The RR Lyrae 2017 Conference

Revival of the Classical Pulsators:
from Galactic Structure
to Stellar Interior Diagnostics

17–21 September 2017
Niepołomice Royal Castle, Niepołomice, Poland

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The conference is organized by the Polish Astronomical Society with the support from the Polish Ministry of Science and Higher Education and from the Nicolaus Copernicus Astronomical Center, Warsaw, Poland.

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Conference program

SUNDAY, September 17th		
19:00–21:00	**Registration & Welcome Reception at the Niepołomice Royal Castle**	
MONDAY, September 18th		
08:00–09:00	Registration	
09:00–09:10	Opening	
Session I: Ground-Based Surveys		**Chair: Katrien Kolenberg**
09:10–09:50	Maurizio Salaris	**(Invited)** Structure and evolution of RR Lyrae and Cepheids (p. 13)
09:50–10:30	Igor Soszyński	**(Invited)** Classical pulsators in optical photometric surveys (p. 14)
10:30–11:00	coffee break	
11:00–11:40	Dante Minniti	**(Invited)** Classical pulsators in infrared photometric surveys (p. 15)
11:40–12:00	Zdenek Prudil	The Oosterhoff dichotomy in the Galactic bulge (p. 16)
12:00–12:20	Gustavo Medina Toledo	Distant RR Lyrae from HiTS: Exploring the outskirts of the Milky Way (p. 17)
12:20–12:40	Martin Groenewegen	Properties of Anomalous and Type-II Cepheids in the Magellanic Clouds (p. 18)
12:40–14:00	lunch	
Session II: Classical Pulsators in Stellar Systems		**Chair: Paweł Moskalik**
14:00–14:40	Marcella Marconi	**(Invited)** Studying stellar systems with classical pulsators (p. 19)
14:40–15:00	Hui Dong	Identification of RR Lyrae stars in the Milky Way Nuclear Star Cluster (p. 20)
15:00–15:20	Javier Alonso-García	RR Lyrae stars in the inner Galactic globular clusters (p. 21)
15:20–15:40	coffee break	
15:40–16:00	Nina Hernitschek	The geometry of Sagittarius Stream from Pan-STARRS1 3π RR Lyrae (p. 22)
16:00–16:20	Anna Jacyszyn-Dobrzeniecka	Three-dimensional structure of the Magellanic System using OGLE Cepheids and RR Lyrae stars (p. 23)
16:20–16:40	Bertrand Lemasle	Chemical composition of Cepheids in the Milky Way and in the Magellanic Clouds (p. 24)
16:40–17:00	Dorota Skowron	Photometric metallicity from OGLE-IV RRab stars in the Magellanic Clouds (p. 25)
18:00–19:00	**Sightseeing of the Niepołomice Castle**	
19:00–21:00	**Open-air BBQ dinner at the Podegrodzie Settlement (Niepołomice Castle)**	

TUESDAY, September 19th		
09:00–09:30	Poster session	
09:30–09:50	Nahathai Tanakul	RR Lyrae variables in M31 and its satellites: an analysis of the galaxy's population (p. 26)
Session III: Classical Pulsators from Space		**Chair: Karen Kinemuchi**
09:50–10:30	Gisella Clementini	**(Invited)** Gaia and classical pulsators (p. 27)
10:30–11:00		coffee break
11:00–11:20	Lorenzo Rimoldini	All-sky RR Lyrae stars in the Gaia data (p. 28)
11:20–12:00	László Molnár	**(Invited)** Letters from the revolution: how is space photometry changing our view of stars (p. 29)
12:00–12:20	Emese Plachy	K2 photometry of RR Lyrae stars (p. 30)
12:20–12:40	Róbert Szabó	The Kepler Pixel Project (p. 31)
12:40–14:10		lunch
14:10–14:30	Ottó Hanyecz	New RR Lyrae stars in the original Kepler field (p. 32)
14:30–14:50	Géza Kovács	Big signals, small signals, systematics (p. 33)
Session IV: Blazhko Effect and Other Dynamical Phenomena		**Chair: Johanna Jurcsik**
14:50–15:30	Zoltán Kolláth	**(Invited)** Modeling and/or understanding the Blazhko effect (p. 34)
15:30–15:50	József Benkő	Blazhko light curves – non-modulated and harmonic detuned signals (p. 35)
15:50–16:20		coffee break
16:20–16:40	Radek Smolec	Unstable standard candles – periodic modulation of pulsation in Magellanic Clouds' Cepheids (p. 36)
16:40–17:00	Ennio Poretti	Cyclic variations on the periods of RR Lyr and Cepheid stars (p. 37)
17:00–17:20	Maria Süveges	Beyond strictly repetitive radial-mode pulsation: time-resolved analysis of the pulsation of OGLE Cepheids (p. 38)
17:20–17:40	Henryka Netzel	First-overtone RR Lyrae stars in the OGLE collection (p. 39)
17:40–18:00	Paweł Moskalik	K2 observations of double-mode RR Lyrae stars (p. 40)
19:00–21:00	**Presentation of the Youth Astronomical Observatory in Niepołomice**	

WEDNESDAY, September 20th		
Session V: Period-Color-Luminosity Relations		**Chair: Nancy Evans**
09:00–09:40	Jesper Storm	**(Invited)** Distances of classical pulsators (p. 41)
09:40–10:00	Jan Lub	Metallicity dependence of RR Lyrae absolute magnitudes and GAIA (p. 42)
10:00–10:20	Johanna Jurcsik	Baade-Wesselink analysis of RR Lyrae stars in the globular cluster M3 (p. 43)
10:20–10:40	Matteo Monelli	WINERED as a stepping stone for cosmic distance scale (p. 44)
10:40–11:10		coffee break
Session VI: Interferometry, Radial Velocities and p-factor		**Chair: Róbert Szabó**
11:10–11:50	Richard Anderson	**(Invited)** Radial velocity observations of classical pulsators (p. 45)
11:50–12:30	Pierre Kervella	**(Invited)** Interferometry of classical pulsators (p. 46)
12:30–14:00		lunch
14:00–14:20	Simon Borgniet	Deriving the pulsation velocities and temperatures of Cepheids and other pulsators from high-resolution spectra (p. 47)
14:20–14:40	Boris Trahin	Pulsational modelling and projection factor of RR Lyrae stars (p. 48)
14:40–15:00	Nicolas Nardetto	The atmosphere, the p-factor and the bright visible circumstellar environment of the prototype of classical Cepheids delta Cep (p. 49)
15:00–15:20	Valeriy Vasilyev	Spectroscopic properties of a multi-dimensional Cepheid model (p. 50)
15:20–15:50		coffee break
15:50–16:50	Kepler & TESS WG Meeting	
17:30–23:00	**Wieliczka Tour & Conference Dinner**	

THURSDAY, September 21st		
Session VII: New Phenomena		**Chair: Nicolas Nardetto**
09:00–09:20	Nancy Evans	Outward from Cepheids (p. 51)
09:20–09:40	Paweł Pietrukowicz	The discovery of Blue Large-Amplitude Pulsators (p. 52)
Session VIII: Binarity		**Chair: Nicolas Nardetto**
09:40–10:20	Grzegorz Pietrzyński	**(Invited)** Classical pulsators in binary systems (p. 53)
10:20–10:50		coffee break
10:50–11:10	Bogumił Pilecki	What (and how) we can learn about pulsating stars using eclipsing binaries (p. 54)
11:10–11:30	Marek Skarka	On the interpretation of the long-term cyclic period variations (p. 55)
11:30–11:50	Gergely Hajdu	Continued search of RR Lyrae binary systems towards the Galactic bulge (p. 56)
11:50–12:20	Discussion – Present and future of classical pulsators studies. Moderators: Karen Kinemuchi & Katrien Kolenberg	
12:20–12:30	Closing Remarks	
12:30–14:00		lunch

Poster contributions

	First Author	Title
1	Abdelmjid Benhida	Campaign of spectrophotometric measures of the variable star RR Lyrae obtained in 2015 and 2016, in the Astronomical Observatory Oukaimeden in Morocco (p. 59)
2	Attila Bódi	Shockwave behaviour in RR Lyrae stars (p. 60)
3	Jean-Francois Le Borgne	The GEOS RR Lyr database (p. 61)
4	Borbála Cseh	Multicolor photometry of peculiar Cepheid stars observed in the Konkoly Observatory (p. 62)
5	Alexandre Gallenne	Toward a universal period-p-factor relation (p. 63)
6	Paul Greer	O-C investigations of RRab from the SuperWASP archive (p. 64)
7	Gergely Hajdu	The hidden potential of VVV RR Lyrae light curves (p. 65)
8	Seokjoo Joo	A KMTNet search for RR Lyrae stars in the ultra-faint dwarf galaxies in the southern sky (p. 66)
9	Áron Juhász	From PanSTARRS candidates to new RR Lyraes in the K2 mission (p. 67)
10	Johanna Jurcsik	On the relations of the light curve parameters of RR Lyrae stars in globular clusters (p. 68)
11	Monika I. Jurkovic	Anomalous Cepheids among short period Type II Cepheids in the Milky Way (p. 69)
12	Paulina Karczmarek	The occurrence of binary evolution pulsators in classical instability strip of RR Lyrae and Cepheid variables (p. 70)
13	Krzysztof Kotysz	Close non-radial modes and modulation in first overtone Cepheids (p. 71)
14	Charles Kuehn	RR Lyrae in the dSph UMi Galaxy (p. 72)
15	Ricardo Munoz	Serendipitous discovery of RR Lyrae in the Leo V dwarf galaxy (p. 73)
16	Weronika Narloch	A ground-based proper motion study of twelve nearby globular clusters (p. 74)
17	Chow Choong Ngeow	A brief overview of the Palomar Transient Factory (PTF) and recent progress of PTF-RRL Program at the National Central University (p. 75)
18	Emese Plachy	On the period doubling behaviour of three W Vir stars (p. 76)
19	Emese Plachy	The global flow reconstruction of DF Cyg (p. 77)
20	Joonas Saario	The evolutionary picture of Type II Cepheids (p. 78)
21	Fouad Sefyani Lakrizi	Behavior of the doubling of metal Lines as function to the Blazhko phase in the spectra of RR Lyrae star (p. 79)
22	Marek Skarka	Photometric differences between modulated and non-Blazhko RRab Lyrae stars in the Galactic bulge (p. 80)
23	Radek Smolec	Periodic modulation and period doubling in type II Cepheids from the OGLE Galactic bulge collection (p. 81)
24	Marzena Śniegowska	Non-radial pulsation in the first overtone Cepheids of the Magellanic Clouds (p. 82)

