and inner radius of shell, are found to have nearly the same trend as that of the light curve. The other parameters grain size, optical depth, radius of central star, and dust temperature at the inner boundary of envelope, are inversely varying to the light curve.

7p03 - From ancestors to offspring: tracing the connection between magnetic fluxes of OB and neutron stars using the population synthesis technique

Makarenko, Ekaterina I. (Saint Petersburg State University, Saint Petersburg, RUS); Igoshev, Andrei P. (Israel institute of Technology, Haifa, ISR); Kholtygin, Alexander F. (Saint Petersburg State University, Saint Petersburg, RUS)

Nowadays the origin and evolution of magnetic fields (MFs) of young neutron stars (NSs) is an open question. We want to test if MFs of young NSs are the relict of their progenitors, massive OB stars. This could happen due to the magnetic flux conservation: the magnetic field of massive stars is core confined; therefore the collapsed core might keep exactly the same magnetic flux as the whole star. Our intuition is guided by the apparent similarity between different groups of OB and neutron stars. Namely, the magnetic OB stars are divided into two groups: highly-magnetic stars (200-10000 G) and weakly-magnetic stars (B < 100 G) or Vega-like stars. NSs are also divided into normal pulsars (magnetic field approximately 10^{12} G) and magnetars ($B > 4 \cdot 10^{13}$ G). We assume that normal pulsars are descendants of weakly-magnetic stars; magnetars originate from highly-magnetic OB stars and test our hypothesis using the population synthesis technique. Our population synthesis code takes into account the severe selection effects in the NS sample and allows us to compare observed numbers of pulsars and magnetars with the observed numbers of weakly-magnetic and highly-magnetic OB stars.

7p04 - Rotational inversions along the lower part of the red giant branch

Ahlborn, Felix (Max Planck Institute for Astrophysics, Garching bei München, GER); Hekker, Saskia (Max Planck Institute for Solar System Research, Goettingen, GER); Bellinger, Earl (Stellar Astrophysics Centre, Aarhus, DNK); Basu, Sarbani (Department of Astronomy, Yale University, New Haven, USA)

Post main sequence stars are important for the study of the evolution of stellar internal rotation profiles. We report results of an investigation into how the accuracy of estimated internal rotation rates changes as the models evolve along the red giant branch (RGB).
We use stellar models of different masses and metallicities from the base of the RGB up to the bump in the luminosity. For each model we perform a rotational inversion based on a set of dipole modes. We find a range of increased sensitivity to the surface rotation just below the red-giant bump. This range follows a minimum in surface sensitivity that occurs at about 60-80% of the bump luminosity. This behaviour is common to all masses and metallicities considered. We study properties of the models, structural and seismic, that cause this change of sensitivity.

7p05 - A Search of Multi-Fractality into the Solar Flux Emission Spectrum obtained by Nobeyama Radio Observatory During Solar Cycle 24

Prasad, Amrita (Jadavpur University, Kolkata, IND); Roy, Soumya (Haldia Institute of Technology, Haldia, IND); Ghosh, Koushik (UIT, BU, Burdwan, IND); Panja, Subhash (Jadavpur University, kolkata, IND); Patra, Sankar Narayan (Jadavpur Unversity, Kolkata, IND)

Solar radio emissions at different wavelength have been routinely monitored by diverse observatories situated around the world. The study of these emissions gives distinct information about their sources from which they emanate. In this work the non-linear characteristics of the Solar flux emission from 1000 MHz-17000 MHz from Nobeyama Radio observatory has been studied using the Multifractal Detrended Fluctuation Analysis (MF-DFA) technique. The solar flux data at different frequencies may consists of many unforeseen short-lived variations in intensity. These abrupt variations can be the outcome of some momentary-lived process within different emitting sources hence the appearance of unsmooth variations in temporal domain. In order to understand these unsmooth variations one can take into consideration the singularities within the time series giving rise to the singularity or multifractal spectrum. The wider the spectrum, more rich and complex is the structure with high degree of multifractality. In this analysis , the 1000 MHz frequency originating from the upper chromosphere exhibits short memory owing to the value of Hurst exponent *h(q=2)*=0.0593. The multifractal spectrum peaks at 1 for Holder exponent 1.2 with the width of the multifractal spectrum $\Delta\alpha$ =0.86. The 2000 MHz frequency exhibits anti-persistent nature as Hurst exponent *h(q=2):* 0.0644. The multifractal spectrum peaks at 1 for Holder exponent 1.231 with the broadness value of $\Delta\alpha$ =1.082. The 3750 MHz frequency originating from the middle chromosphere exhibits anti-persistent behavior owing to the value of *h(q=2):* 0.0271. The multifractal spectrum peaks at 1 for Holder exponent 1.257 with the broadness value of $\Delta\alpha$ =1.244. The 9400 MHz frequency originating from the upper chromosphere exhibits anti-persistent behavior owing to the value *h(q=2):* 0.1118. The spectrum peaks at 1 for Holder exponent 1.246 with the broadness value of $\Delta\alpha$ =1.216. The 17000 MHz frequency also exhibits same behavior owing to the value of *h(q=2)*=0.2782. The analysis peaks at 1 for Holder exponent 1.359 with the broadness value of $\Delta\alpha$ =0.786. From the results we can see that for solar cycle 24 (SC24) the lower frequencies corresponding to 1000-3000 MHz has anti-persistent behavior with 2000 MHz has high complexity and is much richer in structure as compared to 1000 MHz. According to Schmahl and Kundu (1995), these emissions are predominantly from the free-free emission from coronal loops linked with plages. The frequency at 3750 MHz for SC 24 appears to be short memory but has the higher complexity as compared to other frequencies. The frequency range between 2000-5000 MHz stems from free-free gyroresonance emission from sunspots and the plage associated structures with gyroresonance emission dominates this range. Lastly for the frequency range corresponding to 9400 MHz is again from the free-free emission from coronal loops linked with plages. The frequency within this range has anti-persistent behavior with 9400 MHz has higher complexity as compared to 17000 MHz as compared to solar cycle 24. So it can be said that for solar cycle 24 the gyroemission from the sources atop the sunspots has higher complexity as compared to free-free emission from coronal loops linked with plages also these emissions appears to have anti-persistent behavior and is non-stationary in nature.

7p06 - Recognition of M-type stars in the unclassified spectra of LAMOST DR5 using a hash learning method

Guo, Yanxin (NAOC, Beijing, CHN); Luo, Ali (NAOC, Beijing, CHN)

Our study centers on the recognition for M type stars in the fifth data release (DR5) of LAMOST, which is classified as unknown. A binary nonlinear hashing algorithm based on multilayer pseudo inverse learning is proposed to effectively solve the large spectra retrieval problem. We describe the key steps in the search procedure and present the performance of the search scheme. Considering the low signal-to-noise ratios of unknown spectra, we assemble a representative positive dataset by clustering the existing M-type spectra before the searching period. By employing this new method, we find 11,441 M-type stars out of 642,178 unknown spectra, and a spectroscopic catalog is provided. The same approach is also useful for purifying the released M-type star spectra from LAMOST DR5. More reliable analyses are conducted for the luminosity feature and magnetic activity with Gaia DR2.

7p07 - Gravitational fragmentation of a filamentary molecular cloud using SPH

Danesh Manesh, Fatemeh (Ferdowsi University of Mashhad, Mashhad, IRN); Hosseinirad, Mohammad (Ferdowsi Univrsity of Mashhad, Mashhad, IRN); Abbassi, Shahram (Ferdowsi University of Mashhad, Mashhad, IRN)

Gravitational instability of filamentary molecular clouds leads to formation of high-density regions which are sites of star formation. The presence of magnetic field can hinder or facilitate this process. We investigate the fragmentation of a filamentary molecular cloud with uniform density and different mass per unit length. We also study the effect of magnetic field orientation by taking into account parallel and perpendicular magnetic field in respect to the filament axis. To this end, we use three-dimensional smoothed particle magnetohydrodynamic simulation with the Phantom code. We study the filament evolution and fragment formation including the filament width, number of fragments and their mass distribution and also compare their separation with the linear theory.

7p08 - Analysis of Photometry of Stars from Space and Ground-Based Surveys

Tvardovskyi, Dmytro (Odessa I.I. Mechnikov National University, Odessa, UKR); Andronov, Ivan (Odessa National Maritime University, Odessa, UKR); Andrych, Kateryna (Odessa National I.I.Mechnikov University, Odessa, AUT); Chinarova, Lidiia (Odessa National Maritime University, Odessa, AUT)

Methods for extended analysis of signals with irregularly spaced times are discussed with an application to variable stars of different types: eclipsing, cataclysmic, symbiotic, short- and long- periodic pulsating variables.

The reviews on the methods were published (2019OEJV..197...28A, 2003ASPC..292..391A). Some of them are realized in the "Multi-Column Viewer" (MCV, 2004AstSR...5..264A) and in a newly developed program MAVKA (2019OEJV..197...65A), which realizes 20 approximations of the near-extremum parts of the light curve. Some methods use generally asymmetrical fits (mainly for the pulsating variables with significant asymmetry), some use symmetrical fits with splitting the data interval in 1, 2 or 3 subintervals with a statistically optimal determination of the borders between such subintervals. These methods are effective for studies of eclipsing variables, transits of exoplanets and pulsating variables with negligible asymmetry.

The comparison of the accuracy estimates for these methods was made for artificial data, as well as for real stars

For complete phase curves of eclipsing variables, phenomenological models with special "shapes" (or "patterns") were previously proposed (2012Ap.....55..536A, 2016JPhSt..20.4902T). The main difference for the "short time series" (often used for a CCD monitoring) is in a restriction of the number of parameters, because some parameters may not converge to finite values during iterations to a best fit.

Such methods allow determination of ToM (Times of Minima/Maxima), which are used for studies of period variations and search for 3 or more bodies in the eclipsing systems. Some of them were discovered during our studies (2018OAP....31..103T, 2017OAP....30..135T, 2015AASP....5...75T).

The methods were tested and applied to photometric observations from space and ground-based Surveys, as well as "one-target" monitoring.

7p09 - From monitoring survey of variable red giant stars in Andromeda VII to the evolution

Navabi, Mahdieh (The Institute for Research in Fundamental Sciences (IPM), Tehran, IRN); Noori, Majedeh (Institute for Research in Fundamental Sciences, Tehran, IRN)

We have observed Cassiopeia galaxy (Andromeda VII) using infrared multi-epochs with the Isaac Newton Telescope (INT) to identify Asymptotic Giant Branch (AGB) stars. AGB stars are cool at the end of their evolution and their luminosities reach to maximum in the lifetime, therefore directly reveal their birth mass by employing theoretical evolutionary tracks (isochrones). Due to the changing temperature, AGB stars vary on timescales of months to years and their brightness alteration at optical wavelengths extend to the largest amplitudes.
Hence, we have taken the 10 epochs from And VII during the period 2015-2017 at V and i band spaced by a month or more, using (INT)/ WFC Camera in 34*9 arc-min square, to obtain comprehensive data from AGB stars with the lowest effect of dust.

we have done PSF photometry to all stars discovered by a threshold related to the local sky background noise. Therefore a catalog of 15000 stars in common fields of CCD4 in different nights was manufactured
that 30 of these stars show the characteristics of long period variables (LPVs), most of which are AGB stars. It is the first optical catalog of AND VII that determine the LPVs from monitoring. Therefore, this authorizes us to extract the star formation history (SFH) of the galaxy from the LPVs that are placed at the end of isochrones over ages from 30 Myr to 10 Gyr. Also, our data were matched to the catalog of Spitzer Space Telescope and Sloan Digital Sky Survey (SDSS).

8. STELLAR SPHERES OF INFLUENCE

8k01 - Discs around Be stars and complex radiation effects
Kee, Nathaniel Dylan (Institute of Astronomy, KU Leuven, Leuven, BEL)

Observations of classical Be stars show significant variability in the signatures arising from their circumstellar discs on relatively short (month to year) timescales. Indeed, these stars are even inferred to be able to construct and fully destroy their discs in these short times. Given the high luminosity of the massive stars at the center of these systems, interpreting and understanding these observations requires detailed modeling of the often quite complex interplay of stellar irradiation with disc material. In this talk, I will discuss recent efforts in this modeling, including the treatment of radiative acceleration of disc material, the thermal structure of the disc, and role that these effects play in the observed variability of classical Be stars.

8k02 - Tides in star-planet systems and angular momentum exchanges
Mathis, Stephane (CEA - Department of Astrophysics, Gif-sur-Yvette, FRA)

The revolution of high-precision photometry space missions has put simultaneously on the forefront the discovery of new planetary worlds thanks to the transit method and the characterisation of the structure and the dynamics of their host stars thanks to asteroseismology. Among the broad diversity of discovered planetary systems, some are very compact, with short period planets orbiting their star at distances lower than the Sun-Mercury one. These systems are the seat of strong star-planet tidal interactions similar to those we observe in the Earth-Moon system and in our solar system in general. These interactions are shaping the orbital architecture of the systems and the rotational and structural evolutions of their components, from the host star to the planets. The physical mechanism driving this evolution is the friction applied on tidal flows and displacements in stellar and planetary interiors and the related tidal energy dissipation. In this review, I will show how this tidal dissipation varies over several orders of magnitude as a function of the internal structure and dynamics of stars and planets, and how tides should be studied simultaneously with other star-planet interactions to get a coherent picture of stellar spheres of influence.

8k03 - Tracing stellar wind variability from space
Krticka, Jirí (Masaryk University, Brno, CZE); Feldmeier, Achim (Universitat Potsdam, Potsdam-Golm, GER)

Mass-loss by winds belongs to one of the crucial processes that determines the evolution and fate of stars. The amount of mass lost by a star per unit of time, the mass-loss rate, and its dependence on stellar parameters is, therefore, one of the crucial ingredients of any stellar evolutionary model. Being derived either from observation or theory, the wind mass-loss rates are highly uncertain, in many cases by a factor of a few. The uncertainty of the mass-loss rate determination is to a large extent connected with the variability of the wind. We discuss how the observation of the stellar wind from space can help to trace the wind variability, its origin, and how this information can be used to derive more precise constraints on the mass-loss rates from winds for different types of stars.

8k04 - Star-planet magnetic interactions
Lanza, Antonino Francesco (INAF-Osservatorio Astrofisico di Catania, Catania, ITA)

I shall briefly review the interactions between stellar magnetic fields and close-by planets considering theoretical models proposed to describe them as well as observations with ground-based and space-borne telescopes. Close-by planets can affect the stellar magnetized winds, thus modifying the angular momentum loss along the evolution of main-sequence late-type stars. Moreover, those planets can produce Alfven waves and magnetic stresses that convey energy to the outer atmospheres of their stars leading to time-variable enhancements of their activity or triggering episodic magnetic energy releases such as in flares.

8k05 - Dynamics of star-disk interaction processes in young, low-mass stars as seen from space
Venuti, Laura (NASA Ames Research Center, Mountain View, CA, USA)

High-precision time series photometry provides a unique window into the dynamics of the inner diskregions (< 1 AU) around young stars (< 5-10 Myr), currently inaccessible via direct imaging techniques. Exquisite surveys carried out with CoRoT and Kepler have revealed a bewildering variety of photometric behaviors that young stars with disks may exhibit. These bear the imprints of variable mass accretion onto the star, of stellar magnetic activity, of rapidly evolving inner disk structures, all filtered through the geometric angle of view to the systems. In this talk, we discuss the breakthrough brought in by space-based missions in our understanding of the physics and characteristic timescales of variability of protoplanetary disks in connection with their host stars.

8o01 - Cepheid Spheres of Influence

Evans, Nancy R, (SAO, Cambridge, USA); Guenther, H. Moritz (MIT Kavli Institute for Astrophysics and Space Research, Cambridge, MA, USA); Bond, Howard (PSU, University Park, PA, USA); Schaefer, Gail (The CHARA Array, Georgia State University, Atlanta GA, USA); Mason, Brian (US Naval Observatory, Washington, D.C., USA); Karovska, Margarita (SAO, Cambridge MA, USA); Tingle, Evan (SAO, Cambridge MA, USA); Wolk, Scott (SAO, Cambridge MA, USA); Engle, Scott (Villanova University, Villanova, PA, USA); Guinan, Edward (Villanova University, Villanova, PA, USA); Pillitteri, Ignazio (INAF-Osservatorio di Palermo, Palermo, ITA); Proffitt, Charles (Space Telescope Science Institute, Baltimore, MD, USA); Kervella, Pierre (LESIA, Observatoire de Paris, Meudon, FRA); Gallenne, Alexandre (Observatoire de la Co^te dAzur, Nice, FRA)

Satellite data from HST, Chandra, XMM, IUE, and Gaia have provided important information for Cepheids to supplement ground based light and velocity studies. Since massive star systems frequently have multiple components, it is not surprising that many approaches are needed to derive parameters of the components, in particular the distribution of separations and mass ratios. The final seqment of the HST WFC3 survey (companions between 0.5 and 5.0 ") identifies companions between 100 and 2000 AU. Their unusual property is that all have an inner binary as well (compared with 29\% of the overall Cepheid population in a spectroscopic binary). This suggests that dynamical evolution of these triple systems plays a part in setting the configuration.