Invited and contributed talks

Structure and evolution of RR Lyrae and Cepheids

(Invited review)

Maurizio SALARIS

Astrophysics Research Institute – Liverpool John Moores University, UK

The 'classical' RR Lyrae and Cepheids pulsators have played and still play a major role in the determination of Galactic and extragalactic distances. This review will focus on the evolution of both surface and internal properties of these pulsators, discussing in particular the evolution in the Hertzsprung-Russell diagram, the crossing(s) of the appropriate instability strip (that determine the observed period distribution in a given stellar population), and the major existing uncertainties in modelling the evolutionary paths and the internal structure of these objects.

Classical pulsators in optical photometric surveys

(Invited review)

Igor SOSZYŃSKI

Warsaw University Observatory, Poland

The first large-scale long-term sky variability surveys – EROS, MACHO and OGLE – were launched a quarter of a century ago and in the next years they found many followers. Such projects have quickly revolutionized the studies on variables stars, in particular on classical pulsators. Tens of thousands of new Cepheids, RR Lyr stars and other pulsating variables have been discovered and analyzed. These huge samples of pulsating stars contain objects of very rare or even previously unknown types. Well-sampled, long-term light curves have been used to identify and characterize exotic multi-mode pulsations, secular changes, mode switching, Blazhko effect, and pulsating stars in binary systems. The complete catalogs of standard candles have been used to study the structure and evolution of the Milky Way and other galaxies. I will present the latest results on classical pulsating stars from the optical sky surveys, with particular focus on the OGLE project which continuously collects photometric data for over one billion stars.

Classical pulsators in infrared photometric surveys

(Invited review)

Dante MINNITI

Universidad Andrés Bello/Millennium Institute of Astrophysics/CATA/Vatican Observatory

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RR Lyrae and classical Cepheid variable stars are excellent distance indicators, and they allow us to measure reddenings. They probe extremes of the Milky Way stellar populations: the very old and metal-poor *vs* the very young and metal-rich. Their study impacts on the fields of Galactic structure, stellar evolution, star clusters, the interstellar medium, and Galaxy formation, among others. In this review talk I will cover the results of the infrared photometric surveys on these classical pulsators in different Galactic environments: the Galactic disk, centre, bulge, halo, and clusters. I will concentrate mostly on the VISTA Variables of the Via Lactea Survey (VVV), that is a large ESO Public near-IR survey of the Southern Milky Way (http://vvvsurvey.org). In the first part of the talk I will describe the design, observations, data processing, and current status of the VVV Survey and its on-going extension VVVX. In the second part I will summarize the RR Lyrae and Cepheid discoveries made by this and other IR photometric surveys of the Milky Way.

The Oosterhoff dichotomy in the Galactic bulge

Zdenek PRUDIL [1], *Eva GREBEL* [1], *Istvan DÉKÁNY* [1] & *Radek SMOLEC* [2]

[1] Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Germany
[2] Nicolaus Copernicus Astronomical Center, Warsaw, Poland

We explore the possibility that the Oosterhoff dichotomy in fundamental-mode RR Lyrae stars exists also in the Galactic bulge. We utilized data from the OGLE-IV survey together with a recently published list of non-modulated RR Lyraes in this region. The aforementioned stars form two hook patterns in the Fourier parameter space. These structures can be well separated by dividing them in the period-I band amplitude plane, which resembles the division of Oosterhoff groups known from other samples of RR Lyrae stars. In addition, we compare detected Oosterhoff groups in the Galactic bulge with the two Oosterhoff populations in the Sagittarius dwarf galaxy.

Distant RR Lyrae from HiTS: Exploring the outskirts of the Milky Way

Gustavo MEDINA TOLEDO [1], *Ricardo MUNOZ* [1] & *Kathy VIVAS* [2]

[1] Universidad de Chile, Chile

[2] Cerro Tololo Inter-American Observatory, Chile

I will present the results from an RR Lyrae search using data from the High cadence Transient Survey (HiTS), which was carried out with the Dark Energy Camera (DECam) imager at the Blanco (4m) telescope on Cerro Tololo, Chile. HiTS is a campaign primarily aimed at detecting in real-time early supernovae explosions with the deep optical images DECam provide. However, the cadence and the strategy followed for the survey are well matched for RR Lyrae detection as well. Using data from 2014 we were able to detect new RR Lyrae stars out to 200 kpc from the Sun. In this talk I will discuss the results of the search for RR Lyrae stars using HiTS' data from 2014 and 2015, their connection with known or previously undiscovered satellite systems and halo substructures, as well as the further implications of these findings.

Properties of Anomalous and Type-II Cepheids in the Magellanic Clouds

Martin GROENEWEGEN [1] & *Monika I. JURKOVIC* [2]

[1] Koninklijke Sterrenwacht van Belgie, Belgium
[2] Astronomical Observatory Belgrade, Serbia

We have analysed 335 Anomalous and Type-II cepheids in the Magellanic Clouds found in the OGLE-III survey. The spectral energy distributions were constructed and fitted with model atmospheres to derive effective temperatures and luminosities. We analysed the light curves to look for period changes and binarity. We find stars with infrared excess at luminosities below those predicted for single star post-AGB tracks. Using period-mass-radius relations we find good agreement with literature values for the BL Her ($\sim 0.5 M_{\odot}$) and Anomalous Cepheids ($\sim 1.3 M_{\odot}$), but confusing results for the W Vir and RV Tau stars. Period-luminosity and period-radius relations will be presented.

Studying stellar systems with classical pulsators

(Invited review)

Marcella MARCONI, *Roberto MOLINARO*, *Maria Ida MORETTI*, *Vincenzo RIPEPI* & *Ilaria MUSELLA*

INAF-Osservatorio Astronomico di Capodimonte, Italy

Classical Cepheids and RR Lyrae are very important primary distance indicators and stellar population tracers, thanks to the relations between pulsation properties and intrinsic stellar parameters. Through the theoretical prediction of these relations as well as through the direct comparison between predicted and observed light and radial velocity variations, we are able to constrain the stellar properties of the investigated pulsating stars and their host stellar populations, as well as to study the dependence on chemical composition.

Identification of RR Lyrae stars in the Milky Way nuclear star cluster

Hui DONG [1], *Rainer SCHOEDEL* [1], *Benjamin WILLIAMS* [2], *Francisco NOGUERAS-LARA* [1], *Eulalia GALLEGO-CANO* [1], *Teresa GALLEGO-CALVENTE* [1], *Q. Daniel WANG* [3], *Michael RICH* [4], *Mark MORRIS* [4], *Tuan DO* [4] & *Andrea GHEZ* [4]

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[2] University of Washington, Seattle, USA
[3] University of Massachusetts, Amherst, USA
[4] University of California, Los Angeles, USA

Nuclear star clusters have been found in 75% of local spiral galaxies. They are very compact and massive and seem to co-evolve with central massive black holes. Their origins are still not very clear. Due to its proximity, the Milky Way nuclear star cluster (MWNSC) is a unique lab to study its stellar populations and star formation histories, which help us to understand how MWNSC formed. Recently, we have performed a time-domain study of the MWNSC by using the archived HST observations from 2010 to 2014. We identified $\sim$3900 variable stars, distributing widely in the color-magnitude diagram, which indicates their various origins. In particular, we found 4 RRabs and 3 candidates, which fall exactly onto the Oosterhoff I division in the Bailey diagram. The extinction and distance of one RRab match those for the nuclear star cluster given in previous works. Through comparing with the number of RRabs in the known globular clusters of the Milky Way, we estimate that if there exists an old, metal-poor ($-1.5 < [\mathrm{Fe/H}] < -1$) stellar population in the Milky Way nuclear star cluster, then it contributes at most 4.4×10^5 solar mass, i.e., $\sim$17% of the stellar mass, which means that infall globular clusters play an insignificant role in the construction of the MWNSC.

RR Lyrae stars in the inner Galactic globular clusters

Javier ALONSO-GARCÍA
Universidad de Antofagasta / Millennium Institute of Astrophysics, Chile

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The Vista Variables in the Vía Láctea (VVV) survey, and its extension, the VVV-X survey, have been observing the inner regions of the Milky Way since 2010 to 2015. There are more than 50 known globular clusters in the area surveyed. Most of them are poorly known, due to the high reddening produced by the presence of gas and dust in their lines of sight. The VVV and VVV-X surveys allow us not only to observe these globular clusters from their very centers out to their tidal radii and beyond at near-infrared wavelengths were the effect of extinction are highly diminished, but also to search for their variable stars thanks to their multi-epoch observations.
In our contribution, we show the preliminary results of the analysis of the color magnitude diagrams of some of these clusters and the light-curves of their variable stars, paying special attention to the RR Lyrae present in these clusters, and the crucial information they provide, not only to infer such important parameters as the distance and extinction to these objects, but also to better understand to general behaviour of reddening towards the inner Galaxy. We investigate also where these clusters stand in the the Oosterhoff dichotomy followed by most Galactic globular clusters.