8o02 - The distance of the Cepheid RS Puppis from its light echoes

Kervella, Pierre (Observatoire de Paris, Meudon, FRA)

The Milky Way Cepheid RS Puppis is a particularly important calibrator for the Leavitt law (the Period-Luminosity relation). It is a rare, long period pulsator (P=41 days), and a good analog of the Cepheids observed in distant galaxies. It presents the unique characteristic among Cepheids to be embedded in a large (~0.5 pc) dusty nebula, that scatters the light from the star. Due to the light travel time delay introduced by the scattering on the dust, the brightness and color variations of the Cepheid imprint spectacular light echoes on the nebula. I will present the imaging polarimetric observations of the light echoes of RS Pup that we obtained with the HST-ACS instrument. These observations enabled us to determine the geometry of the nebula and the distance of the Cepheid, based on the analysis of its light echoes. I will briefly compare this result with the parallax from Gaia DR2, and discuss the importance of this distance determination in the context of the Leavitt law.

8o03 - Coronal Cycles of Nearby Stars: Alpha Cen AB, Procyon, and the Sun

Ayres, Thomas (University of Colorado, Boulder, USA)

For more than a decade, the High-Resolution Camera on *Chandra* X-ray Observatory has been imaging α Centauri AB (G2V+K1V) — central pair of the famous close-by triple system — to follow coronal (*T*~1MK) variations of the two sunlike stars, produced by analogs of the 11-year solar activity cycle. More recently, F-subgiant Procyon (F5IV-V) was added to the program. Coronal periods of 19 yr and 8 yr are indicated for A and B, respectively. Considering also the Sun's contemporary cycle, the X-ray amplitudes (MAX/MIN) are large: several to ten, up to a hundred times the contemporaneous CaII HK variations. Procyon, in contrast, has shown only a smooth, modest decline over the past nearly 20 yr (including previous archival X-ray pointings), possibly consistent simply with long-term instrumental degradation. All four stars have similar rotation periods, but different surface temperatures, gravities, and ages (more massive Procyon is younger than α Cen AB or the Sun); which potentially can inform theories of Dynamo magnetic cycling in cool stars. The long-term sequence of *Chandra* observations of α Cen also has captured about a dozen serendipitous X-ray sources in the central 17'x17' of the HRC field. Most of these are highly variable, flaring in a few of the pointings, absent in the others. The transient nature of the X-ray field around α Cen — in the Galactic plane dominated by nearby stars — emphasizes the importance of the time domain for studies of the stellar content of the high-energy sky.

8o04 - Brite Photometric Variability of the Intriguing Wolf-Rayet Star WR6: Rotational or Binary Modulations

St-Louis, Nicole (Université de Montréal, Montréal, CAN)

We will present results from a simulateous Brite photometric and optical spectroscopic observing campain of the Wolf-Rayet Star WR6 spaning a 135-day time interval.

This star is one of the brightest and most extensively observed WR stars. Periodic (P = 3.766 days) but *epoch-dependant* variations are seen in photometry, polarimetry and spectroscopy over the same time scale, suggesting that a common mechanism is responsible for the changes. The light and polarization curves slowly evolve over a short timescale of the order of weeks. In spite of all the available observations, it is still unclear what is the physical mechanism behind the variability. Its puzzling nature has been attributed either to the modulation of a rotating single star or to binarity. For the single-star interpretation, the presence of Co-rotating Interaction Regions, CIRs, in its wind has been suggested, mainly to explain the S-shape variability pattern in optical spectra but also the periodic P Cygni blue edge variations seen in strong resonnace lines in the UV and that are very similar to those found

associated with the ubiquitous Discrete Absorption Components in O stars and also thought to be associated to CIRs. For the binary scenario, very rapid apsidal motion in a binary system have been suggested to explain the light-curve as an explanation of the lack of coherency of the periodic changes.

The simulaneous photometric and spectroscopic datasets covering 36 cycles of the 3.76-day period will help discriminate between the two scenarios as the kinematic signatures in the spectroscopy should agree with the models used to reproduce the Brite light-curve.

8o05 - Do planet systems influence the host star atmospheric abundances

Ryabchikova, Tatiana (Institute of Astronomy of Russian Academy of Sciences, Moscow, RUS)

The question of planet formation effect on the host star atmosphere was widely discussed during the last years. We performed a comparative abundance analysis of the sample of stars hosting planets and without planets. The observed trends in relative to the sun atmospheric abundances with the condensation temperature are rather connected with the overall metallicity of the star than with the planet formation. Abundance difference for the pairs of host/non-host stars with similar metallicities in -0.1 – +0.3 dex metallicity range does not show any significant trend with the condensation temperature.

8p01 - New powerful outburst of the unusual young star V1318 Cyg S (LkHa 225 S)

Andreasyan, Hasmik (Byurakan Astrophysical Observatory, Yerevan, ARM)

Young double star V1318 Cyg has very unusual photometric and spectral behavior. We analyze its historical lightcurve and show, that the southern component V1318 Cyg S after being rather bright (13-14 magnitude in V) in 70ies started to lower brightness and in the 1990 became practically invisible in optics and very faint in IR. After its reappearance in the second half of 90ies the star very slowly raised its brightness. In 2015 we found that V1318 Cyg S again brightened up to 7 magnitudes in visible light. We present the new photometric data and discuss its spectrum. V1318 Cyg S can be an extreme case of EXors or even belong to some intermediate class between EXors and FUors.

8p02 - Satellite observations as a powerful tool to study flares of you M-stars

Guenther, Eike (Thüringer Landessternwarte Tautenburg, Tautenburg, GER)

In our Solar System there are basically two species of planets: gas, or ice giants which have masses larger than 15 MEarth and densities between 0.7 to 1.6 gcm-3, and low mass, rocky planets with densities between 3.7 to 5.5 gcm-3. It was thus generally assumed that extrasolar planets should be the same. It was therefore a big surprise when it was found that exoplanets have an enormous diversity in densities. Some planets must have extended Hydrogen atmospheres while others are rocky. This diversity can naturally be explained if we assume most planets initially have a Hydrogen-rich atmosphere, where some lost it other did not. Theoretical studies show that the stellar EUV and X-ray (XUV) play a critical role for the atmospheric loss processes. Atmospheric loss processes, and thus the XUV-radiation from the host stars, determine whether planets become mini-Neptunes, or rocky planets with CO₂, or Nitrogen dominated atmospheres. Since young stars are more active than older ones, the main planetary erosion phase happens during the earliest stages of their evolution. In recent years it has become fashionable to search for low-mass planet in the so-called habitable zone of M-stars, because these are comparably easy to detect. However, the environment of such planets certainly is striking different from the environment of the current Earth, particularly during the first Myr of their lives. Important for the loss-processes are not only the EUV and X-ray (XUV) radiation of the star in quiescence but also the radiation released during flare events. In order to learn more about evolution of planets of M-stars we have carried out a study of the flare-activity in the 6-11 Myr old Upper Sco region using Kepler K2- data. The planet K2-33, which is orbiting an M-star, is also located in this region. The advantage in using space-based observations for this project is not only the high photometric accuracy but also the continuous time coverage that allows determining the statistics of these events
However, space-based observations always have to be flanked by ground-based observations to determine the properties of the stars and to study coronal-mass ejections.