The geometry of Sagittarius Stream from Pan-STARRS1 3π RR Lyrae

Nina HERNITSCHEK
Caltech, USA

We present a comprehensive and precise description of the Sagittarius (Sgr) stellar stream's 3D geometry. This analysis draws on the sample of 44,000 RR Lyrae (RRab) stars from the PanSTARRS1 (PS1) 3π survey (Hernitschek et al. 2016, Sesar et al. 2017b), which is complete at $\sim$80% and pure at $\sim$90% within 80 kpc, and extends to $\sim$120 kpc with a distance precision of 3%. A projection of stars within $|\tilde{B}|_{\odot} < 9^{\circ}$ of the orbital plane of the Sgr stream reveals its morphology, its leading and trailing arms, at very high contrast across much of the sky. In particular, the map traces the stream near-contiguously through the distant apocenters. We fit a simple model for the mean distance and line-of-sight depth of the Sgr stream as a function of the orbital plane angle $\tilde{\Lambda}_{\odot}$, augmented by a power-law background-model for the field stars. The modeling resulted into estimates of the mean stream distance precise to $\sim$1% and resolved the stream's line-of-sight depth. These improved geometric constraints can serve as new constraints for dynamical stream models.

Three-dimensional structure of the Magellanic System using OGLE Cepheids and RR Lyrae stars

Anna JACYSZYN-DOBRZENIECKA & Dorota SKOWRON
Warsaw University Observatory, Poland

I will present a three-dimensional structure of the Magellanic Clouds and Magellanic Bridge using over 9000 Classical Cepheids (CCs) and almost 23000 RR Lyrae (RRL) stars from the OGLE-IV.
For the CCs we calculated distances based on period-luminosity relations. CCs in the LMC are situated mainly in the bar that shows no offset from the plane of LMC. The norther arm is also very prominent with an additional smaller arm. Both are located closer to us than the entire sample. The SMC has a non-planar structure that can be described as an ellipsoid extended almost along the line of sight. We also classified nine of our CCs as Magellanic Bridge objects. These Cepheids show a large spread in three-dimensions.
For the RRL stars we calculated distances based on photometric metallicities and theoretical relations. Both Magellanic Clouds revealed a very regular structure. We fitted triaxial ellipsoids to our LMC and SMC samples. In the LMC we noticed a very prominent, non-physical blend-artifact that disabled us from analyzing the central parts of this galaxy.

Chemical composition of Cepheids in the Milky Way and in the Magellanic Clouds

Bertrand LEMASLE
Astronomisches Rechen-Institut, Heidelberg, Germany

Cepheids are excellent stellar tracers: they are bright enough to be observed even at very large distances (which can be accurately determined), and their spectra contain numerous lines that enable us to derive abundances for many alpha, iron peak or neutron capture elements. Classical Cepheids are yellow supergiants that trace the young populations (<300 Myr) while type II Cepheids are post Horizontal Branch (>10 Gyr), low mass stars that belong to the Population II. In this talk I will review recent results (in particular abundance gradients) concerning the chemical composition of Cepheids in the Milky Way and in the Magellanic Clouds.

Photometric metallicity from OGLE-IV RRab stars in the Magellanic Clouds

Dorota SKOWRON
Warsaw University Observatory, Poland

We use almost 6500 *V*- and *I*- band light curves of fundamental mode RR Lyr stars from the OGLE-IV survey to provide a relation between the *V*- and *I*- band phase parameter φ_{31} used to estimate [Fe/H]. The relation depends on metallicity, which limits its applicability. We apply this relation to metallicity formulae developed for the Johnson *V*- and the Kepler *Kp*- band to obtain the relation between [Fe/H] and φ_{31} for the *I*- band photometry. Last, we apply the new relation of Nemec et al. (2013) to almost 15000 OGLE-IV fundamental mode RR Lyr stars data and construct a metallicity map of the Magellanic Clouds.

RR Lyrae Variables in M31 and its satellites: an analysis of the galaxy's population

Nahathai TANAKUL [1] & *Ata SARAJEDINI* [2]

[1] National Astronomical Research Institute of Thailand
[2] Florida Atlantic University, University of Florida, USA

RR Lyrae variable stars can serve as powerful probes of their host stellar populations. Information such as distance, metallicity, reddening, and age can be obtained from their pulsation properties. Therefore, studying them in the nearest spiral galaxy M31 will yield important information about the early history of this galaxy. The main goals of this study are: 1) To investigate the Oosterhoff type of RR Lyrae stars in M31 and its satellites and compare them with the Milky Way to better understand the formation of these galaxies. 2) To investigate the early formation history of these galaxies through knowledge of their RR Lyrae stars. In order to achieve these goals, we have analyzed 6 fields in M31 using archival imaging from the Hubble Space Telescope. Published data for M31, M33, and several M31 dwarf spheroidal galaxies are also used to study the global properties of RR Lyrae variables in these systems. The results are then compared with those in the Milky Way galaxy.

Gaia and classical pulsators

(Invited review)

Gisella CLEMENTINI

INAF Osservatorio Astronomico di Bologna, Italy

We discuss the impact that Gaia, a European Space Agency cornerstone mission that has been in scientific operations since July 2014, is expected to have on the study of classical pulsators such as RR Lyrae stars and Cepheids and, consequently, on the definition of the cosmic distance ladder and the study of resolved stellar populations in and beyond the Milky Way.

With its multi-epoch monitoring of the whole sky, Gaia is expected to observe and measure positions, trigonometric parallaxes, proper motions and time-series photometry in 3 pass-bands for thousands of Cepheids and hundreds of thousands of RR Lyrae stars down to a faint magnitude limit of G$\sim$20.7 mag and with parallax errors of around 10 microarcsec for sources brighter than V$\sim$ 12, 13 mag.

This will allow an accurate re-calibration of the fundamental relations that make RR Lyrae stars and Cepheids primary standard candles of the cosmic distance scale and will provide a fresh view of the systems and structures that host these classical pulsators.

Results for Cepheids and RR Lyrae stars published in Gaia Data Release 1 (DR1) will be reviewed along with some perspectives on Gaia DR2, scheduled for April 2018, which is expected to contain parallaxes based only on Gaia measurements and a first mapping of full-sky RR Lyrae stars.

All-sky RR Lyrae stars in the Gaia data

Lorenzo RIMOLDINI [1], *Laurent EYER* [1], *Nami MOWLAVI* [1], *Dafydd EVANS* [2], *Krzysztof NIENARTOWICZ* [3], *Berry HOLL* [1], *Marc AUDARD* [1], *Leanne P. GUY* [1], *Grégory JEVARDAT DE FOMBELLE* [3], *Isabelle LECOEUR-TAÏBI* [1], *Olivier MARCHAL* [1], *Gisella CLEMENTINI* [4], *Vincenzo RIPEPI* [5], *Alessia GAROFALO* [6,4], *Roberto MOLINARO* [5], *Tatiana MURAVEVA* [4], *László MOLNÁR* [7], *Áron JUHÁSZ* [7,8], *László SZABADOS* [7], *Joris DE RIDDER* [9], *Sara REGIBO* [9], *Luis Manuel SARRO BARO* [10] & *Mauro LÓPEZ DEL FRESNO* [11]

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The second *Gaia* data release is expected to contain data products from about 22 months of observation. Based on these data, we aim to provide an advance publication of the first *Gaia* full-sky map of RR Lyrae stars. Although comprehensive, these data still contain a significant fraction of sources which are insufficiently sampled for Fourier series decomposition of the periodic light variations. The challenges in the identification of RR Lyrae candidates with (much) fewer than 20 field-of-view transits are described. General considerations of the results, their limitations and interpretation are presented together with prospects for improvement in subsequent *Gaia* data releases.

Letters from the revolution: how is space photometry changing our view of stars

(Invited review)

László MOLNÁR
Konkoly Observatory, MTA CSFK, Hungary

It might sound repetitive by now, but continuous, high-precision photometry from space did, in fact, revolutionise stellar astrophysics. After the pioneering work of MOST, the CoRoT and Kepler missions released an avalanche of discoveries, and this revolution extends to RR Lyrae and Cepheid stars too. We found signals that needed exquisite precision, such as an abundance of additional modes and granulation. Other discoveries, like period doubling, simply needed us to break away from the day-night cycle of the Earth. And the future is even brighter, with the BRITE, K2 and Gaia missions at full swing; TESS, taking physical shape; and PLATO securing mission adoption. In this review I summarize some of the most important discoveries, the expectations from future missions, and the demands they present for the community in terms of planning, processing, observing, modeling and theory.

K2 photometry of RR Lyrae stars

Emese PLACHY[1], *László MOLNÁR*[1], *Attila BÓDI*[1], *Marek SKARKA*[1], *Róbert SZABÓ*[1], *Ádám SÓDOR*[1], *Péter KLAGYIVIK*[1] & *Áron JUHÁSZ*[1,2]

[1] Konkoly Observatory, MTA CSFK, Hungary
[2] Eötwös University, Hungary

Thousands of RR Lyrae stars have been observed by the Kepler space telescope so far. We developed a photometric pipeline tailored to the light variations of these stars called the Extended Aperture Photometry (EAP). We present the comparison of our photometric solutions for Campaigns 0 through 6 with the other pipelines available, e.g., SAP/PDCSAP, K2P2, EVEREST, and others. We focus on the problems caused by instrumental effects and the detectability of the low amplitude additional modes. We also present some peculiar light curves identified in the data set.

The Kepler Pixel Project

Róbert SZABÓ
MTA CSFK, Konkoly Observatory, Hungary

Kepler photometry is so precise that new ways can be developed to harvest the great wealth of quasi-continuous data that has never been accessible from the ground. We have initiated a new project that we dub *The Kepler Pixel Project* in order to explore approaches and to discover new pulsating stars and other time-variable objects.
In this endeavour we examine individual pixels of the original Kepler mission to find interesting objects around the main Kepler targets. Specifically we launched a project to find background, faint RR Lyrae stars that are missing from the Kepler sample. In this talk the first results of The Kepler Pixel Project are presented. I'll discuss the project, the search algorithms, new findings, as well as the properties of the enlarged Kepler RR Lyrae sample. I will also show other results and examples (flares, outbursts, new eclipsing binaries) to demonstrate the potential and future avenues of the project.

New RR Lyrae stars in the original Kepler field

Ottó HANYECZ & Róbert SZABÓ
Konkoly Observatory, MTA CSFK, Hungary

Our previous results from synthetic Galaxy models shows that there is a large number of “hidden” RR Lyrae stars in the original Kepler FOV. We were informed about many candidate RR Lyrae stars in this area by PlanetHunters and professional astronomers. We extracted the light curves, removed the systematic trends and analyzed the data. The final catalog of these extra RR Lyrae stars contains 23 newly discovered stars. Nearly half of the RRab stars show Blazhko-modulation and the only new RRc appears to have the shortest modulation period among the RRc stars. These extra RR Lyrae stars are mostly in the 14-17 magnitude range which we expect from the Galaxy models. Finally, we discuss the properties of the new and the complete Kepler RR Lyrae sample.

Big signals, small signals, systematics

Géza KOVÁCS
Konkoly Observatory, Budapest, Hungary

We examine the role of instrumental and environmental systematics in the the search for small-amplitude signal components in the presence of large-amplitude signals. Current analyses of variable stars dealing with the above situation seem to ignore the effects of systematics, albeit the consideration of systematics is quite routine in the field of extrasolar planetary science. We discuss the pitfalls of simultaneous signal search and systematics filtering (Kovacs et al. 2016) and examine the power of the more traditional filtering technique that acts in the small signal regime after the pre-whitening of the large components, weakly influenced by systematics. The method is illustrated on the Kepler database.

Modeling and/or understanding the Blazhko effect

(Invited review)

Zoltán KOLLÁTH

Eötvös Loránd University, Savaria Department of Physics, Hungary

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During the last decades several new models have been proposed to understand the still unsolved puzzle of the Blazhko effect. Some of them are just mathematical considerations to provide a simple mechanism of modulations – lacking a real physical interpretation. Other models are based on results from numerical hydrodynamic calculations – although non of the hydrocodes provide anything that is in close relation to the observed modulations.

In parallel to the theoretical attempts to understand Blazhko modulation, space- and ground-based observations of RR Lyrae stars have uncovered a new level of complexity in the pulsation of these stars – new pieces of the great puzzle of RR Lyrae variability have been found. A satisfactory model has to provide a mechanism not only for the modulations but all the dynamical effects found in the observations. We provide a reality check based on the observational facts on all possible theoretical models.

Although hydrodynamic models still contain lots of simplifications (1D approximation, lack of nonradial modes in nonlinear calculations, crude approximation of turbulent convection) they display a very rich behaviour. High order resonances play a crucial role in the nonlinear dynamics representing the interacting modes. The richness of the found phenomena suggests that the interaction of multiple modes should be taken seriously in the understanding of observed features. The final question remains still unsolved: whether any of the proposed models can solve the mystery of the Blazhko effect.

Blazhko light curves – non-modulated and harmonic detuned signals

József BENKŐ
Konkoly Observatory, MTA CSFK, Hungary

In this talk I will show that two common assumptions about RR Lyrae light curves are invalid. (1) I will demonstrate that the best fitting mathematical model of Blazhko stars' light curves is the Fourier representation of general almost periodic functions. It follows that, strictly speaking, the widely used phrase 'Blazhko modulation' is incorrect. Although many features of the Blazhko light curves can be described in the modulation framework, the real light curves are definitely not modulated signals. That is, the external modulation explanations of the Blazhko effect must be wrong, which gives a further support for those theoretical models which produce the effect as an inherent feature of the pulsation. (2) Up to now most studies assumed that the Fourier spectrum of the light curve of an RR Lyrae star, either monoperiodic or showing Blazhko effect, is dominated by the main pulsation frequency and its harmonics. The Fourier representation of the almost periodic function, however, does not consist of the harmonics of the main pulsation frequency, but terms with frequencies which are slightly different from the exact harmonics. I explain the previously found deviation of the harmonic frequencies in the Fourier spectrum of V445 Lyr with this effect. Using the original Kepler RRab data I found an additional star (V2178 Cyg) showing this detuning.

Unstable standard candles – periodic modulation of pulsation in Magellanic Clouds' Cepheids

Radek SMOLEC
Nicolaus Copernicus Astronomical Center, Warsaw, Poland

We report the discovery of periodic modulation of pulsation in 51 fundamental mode classical Cepheids of the Magellanic Clouds observed by the Optical Gravitational Lensing Experiment. Although the overall incidence rate is very low, about 1 per cent in each of the Magellanic Clouds, in the case of the Small Magellanic Cloud and pulsation periods between 12 and 16 d, the incidence rate is nearly 40 per cent. On the other hand, in the Large Magellanic Cloud the highest incidence rate is 5 per cent for pulsation periods between 8 and 14 d, and the overall amplitude of the effect is smaller. It indicates that the phenomenon is metallicity dependent. Typical modulation periods are between 70 and 300 d. In nearly all stars, the mean brightness is modulated, which, in principle, may influence the use of classical Cepheids for distance determination. Fortunately, the modulation of mean brightness does not exceed 0.01 mag in all but one star. Also, the effect averages out in typical observations spanning a long time base. Consequently, the effect of modulation on the determination of the distance moduli is negligible.

Cyclic variations in the periods of RR Lyr and Cepheid stars

Ennio PORETTI [1], *Jean-Francois LE BORGNE* [2] & *Alain KLOTZ* [2]

[1] INAF-Osservatorio Astronomico di Brera, Italy

[2] Institut de Recherche en Astrophysique et Planétologie, Toulouse, France

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We present the new results obtained from the VTT observations of RR Lyr in the last two years to monitor the changes in the amplitude of the Blazhko effect as recorded by Kepler. In the general context of theoretical models of the Blazhko effect, unexplained observational facts still persist. The comparison with the modulations observed in Cepheids is discussed and differences are stressed together with unclear results. We also describe the contribution of the TAROT telescopes in updating the GEOS RR Lyr database. Particular care is given to a few candidates showing possible light-time effects.

Beyond strictly repetitive radial-mode pulsation: time-resolved analysis of the pulsation of OGLE Cepheids

Maria SÜVEGES [1] & *Richard ANDERSON* [2]

[1] Max-Planck-Institut für Astronomie, Germany
[2] European Southern Observatory, Germany

Recent studies have revealed a hitherto unknown complexity of radial-mode pulsators such as RR Lyrae and Cepheids, discovering both regularly and irregularly modulated pulsations using photometry, radial velocities, and interferometry, and presenting a challenge for theory to investigate the physical origin of the various modulation forms. However, both a statistically rigorous assessment of the general prevalence of these phenomena and their detailed characterisation on a large enough population is lacking. Exploiting the long survey timespan, the low photometric errors and the sufficiently dense time sampling of the OGLE survey, we applied local kernel estimation to the light curves of a sample of 53 fundamental and first-overtone classical Cepheids. This method, which does not impose stringent constraints such as linearity or strict repetitiveness of the modulations, obtains an unprecedented insight into the time-resolved features of their pulsation. Our results show a likely ubiquitousness and a rich phenomenological variety of the modulations in our sample. I will present these results, discuss the differences between fundamental and first-overtone classical Cepheids, and present some (preliminary) results of secondary period search after a time-dependent pre-whitening.

First-overtone RR Lyrae stars in the OGLE collection

Henryka NETZEL [1,2] & *Radek SMOLEC* [2]

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We present the results of the analysis of the Optical Gravitational Lensing Experiment (OGLE) data for the first-overtone RR Lyrae stars (RRc) from the Galactic bulge. In the OGLE collection of variable stars there are more than 10 000 RRc stars with six seasons of observations available. We analysed this sample in order to detect non-radial modes and to study the Blazhko phenomenon, which is a quasi-periodic modulation of amplitude and/or phase.
We found new members of the group in which, besides the first-overtone, there is another short-period signal, forming characteristic period ratio around 0.61 with the first-overtone period. Previous analysis of the selected stars from the OGLE collection resulted in a discovery of 262 stars. After our analysis of all RRc stars observed by OGLE, the number of known such stars exceeds 500.
In the previous analysis of selected RRc stars we discovered entirely new double-periodic group in which, besides the first overtone, there is another signal. It has period longer than the period of the first overtone, and forms characteristic period ratio around 0.68. So far, this group consists of 19 stars found in the OGLE data and 1 stars found in the Kepler data. Analysis of the whole sample of RRc stars resulted in a discovery of almost fifty new members of this group.
Additionally, in several stars with non-radial modes we detected the Blazhko phenomenon.