8p03 - Starspots and Rotation Velocities of Normal A and Am Stars

Trust, Otto (Mbarara University of Science and Technology, Mbarara, UGA); Jurua, Edward (Mbarara University of Science and Technology, Mbarara, UGA); Joshi, Santosh (2Aryabhatta Research Institute of Observational Sciences, Manora Peak, Nainital-, IND)

Asteroseismology has proved to provide precise values of rotation frequencies of rotating stars with “hump and spike” features in their periodograms. In the presence of reliable values of stellar radius, precise values of equatorial rotation velocity can be obtained. In this study we determined the rotation velocity, approximate strength of starspots and magnetic field strength based on starspot size and decay lifetime of normal A-type and Am/Fm stars. Normal A-type and Am/Fm stars with “hump and spike” features were analysed using the *Kepler* continuous photometric data. From the “hump and spike” features in the frequency spectra, rotation frequencies and amplitude, and the rotation frequencies, equatorial rotation velocities were calculated. By fitting the autocorrelation function of the combined light-curves with appropriate models, starspot decay-time scale was determined. Spike rotation frequency was found to be equal to or greater than values determined from autocorrelation of light-curve. Spike rotation frequencies resulted in significant differences in equatorial rotation velocities. Using rotation amplitude as a proxy for starspot size, our results suggest that starspots in A/Am stars could be 32% smaller than previously determined values. On average the decay lifetime of A and Am stars is 3.0 and 3.4 days, respectively. In a number of cases, the autocorrelation function showed no signs of existing repeated patterns in the light-curves, yet such stars have the "hump and spike" features in the periodograms. This suggests the absence of co-rotating structures such as starspots. This could mean that the existence of spikes in the frequency spectra may not be strongly dependent on starspots. In comparison with G, K and M stars, starspots in normal A-type and Am stars could be weak or absent and so is the magnetic field.

8p04 - Ultraviolet variability of evolved B and Be stars

Krticková, Iva (Masaryk University, Brno, CZE); Krticka, Jirí (Masaryk University, Brno, CZE)

We study the ultraviolet variability of evolved B and Be stars. We use archival IUE observations to derive magnitudes of individual stars in selected bands in the near and far UV regions. We diagnose the variability in the lines and the total flux variability. From the derived light curves we discuss the origin of the UV light variability of studied stars.

8p05 - Type II Cepheids in the Kepler - K2 mission

Jurkovic, Monika I. (Astronomical Observatory Belgrade, Belgrade)

Type II Cepheids are old, low-mass (~0.5 $M_{\odot}$) stars. They, mainly, pulsate in a radial mode, but recent discoveries have showed that there are first overtone pulsators among them, and they can exhibit a phenomena called “period-doubling”. Anomalous Cepheids have an average mass of 1.2 $M_{\odot}$, and they pulsate in a fundamental mode, as well as, the first overtone. The Kepler space telescope's original field did not contain any Type II Cepheids, but that changed in the K2 mission.

Here we present the 12 stars that were observed in Cycles 1-14 of the K2 mission. We have derived the Fourier parameters for these stars, and compared them to Fourier parameters of known Type II Cepheids and anomalous Cepheids. The luminosities were obtained from a Period-Luminosity relation given by Groenewegen & Jurkovic, 2017, and than the results were cross-checked with the luminosities that were calculated from the parallaxes measured by the Gaia satellite.

We have found two Type II Cepheids that show possible “period doubling”, and four possible anomalous Cepheids among the 12 stars.

8p06 - A transiting exocomet detected in broadband light by TESS in the Beta Pictoris system

Zieba, Sebastian (Universität Innsbruck, Institut für Astro- und Teilchenphysik, Innsbruck, AUT); Zwintz, Konstanze (Universität Innsbruck, Institut für Astro- und Teilchenphysik, Innsbruck, AUT); Kenworthy, Matthew (Leiden Observatory, Leiden University, Leiden); Kennedy, Grant M. (Department of Physics, University of Warwick, Coventry, GBR)

We present the first observation of a falling evaporating body (FEB, also known as exocomet) in broadband photometry in the Beta Pictoris system. For this we used data from the Transiting Exoplanet Survey Satellite (TESS) collected over 105 days. We then identify and remove 54 delta Scuti frequencies. The resulting dip in the light curve has a typical asymmetric shape and is consistent with the predictions made 20 years earlier by Lecavelier et al. (1999). It also fits very well to a model of an evaporating comet with an extended tail crossing the disk of the star. Additionally, we also observe smaller, non-periodic dips of similar shape in the TESS light curve. This discovery confirms the earlier detection of exocomets in the Calcium H and K lines of the Beta Pictoris system using high-resolution spectroscopy.

8p07 - Stellar X-ray and UV irradiation of exoplanets

Joyce, Simon (University of Leicester, Leicester, GBR)

The evolution of planets is closely linked to the radiation received from their host stars. High energy X-ray and UV radiation influences the temperature and structure of the planetary atmosphere. In extreme cases, atmospheres can be evaporated away, such as in the case of some hot-Jupiter planets orbiting close to highly active stars. Investigating the XUV properties of main sequence stars and the evolution of these emissions over the stellar lifetime is key to placing the planets evolution in context with its radiation environment. As part of the Exoplanets-A project we are characterising known exoplanet host stars by gathering all available data, including X-ray and UV spectra. We present preliminary results of X-ray and UV studies and new observations with the Swift satellite designed to answer long standing questions about the variability and long term changes in stellar UV emissions.

8p08 - Numerical simulation on the stellar atmosphere and wind of cool stars.

Sakaue, Takahito (Kyoto University, Kyoto-shi, JPN)

We report the results of one-dimensional magnetohydrodynamics (MHD) simulation of the stellar atmosphere and wind of cool main-sequence stars (especially M-type stars). Cool main-sequence stars offer the good opportunities to observe what environments the Earth-like exoplanets are in, and how they are affected by the host star (e.g., Gillon et al. 2017). In particular, their stellar wind and radiation have a great impact on the interplanetary space, and it is important to realize their underlying physics. Since it is still challenging to measure directly the stellar atmosphere and wind, we have developed the numerical modeling to reproduce their properties. Magnetohydrodynamics (MHD), in this context, is essential to discuss the magnetic energy transfer and dissipation in the stellar atmosphere and wind. The nonlinear process related to MHD has been well investigated to account for the dynamics of the lower solar atmosphere (Kudoh & Shibata 1999) and driving the solar wind (Suzuki & Inutsuka 2005), but not discussed for the stellar atmosphere and wind of M-type stars. In this study, therefore, we performed the one-dimensional MHD simulation to consider the nonlinear process of MHD, and find that the reproduced stellar atmosphere of cool main-sequence stars is characterized with the thick chromosphere and their winds are relatively denser than solar wind.

8p09 - Ondrejov 2-m telescope– ground based support for exoplanetary space

Blažek, Martin (Masaryk University, Brno, CZE)

Ground based telescopes are an integral part of exoplanetary space missions. In this poster, we are going to present results from a high-resolution echelle spectrograph (OES) installed at the Perek 2-m telescope in Ondřejov, Czech Republic. This telescope is operated by the Czech Academy of Sciences and it is used mainly by an exoplanet group that recently formed. We focus here on results from monitoring of Kepler/K2 and TESS objects during 2018– 2019.

8p10 - Study of Far Infrared Nebula at Declination +53° (J2000) in IRAS Map”.

Sherchan, Sami Gauchan (Tribhuvan University-Prithvi Narayan Campus, Pokhara, NPL)

In this present work we studied the flux density variation, calculate temperature, dust mass and finally Jean’s mass of structure using data reduction software ALADIN2.5. Our aim was to test whether this region is star forming or not. Sky view observatory was used for the search of isolated nebular structure in the far infrared (100 μm and 60 μm) in IRAS (Infrared Astronomical Satellite) catalogue. Stellarium software was used to find coordinate of the structure. A far infrared dust structure (about ~ 11.99 × 3.14 pc.) at Right Ascension (J2000):01h 51m 56.02s Declination (J2000): +53deg 27m 39.0s found at the distance of about 550 pc. The dust color temperature was found to lie in the range 18.02 K to 39.56 K. An offset of about 21 K suggests that the structure is not independently evolved, discrete source may play significant role in structure formation mechanisms. The study of flux variation along major and minor axis of structure showed that mass is concentrate at the center of structure. The total mass of the gas structure was found to be about 1.1432× 1031Kg. The Jeans mass was found to be 1.17 x 1033Kg, more than that of the total mass of the structure, suggest no clue of star formation.

8p11 - Southern Bp-e star HD124448

Zboril, Milan (Slovakia, Poprad, SVK)

The atmospheres of early type He-rich stars are believed to be non-standars in several respects. The He-rich star HD124448 indicates also UV and visual emissions. Perhaps it is the reason for a bit broad interval of its basic stellar parameters. Using both UV and ground based observations the basic stellar parameters, evolutionary status, vsini and elemental abundances are re-examined.

9. LESSONS LEARNED

9k01 - Nanosatellite Technology

Koudelka, Otto (Graz University of Technology, Graz, AUT)

The Austrian components of BRITE Constellation are in orbit since February 2013. The BRITE satellites use industry-grade electronic components, which impose higher risk. The CCD sensors of the spacecraft experience degradation by radiation, but chopping was introduced to mitigate these effects. The design and procedures did not strictly follow ECCS standards, but care was taken not to compromise on testing, resulting in the very good performance after more than six years in space, which exceeds significantly the design lifetime of two years. The BRITE mission demonstrates that challenging scientific requirements can be met by small and relatively inexpensive spacecrafts with a lifetime comparable to traditional missions. I will present lessons learned in spacecraft design, spacecraft and payload operations as well as telemetry. Furthermore, experience and design results from other nanosatellite projects will be presented, such as the technology and demonstrator missions OPS-SAT (dedicated to on-board experiments and novel operational procedures) and PRETTY (passive reflectometry and dosimentry). Focus is put on how to make the spacecraft safe and robust despite the fact that COTS components are used.

9k02 - BRITE-Constellation Operations and Data Collection

Kuschnig, Rainer (Graz University of Technology, Graz, AUT)

BRITE-Constellation is a fleet of six nano-satellites, two each funded by Austria, Canada and Poland. The initial concept was introduced by Slavek Rucinski and UTIAS-SFL at the University of Toronto Canada in 2003. Each spacecraft has a 3cm aperture telescope feeding a CCD camera with a 24 degree field of view. The instruments have either a red or a blue passband and are designed to collect high precision photometry of the brightest stars in the sky (mag(V) < 5) during up to 6 months. All satellites have been launched between February 2013 and August 2014. The presentation will focus on challenges in the design, the performance in space during the past 6 years, the operational constraints and the aging effects of the hardware in low earth orbits.

9k03 - Lessons learned from Kepler and TESS

Antoci, Victoria (Stellar Astrophysics Centre, Aarhus, DNK)

Having a successful space mission relies not only on having a well-performing satellite but also on many other aspects connected to data delivery, data reduction as well as science output and dissemination. In this talk I will look back to the NASA Kepler/K2 as well as the ongoing TESS missions and highlight the scientific and non-scientific lessons I learned as a frequent user and being an active member of the Kepler and TESS Asteroseismic Science Consortia (KASC and TASC).

9k04 - Solar-Like Oscillations: Lessons learned and First Results from TESS

Huber, Daniel (University of Hawaii, Honolulu, USA)

The NASA TESS Mission is currently continuing the space-based photometry revolution in asteroseismology by obtaining high-cadence photometry for tens of thousands of stars. In this talk I will review some of the past challenges of detecting solar-like oscillations from the ground and from space. I will then highlight first results from TESS, including the precise characterization of transiting exoplanets orbiting oscillating subgiants, galactic archeology using red giants, and probing stellar models through simultaneous ground-based radial velocity observations. I will conclude with an outlook on future prospects for the study of solar-like oscillations using next-generation facilities.

9k05 - TESS RR Lyrae and Cepheid stars: first results

Plachy, Emese (Konkoly Observatory, MTA CSFK, Sopron, HUN)

With TESS, we are able to sample a large collection of Cepheids, although the mission only provides us with snapshots, due to their long pulsation periods. The Magellanic Clouds include many interesting targets, but blending and contamination is affecting the data quality. Nevertheless the combination of multiple sectors can produce valuable data sets. TESS will also be crucial for a rare and less understood anomalous Cepheid class, as we discovered the first sign of non-radial modes which seem to be the exact analogue to those observed in many overtone RR Lyrae and classical Cepheid stars. TESS is also observing the nearby population of RR Lyrae stars. We identified low-amplitude additional modes in a large fraction of them. We noticed differences in the distribution of these additional modes compared to the Bulge RR Lyrae population.

9o01 - Flares, shocks, and dust in the remarkable nova ASASSN-18fv --- a one in a million chance light-curve

Aydi, Elias (Michigan State University, East Lansing, USA)

Nova eruptions are sudden transient events taking place on the surface of accreting white dwarfs in interacting binary systems. Despite the transient nature of these events, the BRITE satellites network observed nova ASASSN-18fv in eruption, providing a one in a million chance light-curve which revealed multiple flares/maxima during an extended peak brightness. Such flares has puzzled astronomers for several decades while no clear mechanism has emerged to explain their formation. In addition, ASASSN-18fv has been observed as the brightest gamma-ray emitting nova. Such GeV gamma-ray emission from classical novae has altered our understanding of these eruptions and posed big questions on the standard model of novae, leading to a new proposed paradigm for nova emission being powered by strong shocks. The correlation between the optical and gamma-ray light-curves of ASASSN-18fv agrees well with this new paradigm and offers an explanation for the formation of the mysterious flares in nova light-curves.

9o02 - Pulsations in massive close binaries: TESS versus BRITE

Pigulski, Andrzej (Instytut Astronomiczny, Uniwersytet Wroclawski, Wroclaw, POL)

BRITE-Constellation observations allowed to discover p-mode pulsations (Beta Cephei-type) in close binaries that have massive components. This opened an opportunity of studying effects of distortion and heating by a companion on pulsations, including their excitation/damping. We will show and discuss these effects in several stars observed by BRITE and TESS, indicating also the synergy between these two space missions.

9o03 - Progress in the understanding of massive star interiors using BRITE and TESS

Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warsaw, POL)

BRITE and TESS are the two space photometry missions that provide data for the largest number of massive stars. However, the characteristics of the supplied light curves are quite different: whereas BRITE acquired two-colour observations with a time base of half a year, the single colour TESS measurements have much higher precision but are considerably shorter in time. In this presentation, selected asteroseismic results for Beta Cephei pulsators observed with the two missions are presented, and discussed in the context of how best use can be made of the underlying data. Special focus is put onto stars that have so far been observed with both missions, and projections of how BRITE and TESS will advance our knowledge on the interior structure of massive stars are attempted.

9o04 - Magnetic OB[A] Stars with TESS: probing their Evolutionary and Rotational properties - The MOBSTER Collaboration

David-Uraz, Alexandre (University of Delaware, Newark, USA); Neiner, Coralie (Observatoire de Paris, Meudon, FRA); Sikora, James (Queen's University, Kingston, CAN)

The Transiting Exoplanet Survey Satellite (TESS) mission will, over the course of its nominal 2-year mission, produce high-cadence high-precision light curves of stars over nearly the entire sky (~85%). This represents a golden opportunity not only for the exoplanet community but also for the entire field of stellar astrophysics. In particular, I will discuss the transformative potential of TESS to study magnetic massive and intermediate-mass stars, a topic that is currently plagued by small-number statistics. TESS light curves can help characterize known magnetic stars, as well as identify numerous high-priority magnetic candidates that can then be confirmed via ground-based spectropolarimetric follow-up studies. I will also present the MOBSTER Collaboration, a team of over 25 observers and theorists dedicated to using TESS data to better understand stellar magnetism in the upper Hertzsprung-Russell diagram and to developing/improving the theoretical framework required to interpret these data. Finally, I will provide an overview of some of our initial results and explore future plans and potential directions.

9p01 - A Machine Learning Technique to Search Periodic Variability from BRITE Data

Jiang, Ing-Guey (National Tsing Hua University, Hsin-Chu, TWN)

The main characteristics of BRITE data is the high time resolution during an interval of about 30 minutes, but a long silence between these intervals. Considering this characteristics, we have developed a numerical method based on machine learning to search for periodic variability from BRITE data. In addition to presenting our machine learning technique, which can be employed to search for any kind of periodic variability, we will show our recent results on searching exoplanet transits.