K2 observations of double-mode RR Lyrae stars

Paweł MOSKALIK [1], *James NEMEC* [2], *László MOLNÁR* [3], *Emese PLACHY* [3] & *Róbert SZABÓ* [3]

[1] Nicolaus Copernicus Astronomical Center, Warsaw, Poland
[2] Camosun Collage, Victoria, Canada
[3] Konkoly Observatory, MTA CSFK, Hungary

High-precision photometry of 13 double-mode RR Lyrae (RRd) stars observed during Campaigns 1-6 of NASA's Kepler K2 Mission has been analyzed. One of the stars, EPIC 201585823, is the 'rare triple-mode RRd star' studied in detail by Kurtz et al. (2016). Another star, EPIC 205209951, exhibits frequency and amplitude modulations of both modes (first reported by Plachy et al. 2016, in press). With $P_1/P_0 = 0.7409$ and the fundamental radial mode dominating the pulsation, it is similar to the 'anomalous' RRd stars found in Messier 3, in the bulge of the Galaxy, and in the Magellanic Clouds. A detailed frequency analysis has found that the non-radial mode at $P_{nr}/P_1 \sim 0.616$ is present in **all** of the non-modulated RRd stars. In $\sim$80% of these variables at least one subharmonics of the nonradial frequency is also detected.

Distances of classical pulsators

(Invited review)

Jesper STORM

Leibniz Institute for Astrophysics Potsdam, Germany

Pulsating stars are fundamental for the accurate calibration of the extra galactic distance scale and for determining the minimum age of the Universe. At the same time they are excellent tracers of young (classical Cepheids) and old (Pop-II Cepheids, RR Lyrae) stellar populations allowing detailed studies of distinct galaxy populations both in our Milky Way as well as in other galaxies. The recent tension between determinations of the local Hubble constant and the Hubble constant from the microwave background experiments demands ever higher accuracy in the calibration and the understanding of remaining possible systematic errors. Great efforts are therefore underway to recalibrate both the classical Cepheid (pop-I) route as well as the RR Lyrae (pop-II) route to the Hubble constant. Gaia will soon provide parallaxes of unprecedented precision which will set the local zero-points of the many different distance approaches and will allow the precise comparison of the methods in other galaxies to understand any remaining systematic effects. Will it be possible to overcome the classical problems of age, metallicity and reddening effects?

Metallicity dependence of RR Lyrae absolute magnitudes and GAIA

Jan LUB
Sterrewacht Leiden, The Netherlands

Further to the investigation on Period Luminosity relations presented at RRL2015 the results of GAIA Tgas and DR1 are used to comment on the dependence of these relations on Metal Abundance.

Baade-Wesselink analysis of RR Lyrae stars in the globular cluster, M3

Johanna JURCSIK
Konkoly Observatory, Hungary

A parallel extended photometric and spectroscopic observation campaign of M3 provides the largest sample of radial velocity curves of RRL stars ever obtained, and data suitable to perform B-W analysis of dozens of the variables. As a result, the distance of the cluster is determined and different relations between the physical and the observed properties of the variables are documented. It is also shown that the radius variations determined from the photometric and the RV data are significantly different for Blazhko stars, which leads to the failure of the application of the B-W technique on RRL stars showing light curve modulation.

WINERED as a stepping stone for cosmic distance scale

Matteo MONELLI [1], *Giuseppe BONO* [2] & *Noriyuki MATSUNAGA* [3]

[1] Instituto de Astrofisica de Canarias, Spain
[2] University of Rome Tor Vergata, Italy
[3] University of Tokyo, Japan

Our team is involved in an important observational project aimed at collecting accurate optical and near-infrared photometry for old (RR Lyrae, Type II Cepheids), intermediate (Miras) and young (Classical Cepheids) distance indicators. Moreover, we are also planning to provide a detailed elemental abundance (iron, alpha, neutron capture) for both field and cluster variables. To accomplish this goal we plan to use optical spectra collected with UVES@VLT and NIR spectra collected with WINERED@NTT. In this talk we plan to focus our attention on a dozen of RR Lyrae variables for which we have both optical and NIR spectra and on dozen of newly discovered RR Lyrae at the transition between the Bulge and the thick disk. We will introduce pros and cons of high resolution spectra, and in particular, the strategy we adopted removing telluric lines.

Radial velocity observations of classical pulsators

(Invited review)

Richard ANDERSON
Johns Hopkins University, USA

Over the course of more than a century, radial velocity (RV) observations of classical pulsating stars have played a crucial role in establishing pulsations as a mechanism for observed brightness variations, calibrating the distance scale, tracing binary star evolution, tracking Galactic rotation, and tracing the complex velocity fields in stellar atmospheres.

Today's state-of-the-art spectrographs provide meter-per-second precision, sufficient for the detection of extrasolar planets around stable stars. For pulsating stars however, this unprecedented precision cannot immediately be harnessed to detect ever lower-mass companion objects. Instead, high-precision RVs expose the flawed concept of assigning a unique velocity to a pulsating star's atmosphere and our inability to fully interpret the rich information content of RV observations with conventional techniques. Thus, RV observations are providing new insights into stellar pulsations and their interactions with stellar atmospheres. Specifically, recent observations have revealed long-term and cycle-to-cycle modulated variability in classical Cepheids that originates from pulsation cycle-dependent atmospheric velocity fields.

This talk presents the history and practice of measuring RVs of classical pulsators, with a focus on type-I Cepheids. Recent discoveries and challenges are highlighted and discussed in context with contemporary breakthroughs based on photometric and interferometric methods.

Interferometry of classical pulsators

(Invited review)

Pierre KERVELLA [1], *Antoine MÉRAND* [2], *Alexandre GALLENNE* [2], *Simon BORGNIET* [3], *Boris TRAHIN* [3], *Nicolas NARDETTO* [4], *Grzegorz PIETRZYŃSKI* [5] & *Wolfgang GIEREN* [6]

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Long baseline interferometry at optical and infrared wavelengths can now routinely reach milliarcsecond angular resolutions, and thus resolve the apparent disk of nearby pulsating stars. Their changing photospheric angular diameter is a particularly valuable observable, as it is insensitive to interstellar reddening. Angular diameter measurements thus allow for an accurate calibration of their effective temperature. We integrated the interpretation of this novel observable, together with radial velocities and photometric measurements, in the "Spectro-Photo-Interferometry of Pulsating Stars" (*SPIPS*) modeling tool. I will present this code, and its application to a few selected Cepheids. Over the last few years, we collected a significant sample of interferometric angular diameter measurements of Galactic Cepheids. We will use these observations with the coming Gaia parallaxes to calibrate the Baade-Wesselink method. Interferometry also allows us to probe the close environment of nearby pulsating stars for the presence of stellar companions or circumstellar envelopes. I will briefly expose our recent results on these two topics.

Deriving the pulsation velocities and temperatures of Cepheids and other pulsators from high-resolution spectra

Simon BORGNIET [1], *Pierre KERVELLA* [2], *Boris TRAHIN* [1], *Alexandre GALLENNE* [3] & *Antoine MÉRAND* [3]

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The calibration of the Period-Luminosity relation of Cepheids through the Baade-Wesselink technique is currently affected by systematic errors at a 5 to 10% level due to uncertainties on the projection factor. To tackle this problem, we developed the Spectro-Photo-Interferometry of Pulsating Stars (SPIPS) code, to consistently model the pulsation of Cepheids based on the combination of atmosphere models and all reliable observables. SPIPS allows to accurately estimate the physical parameters of pulsating stars (ratio distance/p-factor, Teff, IR excess), using as constraints a diverse set of observables (radial velocities, photometry, interferometry, effective temperatures).

This approach is still imperfect as it relies on different sets of radial velocities computed in different ways, thus with different definitions of the p-factor. The next step for SPIPS is to produce synthetic Cepheid spectra as a function of the pulsation phase and to directly compare them to the observed high-resolution spectra. We will thus derive homogeneous radial velocities as a function of the pulsation phase as well as (directly) the pulsation velocities. This will allow us to bypass the p-factor formalism and result in a more consistent modeling. I will present here the first results of this new approach (HR-SPIPS).

Pulsational modelling and projection factor of RR Lyrae stars

Boris TRAHIN [1], *Pierre KERVELLA* [2], *Simon BORGNIET* [1], *Antoine MÉRAND* [3] & *Alexandre GALLENNE* [3]

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[2] Observatoire de Paris, France
[3] European Southern Observatory

RR Lyrae variables are pulsating stars that play a vital role in the studies of several fundamental astrophysical problems and particularly the definition of the local distance scale. However, the accuracy of their distance scale is still not satisfactory. At the moment, only the prototype, RR Lyr, has a sufficiently accurate distance, and the systematic error on the Baade-Wesselink distances of RR Lyrae stars has been estimated to be 3 to 10% in the galactic field and globular clusters due to the inaccuracy of the projection factor. We developed an innovative method, nicknamed SPIPS (SpectroPhoto-Interferometry of Pulsating Stars), to derive parameters of pulsating stars (such as reddening, distance, projection factor) using a robust implementation of the parallax of pulsation approach. Its application to Cepheids has already shown its robustness and I will present here some results of the application of SPIPS to RR Lyr itself and a sample of non-Blazhko RR Lyrae pulsators.

The atmosphere, the p-factor and the bright visible circumstellar environment of the prototype of classical Cepheids delta Cep

Nicolas NARDETTO [1] & *Ennio PORETTI* [2]

[1] Observatoire de la Côte d'Azur, France
[2] INAF-Osservatorio Astronomico di Brera, Italy

Even 16000 cycles after its discovery by John Goodrick in 1783, delta Cep, the prototype of classical Cepheids is still studied intensively in order to better understand its atmospheric dynamical structure and its environment. Using HARPS-N spectroscopic measurements, we have measured the atmospheric velocity gradient of delta Cep for the first time and we confirm the decomposition of the projection factor, a subtle physical quantity limiting the Baade-Wesselink method of distance determination. This decomposition clarifies the physics behind the projection factor and will be useful to interpret the hundreds of p-factors that will come out from the next Gaia release. Beside, VEGA/CHARA interferometric observation of the star revealed a bright visible circumstellar environment contributing to about 7% to the total flux. Better understanding the physics of the pulsation and the environment of Cepheids is necessary to improve the BW method of distance determination, a robust tool to reach Cepheids in the Milky Way, and beyond, in the local Group.