9p02 - TOSC: an algorithm for the tomography of spotted transit chords

Scandariato, Gaetano (INAF-OACt, Catania, ITA)

Photometric observations of planetary transits may show localized bumps, called transit anomalies, due to the possible crossing of photospheric starspots. The aim of this work is to analyze the transit anomalies and derive the temperature profile inside the transit belt along the transit direction. We develop the algorithm TOSC, a tomographic inverse-approach tool which, by means of simple algebra, reconstructs the flux distribution along the transit belt. We test TOSC against some simulated scenarios. We find that TOSC provides robust results for light curves with photometric accuracies better than 1~mmag, typical of current and future space photometers, returning the spot-photosphere temperature contrast with an accuracy better than 100 K. TOSC is also robust against the presence of unocculted spots, provided that the apparent planetary radius given by the fit of the transit light curve is used in place of the true radius. The analysis of space-borne and ground-based real data with TOSC returns results consistent with previous studies.

9p03 - Searching Exoplanet Transits from BRITE Data through Deep Learning Techniques

Yeh, Li-Chin (National Tsing Hua University, Hsin-Chu, TWN)

We have developed a procedure to search for exoplanet transits from BRITE data. Our procedure employs the convolutional neural network (CNN) of deep learning techniques. The observational data of five BRITE satellites are used as training data for our CNN models. The details of the procedure and the results will be presented.

9p04 - Asteroseismic analysis of the SPB star observed by TESS: HD54967

Walczak, Przemyslaw (Astronomical Institute Wroclaw University, Wroclaw, POL); Szewczuk, Wojciech (Astronomical Institute of the Wroclaw University, Wroclaw, POL); Daszynska-Daszkiewicz, Jadwiga (Astronomical Institute Wroclaw University, Wroclaw, POL)

HD54967 was observed by the TESS mission with 2-min cadence in Sectors 1 and 2. Its light curve revealed a rich frequency spectrum, mostly in the region of high-order g-modes. Our frequency analysis indicates the presence of quasi-equally period spacing, that allow for the mode identification and detailed seismic modelling.

We present the results of our asteroseismic analysis that brings constrains on physical processes occurring inside the star, including various mixing processes.

9p06 - Eclipsing binaries hiding in the background: the Kepler Pixel Project

Forró, Adrienn (MTA CSFK, Sopron, HUN)

The aim of the Kepler Pixel Project is to discover new pulsating and other type of variable stars in the individual pixels of the original Kepler fields in the background of the main targets. In the framework of the Kepler Pixel Project we found 1272 eclipsing binary candidates. After eliminating false positives and those stars that are already present in the Kepler Eclipsing Binary Catalog, we managed to discover more than 700 new eclipsing binaries. This is a substantial and significant addition to the 2909 eclipsing binaries already present in the Kepler Eclipsing Binary Catalog. We present the methods we applied, examine the 4-year (Q0-Q17) light curves of selected newly found variable stars, and discuss the implications of our findings for eclipsing binary and transiting exoplanet occurrence rates.

9p07 - Variability of HADS stars in TESS

Kotysz, Krzysztof (Uniwersytet Wroclawski, Wroclaw, POL)

TESS satellite provides superb-quality light curves for many variable stars. Among them there are high-amplitude δ Scuti stars (HADS) stars which pulsate mainly in radial modes with periods of the order of 1-3 hours. I will present the results of the analysis of TESS light curves for a sample of about 30 HADS stars from sectors 1-4. The pulsational behaviour of the sample will be characterized by means of the parameters of the Fourier decomposition and period ratios (Petersen diagram). The occurrence of non-radial modes and high radial overtones in HADS stars will be also discussed.

9p09 - Open clusters in TESS data

Mikolajczyk, Przemyslaw (Astronomical Institute, University of Wroclaw, Wroclaw, POL)

Even though TESS observatory will not observe the close vicinity of Galactic plane, it will provide substantial amount of photometric data for young open clusters and OB associations. Given the wide TESS field-of-view and its pixel scale (about 21 arcsec per pixel), it should be possible to analyse stellar variability inside sparse and spatially large open clusters. A few such objects have already been observed by TESS.

I will present preliminary results of the analysis of TESS photometry for several open clusters and comparison of these results with the available groundbased observations. I will focus on the variability among B-type stars, the variability due to pulsations in particular. This is the part of the project aimed at the incidence of variability at the upper main sequence and mapping the instability strips of the two main groups of main-sequence B-type pulsators, Beta Cephei and SPB stars.

9p10 - Pulsating Crux: alpha and beta Crucis as seen by BRITE and SMEI

Kolaczek-Szymanski, Piotr (Astronomical Institute of University of Wroclaw, Wroclaw, POL)

Alpha and beta Crucis (also known as Acrux and Mimosa respectively) are known spectroscopic binaries which primary and secondary components are massive B-type stars. During my talk I wolud like to present fourier analysis results of their BRITE and SMEI lightcurves, thanks to which five new pulsation frequencies of Acrux were discovered and ten new pulsation modes were found in Mimosa. Because of the total time span of BRITE and SMEI observations exceeding nearly 8.5 years, it was possible to show that almost every detected pulsation mode has been changing its amplitude over the years. Some of the analysed variations can be defined as rapid, taking their place during time intervals comparable to one year duration. Recently, it is one of the most intriguing questions in astrophysics - which modes are vulnerable to amplitude changes an why they do so? Finally, thanks to the light travel time effect, the orbital elements of Mimosa were detemined with higher precision compared to the ones presented in the literature.

9p11 - Detection threshold relation in Fourier periodograms

Kolaczek-Szymanski, Piotr (Astronomical Institute of University of Wroclaw, Wroclaw, POL)

One of the most popular methods of stellar pulsation frequencies extraction is based on Fourier analysis. Unfortunatelly, the classical Fourier periodograms do not have well defined statistical properties like e.g. signal detection threshold, assuming some specific confidence level. During the pre-whitening procedure one is eventually forced to decide at which level the whole algorithm has to be terminated or (in more statistical sense) what is the confidence level of signal with specific amplitude value? To answer this question I have run 20 sets of Monte Carlo simulations for 20 different values of total lightcurve time span and numerically calculated the probability of positive detections as a function of injected signal amplitude. The simulations were performed on both synthetic and real data (e.g. TESS, BRITE, Kepler, SMEI, OGLE lightcurves). For practical purposes, the low order polynomial was fitted to obtained results and it may be used as estimated detection threshold in fourier-based periodogram.

9p12 - UVSat mission concept as a future extension of BRITE science

Wawrzaszek, Roman (Centrum Badan Kosmicznych PAN, Warsaw, POL); Handler, Gerald (Centrum Astronomiczne im. M. Kopernika PAN, Warsaw, POL); Kosiec, Jacek (Creotech Instruments S.A., Piaseczno, POL); Mochnacki, Stefan (University of Toronto, Department of Astronomy & Astrophysics, Toronto, Ontario,, CAN); Orleanski, Piotr (Centrum Badan Kosmicznych PAN, Warsaw, POL); Pigulski, Andrzej (Instytut Astronomiczny, Uniwersytet Wroclawski, Wroclaw, POL); Sarna, Marek (Centrum Astronomiczne im. M. Kopernika PAN, Warsaw, POL)

The five working BRITE Constellation nanosatellites show outstanding performance. Nevertheless, the oldest satellites in the constellation have now been operating in orbit for seven years, which is much longer than was expected during the preparation of these satellites. To continue successful and fruitful activity, a concept for a new generation of satellites and their mission should be proposed. With this goal, we present results of the Phase 0 study of the UVSat mission, which will introduce a new quality of observation for astroseismology and the investigation of stellar variability. We propose a mission concept which assumes observation and study of stars at shorter wavelengths than currently implemented on the BRITE satellites. The UVSat satellites would be complementary to BRITE and extend their capabilities. The main goal of the proposed new project is to acquire vital astronomical data for various astrophysical objects in the ultraviolet (UV) range. The electromagnetic spectrum can be studied by recording the time-variable flux of incoming radiation integrated over a wide band and covering a wide field of view (imaging photometry), or by spectral analysis at many wavelengths in a small field of view (spectroscopy). Based on the UV Satellite Feasibility Study, and subsequent work and analysis, the following options for the implementation of the satellite UV observation system have been formulated:

1. One satellite with an onboard photometric (imaging) instrument;
2. One satellite with an onboard spectrometric instrument;
3. A constellation of two (photometric plus spectrometric, or two photometric) or three (two photometric and one spectrometric) satellites;
4. One satellite with both instruments (photometer and spectrometer) on board.