Spectroscopic properties of a multi-dimensional Cepheid model

Valeriy VASILYEV [1], *Hans-Günter LUDWIG* [2], *Bernd FREYTAG* [3], *Bertrand LEMASLE* [4] & *Marcella MARCONI* [5]

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[5] INAF-Osservatorio Astronomico di Capodimonte, Italy

I will discuss the physical properties of the two-dimensional time-dependent envelope model of a Cepheid, which was calculated with the radiation-hydrodynamics code CO5BOLD, the first spectroscopic investigation of this model and the impact of convective inhomogeneities for some spectroscopic properties. I will present our evaluations of the microturbulent velocity, line asymmetry and projection factor, and the physical interpretation of the residual line-of-sight velocity (related to the “K-term”).

Outward from Cepheids

Nancy Remage EVANS [1], *Scott ENGLE* [2], *Edward GUINAN* [2], *Hilding NEILSON* [3], *Massimo MARENGO* [4], *Lynn MATTHEWS* [5] & *H. Moritz GUENTHER* [5]

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[4] Iowa State University, USA
[5] Massachusetts Institute of Technology, USA

Pulsation in Cepheids is driven by a wave generated in the envelope of the supergiants. We have long had diagnostics to observe the wave as it passes through the photosphere and chromosphere. At minimum radius there are many signatures of disturbance by the wave passage including ultraviolet lines in emission and an increase in microturbulence. X-ray observations, however, provided a surprise. They have a low level of flux for most phases which persists unchanged through minimum radius. However there is a burst of X-ray flux just after maximum radius, with a rapid rise, short duration and rapid fall similar to a stellar flare. This has been observed four times, including twice for Delta Cep itself. The occurance at a specific phase ties this to the pulsation process. This may be an upper atmosphere phenomenon (at about 1.5 stellar radii) which is related to circumstellar envelopes found via interferometry, at higher levels particularly in the infrared. These new diagnostics may ultimately answer questions about possible pulsation driven mass-loss.

The discovery of Blue Large-Amplitude Pulsators

Paweł PIETRUKOWICZ
Warsaw University Observatory, Poland

I will present the properties of the very recently discovered class of Blue Large-Amplitude Pulsators (BLAPs). These extremely rare, short-period, radially pulsating objects have been detected thanks to regular high-cadence observations of hundreds of millions of stars by the OGLE variability survey. The new variables closely resemble classical pulsators but at effective temperatures at which pulsations are due to the presence of iron-group elements. Theory shows that BLAPs are evolved low-mass stars with a giant-like structure, but their origin remains a mystery.

Classical pulsators in binary systems

(Invited review)

Grzegorz PIETRZYŃSKI

Nicolaus Copernicus Astronomical Center, Warsaw, Poland

Eclipsing binary systems provide a unique opportunity to measure precise physical parameters of stars like mass, radius, temperature, distance, etc. Therefore classical pulsating stars in eclipsing binaries are very important to understand basic physics of pulsating stars, stellar evolution and also calibrate extragalactic distance scale. In many binary systems mass exchange between the components can produce completely new classes of pulsating stars. Such objects can mimic classical pulsators and therefore bias distance and age measurements. We will resume our knowledge of classical pulsating stars in binary systems.

What (and how) we can learn about pulsating stars using eclipsing binaries

Bogumił PILECKI
Nicolaus Copernicus Astronomical Center, Warsaw, Poland

Eclipsing binary systems with pulsating components offer a unique possibility to accurately measure the most important parameters of pulsating stars, study their evolution and test the pulsation theory. I will present the method focusing on what we can learn about pulsating stars from the analysis of such systems and how we can do it. Special attention will be paid to the *mass*, *radius* and *p-factor* determination. The core of the method is based on the observations of double-lined eclipsing spectroscopic binaries, but I will also show that it is possible to measure absolute parameters even for single-lined binaries. In this case we take advantage of the additional information from pulsations, which let us solve the system even though we lack radial velocities of the secondary. The method description will be illustrated with examples of analyzed stars. The newest results will also be presented.

On the interpretation of the long-term cyclic period variations

Marek SKARKA [1], *Jiri LISKA* [2], *Ádam SÓDOR* [1], *Elisabeth GUGGENBERGER* [3] & *Radek DREVENY* [4]

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[3] Max Planck Institut für Sonnensystemforschung, Gottingen, Germany
[4] Private Observatory, Znojmo, Czech Republic

Many RR Lyrae stars show long-term variations of their pulsation period, some of them in a cyclic way. Such behavior can be attributed to the light-travel time effect (LTTE) caused by an unseen companion. Solutions of the LTTE often suggest very eccentric orbits and minimal mass of the companion on the order of several solar masses, thus, in the black hole range. We discuss the possibility of the occurrence of the RR Lyr-black hole pairs and on the case of Z CVn demonstrate that the LTTE hypothesis can be false in some of the binary candidates.

Continued search of RR Lyrae binary systems towards the Galactic bulge

Gergely HAJDU [1], *Márcio CATELAN* [1] & *Johanna JURCSIK* [2]
[1] Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Chile
[2] Konkoly Observatory, Hungary

Binary systems provide the most straightforward way of measuring the mass of individual stars, and through it, constraining models of stellar evolution. Such systems, containing pulsating variables, are even more valuable, as they can test models of stellar pulsation. Very few candidates of RR Lyrae variables in binary systems have been found until very recently, when multiple groups, including ours, have announced a new wave of candidates.
In our contribution, we are presenting our continued search for RR Lyrae binary systems towards the Galactic bulge, announcing more than 30 new candidates. Furthermore, we are introducing a new method of constraining the binary orbit by simultaneously fitting the light curve shape and the light-time effect parameters.

Poster

contributions

Campaign of spectrophotometric measures of the variable star RR Lyrae obtained in 2015 and 2016, in the Astronomical Observatory Oukaïmeden in Morocco

Abdelmjid BENHIDA [1], *Fouad SEFYANI LAKRIZI* [1], *Zouhair BENKHALDOUN* [2], *Thibault DE FRANCE* [3], *Denis GILLET* [4], *Philippe MATHIAS* [5], *Youssef ELJARIRI* [2], *Khadija CHAFAOUI* [2], *Ahmed DAASSOU* [2] & *Mohamed LAZREK* [2]

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In this work we present spectrophotometric results of the variable RR Lyrae star, obtained during the campaigns of measures led in 2015 and 2016 at the Oukaïmeden observatory in Morrocco. This intensive observing campaign spanned over 51 days from October to December 2015, and over 36 days from June to November 2016. Results were obtained with a good optimization of the observation conditions, in particular with a mean seeing of about $1''$. The campaigns took place at the Oukaimeden Observatory, in the High Atlas Mountains, at an altitude of 2700m. The instruments set up includes two telescopes mounted on each other. For spectroscopy, a C14 was used along with an eShel spectrograph [1] (125mm F/5 collimator, R2 echelle Grating, cross-dispersing prism, 85mm F/1.8 objective) from the Shelyak Instruments Company. The eShel system consists of a fiber injection unit, a guiding unit, as well as a calibration unit. For photometry, another C14 is used with an ASA $10''$ and a QSI CCD camera were used with various color filters (U-B-V). This instrumentation set-up is unique in the sense that both spectroscopy and photometry were carried out simultaneously, photometry being mainly used for the determination of the maxima's and thus the calculations of the pulsation phases. The aim of the campaign was to monitor the behavior of several observational signatures of the propagation of shock waves in the atmosphere of RR Lyr, spanning over various Blazhko phases, in particular through the signature of helium emission line. We measured for the first time the profile of the second emission of D3 line of Helium at phase 1.00. The spectral profile has been interpreted as a P-Cygni profile. We suggest that this profile is a natural consequence of the large extension of the expanding atmosphere induced by the main strong shock occurring at each pulsation cycle. The variation of the FeII line (λ4549.214Å) shows a shift in velocity compared to that of the FeII line (λ4923.921Å) : the Van Hoof effect. The emission of helium from the D3 line appears at all Blazhko phases of the star.
References : [1] Thizy, O., & Cochard, F. 2010, in Active OB stars: structure, evolution, mass loss, and critical limits, eds. C. Neiner, G. Wade, G. Meynet, & G. Peters, Proc. IAU Symp., 272, 282 [2] D. Gillet, N. Fabas and A. Lébre, A&A, A59, 553 (2013) [3] D. Gillet, F.L. Sefyani, A. Benhida, N. Fabas, P. Mathias, Z. Benkhaldoun and A. Daassou, A&A. A134, 587 (2016)

Shockwave behaviour in RR Lyrae stars

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Observations of RR Lyrae stars in the K2 mission revealed a peculiar bump progression in respect to the pulsation phase in some modulated RR Lyrae stars. The apparent, unexpected shifts in the occurrence of the bumps, the signatures of shockwaves in pulsating stars, raise the question whether these objects are RR Lyraes at all. We performed a detailed analysis of these targets to search for additional differences from the "ordinary" Blazhko stars.

The GEOS RR Lyr database

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GEOS, an European professional-amateur association, has collected in a database all possible RR Lyr times of light maximum published in the literature. We scanned the publications back to more than one century for this purpose. Recent observations are also added to the database. Measurements from amateur astronomer groups (GEOS, BAV, AAVSO) and from the robotic telescopes TAROT are used. To date, the database contains 95000 maximum times from about 4000 galactic RR Lyr stars. This database is particularly useful to study period variation of RR Lyr stars including phenomenon like Blazhko effect and light travel time effects in potential binary systems. http://rr-lyr.irap.omp.eu/dbrr/

Multicolor photometry of peculiar Cepheid stars observed in the Konkoly Observatory

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We present preliminary light curves of ten Cepheid stars from 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 were observed. The data were collected between 2011 and 2015 with the 60/90 cm Schmidt telescope of the Konkoly Observatory in BVRI filters. Some of the program stars show strong period change or even cycle to cycle variations that our observations clearly confirm.