The planned research infrastructure will be diverse: on the one hand a satellite or satellite system in low Earth orbit (LEO), on the other hand, a Ground Station connected to dispersed scientific users.

9p13 - The Warsaw BRITE ground station and its potential in small satellite missions

Wozniak, Grzegorz (N.Copernicus Astronomical Center of Polish Academy of Sciences, Warsaw, POL); Marciniszyn, Grzegorz (N.Copernicus Astronomical Center of Polish Academy of Sciences, Warsaw, POL); Handler, Gerald (Nicolaus Copernicus Astronomical Center, Warsaw, POL)

The Warsaw Ground Station for the BRITE mission in Warsaw was built in 2011. It is located in the Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences. Since 2013 it is used to control the two Polish BRITE satellites. Communication with these satellites is based on receiving data in the S-Band and transmitting in the UHF band. The main antenna mast is configured for this purpose. Thanks to the additional VHF/UHF antenna set on a separate mast it is able to work with other small scientific and amateur missions. Its usefulness has been proven during several student satellite missions, ISS, ARISS and weather satellite reception. The BRITE ground station facility is also open for other communication bands and transmission updates and experiments. This poster presents resources and abilities of the BRITE Ground Station which can be used for future small satellite missions.

10. FUTURE

10k01 - PLATO mission status

Rauer, Heike (DLR, Berlin, GER); Cabrera, Juan (Deutsches Zentrum fuer Luft- und Raumfahrt, Berlin, GER); Team, PLATO (Europe, Europe, GER)

PLATO is the M3 ESA Cosmic Vision mission scheduled for launch in 2026. It is devoted to the search for planets, down to the size of the Earth orbiting up to the habitable zone of solar like stars, and the characterization of stars and planetary systems with asteroseismology in terms of radii, masses, and ages. The instrument consists of 26 cameras of 12 cm pupil diameter, equipped with 104 CCDs, operating in the visible wavelength range. In 2019 the instrument successfully passed the preliminary design review and the project has started the implementation phase. In this talk we will present a summary of the current status of the mission with focus on the instrument development, the instrument calibration and characterization activities, and the system level performance.

10k02 - PLATO instrument: end-to-end photometry performance and seismic potentials

Samadi, Réza (LESIA - Observatoire de Paris, Meudon, FRA)

After a quick presentation of the instrumental concept of the PLATOmission, we will describe the different sources of disturbances that the payload will face and the methods envisaged to correct them. We will present the photometric extraction method adopted on board as well as the ground correction chain of light curves. Then, we will show the expected photometric performances of the mission together with the PLATO solar-like light-curve simulator (PSLS) developed as part of the scientific preparation. Finally, we will describe the expected seismic potentials for the main targets of the mission.

10k03 - PLATO: Complementary Science

Tkachenko, Andrew (Institute of Astronomy, KU Leuven, Leuven, BEL)

In this talk, we will introduce the concept of the PLATO Complementary Science (PLATO-CS) program which stands for 8% of the total PLATO mission observing time. Following short introduction into the organization and management of the PLATO-CS program, we will provide overview of its individual scientific components that have been identified so far. We will outline steps that are currently being taken to test the scientific model of PLATO-CS using both simulated data by means of the PlatoSim end-to-end simulator tool and real white-light space-based photometric data that is being currently delivered by the TESS mission.

10k04 - The CHEOPS mission

Benz, Willy (University of Bern, Bern, CHE)

The CHaracterising ExOPlanet Satellite (CHEOPS) was selected as the first small mission (S-mission) in the ESA Science Programme. CHEOPS will be the first mission dedicated to search for transits of exoplanets by means of ultrahigh precision photometry on bright stars already known to host planets. The science case of CHEOPS includes among others improving the mass-radius relation for small mass planets, measuring characteristics of planetary atmospheres by following phase curves, and more generally providing the best possible targets for later spectroscopy studies.

10k05 - CHEOPS & stars (& asteroseismology)

Moya Bedon, Andres (University of Birmingham, Birmingham, GBR); Barcelo-Forteza, Sebastia (Centro de Astrobiología (CAB, CSIC-INTA), GBR)

CHEOPS is the first ESA-S mission. It is mainly devoted and designed for monitoring exoplanetary transits. Despite this fact, stellar physics is needed to properly analyze the observational data in the context of the main scientific goal. There is also a number of additional science that can be carried out related to stellar physics. And, finally, there is also room for the asteroseismic analysis of the CHEOPS lightcurves. In this talk, I present all the work being done by the stellar physics community for the CHEOPS mission, the asteroseismic potential of CHEOPS, and open opportunities this mission offers.

10k06 - ARIEL – Atmospheric Remote-sensing Infrared Exoplanet Large-survey

Tinetti, Giovanna (University College London, London, GBR)

ARIEL, the Atmospheric Remote-sensing Infrared Exoplanet Large-survey, was selected as the fourth medium-class mission in ESA's Cosmic Vision programme. During its 4-year mission, ARIEL will study what exoplanets are made of, how they formed and how they evolve, by surveying spectroscopically a diverse sample of about 1000 extrasolar planets, simultaneously in visible and infrared wavelengths. It is the first mission dedicated to measuring the chemical composition and thermal structures of hundreds of transiting exoplanets, enabling planetary science far beyond the boundaries of the Solar System. The ARIEL mission payload and science case is developed by a consortium of more than 50 institutes from 18 ESA countries. This talk provides an overall summary of the science and baseline design derived during the phase A study and further progressed during phase B1.

10k07 - Glorious future

Lüftinger, Theresa (Institut für Astrophysics, Wien, AUT)

Space missions like BRITE-C, CHEOPS, and PLATO are upcoming in the near future or already operational. They have been and are hugely enriching our knowledge on stars and their planets, but of course additional quests and open issues will be tackled by a number of groundbreaking space missions in the near and also more distant future. In this talk we will - scientifically and technically - review relevant space missions from ESA, NASA, JAXA, CNSA, etc. - planned and already selected, that have the potential to enormously advance our knowledge on stars and their planets and provide a Glorious Future for Stars from Space.

10o01 - Pulsating stars in Ultraviolet: GALEX and WSO-UV

Sachkov, Mikhail (Institute of Astronomy RAS, Moscow, RUS)

We present recent results of pulsating star studies based on ultraviolet data of GALEX mission. Data were obtained for stars of the Galaxy Evolution Explorer (GALEX) Complete All-Sky UV Survey Extension (CAUSE) in the photometric waveband GALEX NUV (1771-2831 Å). Amplitude of UV light curves are much larger than that in Johnson R and hence they are much more sensitive to the effective temperature change during pulsation cycle. Using of UV data allows to increase an accuracy of Cepheid fundamental parameter estimation such as radius and hence this is a key to distance determination. We also discuss future prospects of WSO-UV mission for such studies.

10p01 - The CUTE Small Satellite Mission

Fossati, Luca (Austrian Academy of Sciences, Space Research Institute, Graz, AUT)

Exoplanets in short-period orbits provide a unique opportunity to observe phenomena critical to the development and evolution of our own solar system, including atmospheric escape, interaction with the host star, and the potential to study exoplanetary magnetism. At present, the theories explaining atmospheric mass-loss exceed the number of relevant transit observations because these processes cannot be observed in broad-band visible/NIR light curves. Owing to their large sizes and short-periods, the physics of atmospheric mass-loss can be studied with a dedicated small instrument operating in the near-ultraviolet. I will present the Colorado Ultraviolet Transit Experiment (CUTE), a 6U CubeSat mission that will spectrally isolate diagnostic atomic and molecular transitions arising within the upper planetary atmospheres to study the physics of atmospheric escape and possibly detect the presence of magnetic fields on exoplanets. CUTE is planned for launch in mid-2020, with a baseline survey program designed to observe about 10 transits of approximately 12 bright exoplanetary systems. CUTE's flexible observing plan also allows for coordinated UV-optical-infrared observations of particularly interesting bright targets with a number of current and future facilities.

10p02 - Multi-Epoch Asteroseismology and Stellar Evolution at the Top of the Main Sequence

Buzasi, Derek (Florida Gulf Coast University, Fort Myers, USA)

Though few in number, massive stars play an outsized role in the dynamics of the universe through their roles in chemical enrichment and as Type II supernova progenitors. Models of their stellar structure and evolution are limited by our understanding of internal stellar processes such as angular momentum transport, internal rotation profiles, chemical mixing, and magnetic fields. However, improving our understanding of these objects remains fundamental to our knowledge of astrophysical topics as diverse as star formation, stellar winds, and the evolution of the interstellar medium. Asteroseismology is a key component to this understanding and fortunately, many massive stars show Beta Cep and SPB oscillations. These oscillations are accessible to space-based observatories of small aperture due to the intrinsic brightness of the stars and the relatively large oscillation amplitudes, though mode identification remains a problem.