Toward a universal period-p-factor relation

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The Baade-Wesselink (BW, or parallax of pulsation, PoP) method is the most common way to have independent distance measurements. It combines the stellar linear radius variations, estimated from radial velocities, with the angular diameter variations, estimated from interferometry or a surface-brightness relation. However, to convert from radial to pulsation velocity, we conventionally choose a multiplicative factor, called the p-factor. This factor depends on the limb darkening and the dynamical behavior of the line-forming regions, which is rather difficult to quantify without a detailed modeling of the stellar atmosphere. This parameter is currently the main source of uncertainty in the application of the BW method, leading to a global uncertainty of about 5-10% on the distance. Here we present an empirical approach which makes use of the SPIPS algorithm to derive a period-p-factor relation for Galactic and Large Magellanic Cloud Cepheids. SPIPS is based on the PoP method, but uses all available observables, i.e. radial velocities, multi-band photometry and interferometry, which make it more robust than other usual BW application.

O-C investigations of RRab from the SuperWASP archive

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Early results are presented from O-C investigations into the phase modulation of RRab class RR Lyrae stars from the SuperWASP archive. These results show several objects with good parabolic fits which could be segments of longer sinusoidal period changes due to LTTE. Visual inspection of O-C diagrams suggest some long period sinusoidal phase modulation, and some cases of phase modulation with periods too short to be LTTE which could be previously unidentified cases of the Blazhko effect.

The hidden potential of VVV RR Lyrae light curves

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The VVV survey is a real treasure trove of stellar variability towards the Galactic bulge and disk in the K_S band, and the RR Lyrae variables are playing a pivotal role in constraining their parameters. However, the lower amplitudes, noisier light curves and fewer available light curve points than what we are used to be dealing with in the optical bands, hamper the determination of accurate magnitudes, which are necessary to determine the distances of individual variables.
We have developed a new, robust fitting method, based on the Principal Components of a set of high-quality K_S-band light curves of RR Lyrae variables, which is capable of accurately estimating the mean magnitude among such circumstances. Furthermore, we show that the J-band light curve shape can be predicted to a precision of 0.01 magnitude in any phase of the pulsation, using the amplitudes of individual Principal Components. In addition to this, we demonstrate that the K_S-band light curve shapes of RR Lyrae variables allow us to estimate the metallicity of each RR Lyrae to a level comparable to the accuracy of the optical photometric estimate.

A KMTNet search for RR Lyrae stars in the ultra-faint dwarf galaxies in the southern sky

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Korea Astronomy and Space Science Institute

We report the first detection of RR Lyrae variable stars in the Crater II dwarf galaxy, a recently discovered ultra-faint satellite of the Milky Way. Based on B, V time series photometry obtained with the Korea Microlensing Telescope Network (KMTNet) at CTIO, Chile, we have identified $\sim$71 fundamental-mode (ab-type) and $\sim$9 first-overtone (c-type) RR Lyrae stars by adopting template light-curve fitting method. Our preliminary analysis suggests an Oosterhoff-intermediate classification of this galaxy from the mean period of the RRab stars, (mean Pab) $\simeq$0.63 days, and the location of them on the period-amplitude diagram. We will discuss the properties of the RR Lyrae stars in other southern ultra-faint dwarf galaxies.

From PanSTARRS candidates to new RR Lyraes in the K2 mission

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The purpose of this study is to search and investigate potential new RR Lyrae stars based on the archive database of the K2 mission. Our goal was to check the RR Lyrae candidates of the PanSTARRS (PS) 3pi survey based on their K2 light curves. This comparison also gives us the opportunity to examine the purity and completeness of the PS catalog within the K2 fields.The candidate stars could be known RR Lyraes or could be undiscovered ones. We identified numerous formerly unknown RR Lyrae variables among the background stars in the Kepler K2 images. In some cases the PS candidates turned out to be RR Lyrae impostors, such as eclipsing binary stars because light curves of some type of binaries resembles to the RR Lyrae variables.

On the relations of the light curve parameters of RR Lyrae stars in globular clusters

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The widly used $[\mathrm{Fe/H}] - (P, \phi_{31})$ formula postulates that a uniform combination of the light-curve parameters yielding a constant value for globular clusters, supposed to show no or negligible spread in the [Fe/H] content of the variables, exists. In order to check the reality and accuracy of any such formula, a data base of the V light-curve parameters of regular RRab stars in Galactic globular clusters is constructed. The results and conclusions are summarized.

Anomalous Cepheids among short period Type II Cepheids in the Milky Way

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The number of Anomalous Cepheids (ACs) in the Milky Way has risen significantly in recent years. In the OGLE-III catalog for the Large and Small Magellanic Clouds they were easy to find, since they form a separate period-luminosity (PL) relation, despite the overlap in period with short period Type II Cepheids (T2Cs), even longer period RR Lyrae stars. In the Milky Way constructing the PL relation is more difficult, so analyzing the light curve data is a way to distinguish them. Catalina Surveys Data Release-1 (CSDR1) (Drake, A. J. et al., ApJS, 213,9, 2014) has found 64 ACs in their data base, among which 7 were known as W Virginis stars. OGLE-IV has found 4 new ACs, and further 7 found in the foreground of the Magellanic Clouds. We have looked into the BL Herculis type (the short period T2Cs) variables given in the General Catalog of Variable Stars (GCVS), and found additional ACs among them. Fourier decomposition was used to analyze the data, and we compared the parameters to the known variables of the same types in the OGLE-III LMC and SMC. Along the ACs other types of variables were also found among the stars in the GCVS. The result is that the total number of BLHs is significantly reduced, which could have implication on our understanding of the Milky Way's evolution.

The occurrence of binary evolution pulsators in classical instability strip of RR Lyrae and Cepheid variables

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Single star evolution does not allow extremely low-mass stars to cross the classical instability strip (IS) during the Hubble time. However, within binary evolution framework low-mass stars can appear inside the IS once the mass transfer is taken into account. This work investigates the occurrence of binary components in the IS, labeled binary evolution pulsators (BEPs) - to underline the interaction between components, which is crucial for substantial mass-loss prior to the IS entrance. Study reveals possible evolution channels to produce BEPs, and reports a contamination value, i.e. how many objects classified as genuine pulsating stars can be undetected BEPs. This analysis was made with population synthesis code StarTrack.

Close non-radial modes and modulation in first overtone Cepheids

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Moskalik & Kołaczkowski (2009) reported close non-radial modes in a significant fraction of first overtone Cepheids based on OGLE-II data. Such modes manifest as additional peaks in the power spectrum, close to the radial mode frequency. We revisit these stars and check their properties with the more extensive OGLE-IV data. The emerging qualitative picture is the same – in all but one star we detect a single close peak at the radial mode frequency. In one star we detect additional peak placed symmetrically, on the other side of radial mode frequency. This indicates that pulsation of this star may be periodically modulated. For other stars, interpretation in terms of non-radial modes remains the most likely scenario.

RR Lyrae in the dSph UMi Galaxy

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Over the past two years we have obtained observations of the Ursa Minor dwarf spheroidal galaxy with the goal of completing an updated catalog of the variable stars in the dwarf galaxy. In addition to finding new variable stars, this updated catalog will allow us to look at period changes in the variables and to determine stellar characteristic for the RR Lyrae stars in the dSph. We will compare the RR Lyrae stellar characteristics to other RR Lyrae stars found in the Local Group dSph galaxies; these comparisons can give us insights to the near-field cosmology of the Local Group. In this poster we present our updated catalog of RR Lyrae stars in the UMi dSph; the updated catalog includes Fourier decomposition parameters, metallicities, and other physical properties for the RR Lyrae stars.

Serendipitous discovery of RR Lyrae in the Leo V dwarf galaxy

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[2] Cerro Tololo Inter-American Observatory, Chile
[3] Large Synoptic Survey Telescope

During the analysis of RR Lyrae stars discovered in the High cadence Transient Survey (HiTS) taken with the Dark Energy Camera at the 4-m telescope at Cerro Tololo Inter-American Observatory, we found a group of three very distant, fundamental mode pulsator RR Lyrae (type ab). The location of these stars agrees with them belonging to the Leo V ultra-faint satellite galaxy, for which no variable stars have been reported to date. The heliocentric distance derived for Leo V based on these stars is 173 ± 5 kpc. The pulsational properties (amplitudes and periods) of these stars locate them within the locus of the Oosterhoff II group, similar to most other ultra-faint galaxies with known RR Lyrae stars. This serendipitous discovery shows that distant RR Lyrae stars may be used to search for unknown faint stellar systems in the outskirts of the Milky Way.

A ground-based proper motion study of twelve nearby globular clusters

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We derive relative proper motions of stars in the fields of the globular clusters M12, NGC 6362, M4, M55, M22, NGC 6752, NGC 3201, M30, M10, NGC 362, M5, and 47 Tucanae based on data collected between 1997 and 2015 with the 1-m Swope telescope of Las Campanas Observatory. We determine membership class and membership probability for over 446 000 objects, and show that these are efficient methods for separating field stars from members of the cluster. In particular, membership probabilities of variable stars including RR Lyrae stars, eclipsing binaries etc. and blue/yellow/red stragglers are determined. Finally, we find absolute proper motions for six globular clusters from our sample: M55, NGC 3201, M10, NGC 362, M5 and 47 Tuc.

A brief overview of the Palomar Transient Factory (PTF) and recent progress of PTF-RRL Program at the National Central University

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The Palomar Transient Factory (PTF) and its successor, the intermediate-PTF (iPTF), are wide-fiend synoptic surveying projects aimed to explore the transient universe. The time-series data from PTF/iPTF can also be used for asteroids and variable stars research. The PTF/iPTF projects utilized the 48-inch Samuel Oschin Telescope located at the Palomar Observatory to carry the surveys, which was equipped with the CFH12K CCD. This mosaic CCD has a pixel scale of $1.01''$ per pixel, resulting a field-of-view of $\sim$7.2 degree squared. With an exposure time of 60 seconds, the PTF/iPTF can reach to a depth of R$\sim$20 mag, suitable to search for RRL located in Galactic Halo. At the Graduate Institution of Astronomy of the National Central University (IANCU), we are interested to use the RR Lyrae (RRL) stars found in PTF/iPTF data for various scientific investigations, including the Galactic Halo sub-structures. In this presentation, we report the recent progress of our PTF-RRL program, including the derivation of metallicity-light curve relation in the native PTF/iPTF R-band filter. Our relation can be immediately applied to distant RRL and estimate their metallicity based on the PTF/iPTF light curves.

On the period doubling behaviour of three W Vir stars

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The alternation of deep and shallow minima is a characteristic of RV Tau stars, but also appears among the intermediate period (10-20 days) Type II Cepheids. This behaviour is the manifestation of the nonlinear phenomenon called period doubling. We examined the historical data of two W Vir stars that clearly show the alternation: W Vir, the eponym of the group, and SZ Mon. We show that both stars underwent at least one interchanging event in the order of the deep and shallow minima during the past decades. We also demonstrate that ST Pup, known for strong period change, also exhibited a period doubling episode.

The global flow reconstruction of DF Cyg

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RV Tau-type pulsation is believed to governed by chaotic dynamics under certain conditions. The success of chaos investigations depends on the data quality and length. DF Cyg is the only RV Tau star that was monitored in the original Kepler mission providing the first extended, continuous and high-precision photometry for this class so far. We used the Kepler light curve in our global flow reconstruction to search for the quantitative properties of the pulsation dynamics such as the Lyapunov exponents and dimension. Since this star belongs to the RVB subtype, the analysis is complicated by the presence of the slow, large-amplitude variations atop the pulsation. Here we present our experiences and results.

The evolutionary picture of Type II Cepheids

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Type II Cepheids (T2C) are a puzzling and poorly studied class of pulsating variable stars. Different subclasses of T2C are believed to represent low-mass stars at different phases of post-horizontal-branch evolution. However, the boundaries between these subclasses are vague, and often only the pulsation period defines the subclass of a T2C. Additionally, some discrepancy exists in the literature between the low-period Type II Cepheids and RR Lyrae stars.

In contrast to the simple evolutionary picture painted by the period-based classification scheme, recent research has found stars prematurely evolving off the Red Giant Branch due to binary-induced mass loss. These stars might occupy the same colour-luminosity-period space as the single Type II Cepheids, while they represent a different evolution path in which binary interaction physics dominate the evolution. Furthermore, the luminosities of most Galactic T2C remain unknown. This situation will be greatly improved by the ongoing Gaia mission.

We study the prevalence of binarity among Type II Cepheids as well as the chemical composition and luminosity of these variables using high-resolution spectroscopy and Gaia parallaxes. Our aim is to clarify the evolutionary status of Type II Cepheids and investigate the differences between single and binary stellar evolution from the Cepheid point-of-view. In this poster we give an introduction to the research topic and present our first results.

Behavior of the doubling of metal lines as function to the Blazhko phase in the spectra of RR Lyrae star

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In this work, we present observations of the absorption lines doubling in the spectra of the variable RR Lyrae star on the FeII metal lines (λ4923.921Å) [1-2]. This phenomenon is also observed, for the first time, on the metallic lines of FeII (λ4549.214Å). For the emission, we observed the hydrogen lines H_α and H_β with a very high intensity and the two lines of HeI (λ5875.66Å and λ6678.15Å) [3]. In addition, we detected for the first time the Van Hoof effect between FeII (λ4549.214Å) and H_β line. During the expansion phase of the star and the passage of the shock wave, we have seen a disappearance of the neutral FeI absorption lines (λ4934.006Å and λ4920.503Å) and their reappearance in phase 1.00 [4]. The line D3 HeI (λ5875.66Å) is visible on four consecutive spectra during a period of 20 minutes [3-5-6]. This helium absorption/emission line is directly related to the intensity of the shock wave in the atmosphere of the star during the phase of the Blazhko maximum cycle. These observations were made with a spectrographic resolution of approximately 12,000, installed on the C14 telescope at the Oukaïmeden observatory (J43). The line doubling was observed in particular during the maximum of the Blazhko cycle (0.13). On the other hand, we observed a broadening of the metallic lines for other Blazhko phases (0.26 and 0.47). The lines doubling were interpreted by Schwarzschild on the basis of an atmosphere separated into two velocity population apart a shock front. This interpretation makes it possible to measure the velocity of the shock wave derived from the difference between the two red and blue spectral components on the hydrogen H_α and FeII lines during the observed line doubling.
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Photometric differences between modulated and non-Blazhko RRab Lyrae stars in the Galactic bulge

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Based on the analysis of more than 8000 RRab Lyrae stars in the Galactic bulge we identified about 3000 stars with modulation. We discuss the distribution of pulsation periods, light curve parameters, spatial distribution, and physical parameters calculated on the basis of light-curve shape with putting emphasis on the differences between modulated and non-Blazhko stars. Although the mean pulsation periods, amplitudes and light curve parameters differ for Blazhko and non-modulated stars, the physical parameters agree well in average. This could indicate that evolutionary effects could play an important role in the occurrence of the Blazhko effect.

Periodic modulation and period doubling in type II Cepheids from the OGLE Galactic bulge collection

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We report the analysis of OGLE-IV data for type II Cepheids from the Galactic bulge. Periodic modulation of pulsation, similar to the Blazhko effect was discovered in all sub-classes of type-II Cepheids: BL Her stars, W Vir stars and RV Tau stars, confirming earlier predictions of the nonlinear pulsation models. New examples of period-doubled BL Her stars were detected. Period doubling was also detected in a few longer period stars, but with pulsation periods still below 20d, which is commonly adopted as a borderline between W Vir and RV Tau classes.

Non-radial pulsation in the first overtone Cepheids of the Magellanic Clouds

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We have analysed photometric data for 3530 first overtone Magellanic Clouds' Cepheids from the OGLE collection. In more than 500 stars we have detected additional variability with period shorter than the first overtone period and period ratios in the (0.60, 0.65) range. The sample includes double periodic stars detected previously by the OGLE team as well as new discoveries. In the Petersen diagram these stars form three well separated sequences. In some stars we have found simultaneously two close periodicities corresponding to two sequences in the Petersen diagram. In a significant fraction of stars, we have detected the power excess at half the frequency of the additional variability. Interestingly, most of these stars form the middle sequence in the Petersen diagram. These results favour the theory proposed recently by Dziembowski, in which additional periodicities are due to excitation of non-radial modes of angular degrees 7, 8 and 9.

Pulsation theory models for Cepheids in eclipsing binary systems

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Physical parameters were recently measured for several Cepheids in eclipsing binary systems in the LMC. It is a good opportunity to compare these results with the models obtained from pulsation theory. Having well determined physical parameters of the stars we can calculate corresponding pulsation periods for given mode and check for instability. For stars that lack data, unknown or poorly defined parameters can be further constrained. We present the comparison for six Cepheids, showing that in general the results are in good agreement.

A precision determination of the metallicity effect on Cepheid absolute magnitudes in VIJHK bands

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Comparing relative distance moduli of the Magellanic Clouds as determined from Cepheid Period-Luminosity relations with corresponding value from eclipsing binaries method we determine the Metallicity Effect on the Cepheid Absolute Brightness in VIJHKs bands and optical and near-infrared Wesenheit indices. Within a very small uncertainty which is dominated by the uncertainty on the mean metallicity difference between Cepheids in LMC and SMC we conclude that metallicity effects in all bands are consistent with a zero metallicity effect. Such result resolves the dispute about the size and sign of the metallicity effect and constitute a milestone towards a measurement of the Hubble constant with an accuracy of 1% from the Cepheid-supernova Ia method.

The Araucaria Project. The distance to the Sculptor Group galaxy NGC 7793 from near-infrared photometry of Cepheid variables

Bartłomiej ZGIRSKI [1], *Wolfgang GIEREN* [2], *Grzegorz PIETRZYŃSKI* [1], *Paulina KARCZMAREK* [1], *Marek GÓRSKI* [2], *Piotr WIELGÓRSKI* [1], *Weronika NARLOCH* [1], *Dariusz GRACZYK* [1], *Rolf-Peter KUDRITZKI* [3] & *Fabio BRESOLIN* [3]

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Following the earlier discovery of classical Cepheid variables in the Sculptor Group spiral galaxy NGC 7793 from an optical wide-field imaging survey, we have performed deep near-infrared J- and K-band follow-up photometry of a subsample of these Cepheids to derive the distance to this galaxy with a higher accuracy than what was possible from optical photometry alone, by minimizing the effects of reddening and metallicity on the distance result. Combining our new near-infrared period-luminosity relations with the previous optical photometry we obtain a true distance modulus to NGC 7793 of 27.66 ± 0.04 mag (statistical) ± 0.07 mag (systematic), i.e. a distance of 3.40 ± 0.17 Mpc. We also determine the mean reddening affecting the Cepheids to be $E(B-V) = (0.08 \pm 0.02)$ mag, demonstrating that there is significant dust extinction intrinsic to the galaxy in addition to the small foreground extinction. A comparison of the new, improved Cepheid distance to earlier distance determinations of NGC 7793 from the Tully-Fisher and TRGB methods yields agreement within the reported uncertainties of these previous measurements.

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