Space-based high-precision photometry has now come of age, epitomized by missions past and present such as WIRE, MOST, CoRoT, Kepler, BRITE, and TESS. In fact, 2019 marks the twentieth anniversary of space-based asteroseismology, and we are entering a regime where many massive stars have been observed multiple times during different epochs by multiple missions. Given the speed of evolutionary change at the top of the main sequence, such long temporal baselines may allow the possibility of observing evolutionary changes directly. In this paper, I will describe ongoing projects to make use of multiple space-based photometric data sets to search for such signatures, discuss what we might reasonably expect to learn, and suggest projects for future observers.

10p03 - Gaia Successor with International Participation

Høg, Erik (Copenhagen University, Bagsvaerd, DNK); Hobbs, David (Lund Observatory, Lund, SWE)

Astrometric data from the current Gaia are already revolutionizing astronomy in all branches from the solar system and stellar structure to cosmic distances and the dynamics of the Milky Way. In April 2018, the second data release based on 22 months of observations gave 5-parameter astrometry for more than 1.3 billion sources while subsequent releases will give increasingly accurate and comprehensive sets of astrophysical data. The final Gaia data set will presumably be based on 8-10 years of observations thus providing a new astrometric foundation of all astronomy. It is however clear that a Gaia successor in twenty years for observation of the same stars is required in order to maintain and strengthen the astrometric foundation of astronomy. The two missions together will provide motions with 10-20 times better accuracy than Gaia alone for the observed objects, be it stars in the Halo or in galaxies or objects in our solar system or binary stars with sub-stellar components etc.

Gaia operates in optical wavelengths, and thus it is blind to several physical processes taking place within obscured regions of the Milky Way. A mission in NIR (at a bandpass of 400-1800 nm), however, would be able to unravel these processes, and would also multiply the number of observed objects by a factor about ~2.5 down to G=21 mag. This is the factor for the whole sky while a further factor 2 is expected in the Galactic region (b=+-10 deg). In 2017 ESA studied such a NIR space observatory (GaiaNIR). The outcome was that it requires new types of NIR Time Delay Integration (TDI) detectors to scan the entire sky and to measure global absolute parallaxes. The ESA study also hinted that a US-European collaboration would be the optimal answer to make GaiaNIR science and technology a reality. We have therefore in March together with US colleagues submitted a proposal, available at http://www.astro.ku.dk/~erik/xx/WhitePaperNIRSpaceAstrometry.pdf, for such a study in the US Decadal Survey.

Gaia is an ESA-only mission as Hipparcos was and we thought a Gaia successor should be the same. Recently however, we have realized the importance of strengthening our efforts by international collaboration. This has begun by involving the USA and it appears there is considerable interest also in Japan.

10p04 - CHEOPS: CHaracterising ExOPlanet Satellite – Community Access to CHEOPS

Isaak, Kate (ESA/ESTEC, Noordwijk)

CHEOPS (CHaracterising ExOPlanet Satellite) is the first exoplanet mission dedicated to the search for transits of exoplanets by means of ultrahigh precision photometry of bright stars already known to host planets.

The first S- or small-class mission in ESA's Cosmic Vision 2015-2025, the mission is a partnership between Switzerland and ESA, with important contributions from 10 other member states. It will provide the unique capability of determining accurate radii for a subset of those planets in the super- Earth to Neptune mass range, for which the mass has already been estimated from ground-based
spectroscopic surveys. It will also provide precision radii for new planets discovered by the next generation of ground- and space-based transit surveys. By combining known masses with CHEOPS sizes, it will be possible to determine accurate densities of subsaturn size planets, providing key insight into their composition and internal structure. By identifying transiting exoplanets with high potential for in-depth characterisation – for example, those that are potentially rocky and have thin atmospheres - CHEOPS will also provide prime targets for future instruments suited to the spectroscopic characterisation of exoplanetary atmospheres.

The high photometric precision of CHEOPS will be achieved using a photometer covering the 0.35 - 1.1um waveband, designed around a single frametransfer CCD which is mounted in the focal plane of a 30 cm equivalent aperture diameter, f/5 on-axis Ritchey-Chretien telescope.

CHEOPS will reach a photometric precision of 20 parts per million in a 6 hour observation of a v-band magnitude 9, G-type (Teff=5500K) dwarf, commensurate with measuring the transit depth of an Earth-size planet transiting the same star to a signalto-noise of 5. In the case of fainter stars, CHEOPS will reach a photometric precision of 85 parts per million in a 3 hour observation of a v-band magnitude 12, K-type (Teff=4500K) dwarf.

CHEOPS will launch in the timeframe of October- November 2019. 80% of the observing time in the 3.5 year nominal mission lifetime will be taken by the Guaranteed Time Programme, defined by the CHEOPS Science Team. The remaining 20% will be available to Guest Observers from the Community through a competitive proposal submission process, comprising annual Calls and a discretionary time component.

In this poster we give an overview on Community access to CHEOPS, with an emphasis on the ESArun Guest Observers Programme.

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Schedule: August 19 to 23 – Morning

MORNING SESSIONS

	MO	TU	WE	TH	FR
09:00	OPENING	Key-4k1	Oral-5o10	Key-8k1	Key-10k1
09:10			Oral-5o11		
09:20		Key-4k2		Key-8k2	Key-10k2
09:30	Introduction		Oral-5o12		
09:40			Oral-5o13		
09:50	1i01 1i02 1i03 1i04 1i05 1i06	Key-4k3		Key-8k3	Key-10k3
10:00			Oral-5o14		
10:10		Oral-4o1	Oral-5o15	Oral-8o1	Oral-10o1
10:20					
10:30	COFFEE				COFFEE
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11:00	Key-2k1	Oral-4o2	Key-6k1	Key-8k4	Key-10k4
11:10		Key-5k1			
11:20	Key-2k2		Key-6k2	Key-8k5	Key-10k5
11:30					
11:40		Key-5k2			
11:50	Oral-2o1		Oral-6o1	Oral-8o2	Key-10k6
12:00	Oral-2o2	Key-5k3	Oral-6o2	Oral-8o3	
12:10					Key-10k7
12:20			Oral-6o3	Oral-8o4	
12:30	LUNCH BREAK				LUNCH BREAK .....
12:40					12:40 **Conf. Summ.**
12:50					
13:00					
13:10					
13:20					

Conference Picture: Tuesday 12:30

Schedule: August 19 to 22 – Afternoon

3.7.19

AFTERNOON SESSIONS

		MO	TU	WE	TH		
13:50	.... Lunch break	Key-3k01				.... Lunch break	13:50
14:00			Key-5k04	Oral-6o04	Oral-8o05		14:00
14:10		Key-3k02		Oral-6o05	Key-9k01		14:10
14:20			Key-5k05				14:20
14:30				Oral-7o01			14:30
14:40		Key-3k03		Oral-7o02	Key-9k02		14:40
14:50			Key-5k06				14:50
15:00		Key-3k04		Oral-7o03	Key-9k03		15:00
15:10			Key-5k07	Oral-7o04			15:10
15:20							15:20
15:30		Key-3k05		Oral-7o05	Key-9k04		15:30
15:40			Oral-5o01	**Social Program**			15:40
15:50							15:50
16:00	C O FF EE					C O FF EE	16:00
16:10							16:10
16:20		Key-3k06	Oral-5o02	**open end**	Key-9k05		16:20
16:30							16:30
16:40			Oral-5o03				16:40
16:50		Key-3k07	Oral-5o04		Oral-9o01		16:50
17:00					Oral-9o02		17:00
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17:20			Oral-5o06		Oral-9o03		17:20
17:30					Oral-9o04		17:30
17:40		Oral-3o01	Oral-5o07				17:40
17:50		Oral-3o02	Oral-5o08				17:50
18:00							
18:10		Oral-3o03	Oral-5o09				

19:15 Reception Townhall ... (MO)

19:00 Reception Academy of Sciences ... (TH)