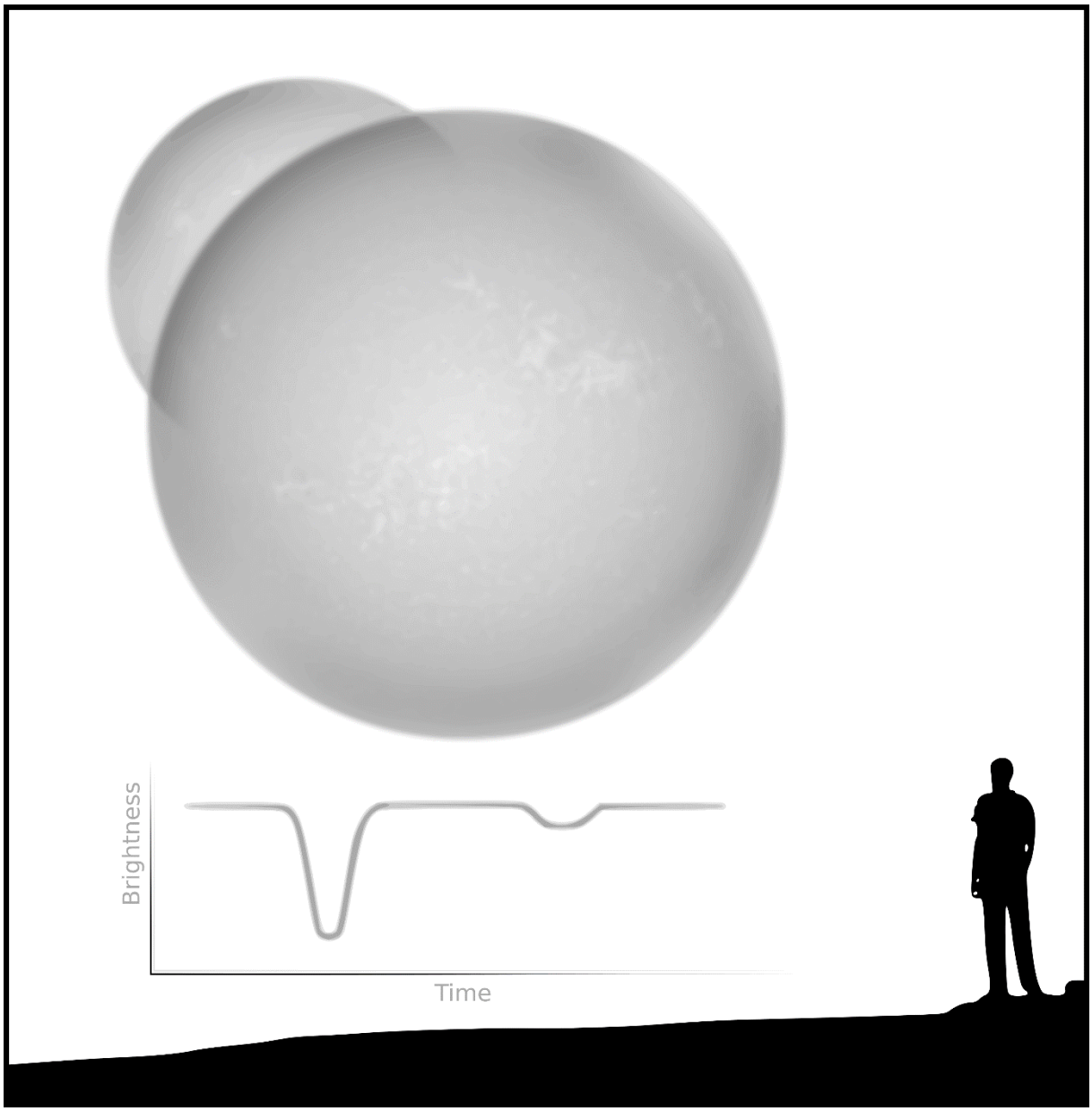
Universe of Binaries, Binaries in the Universe



7-11 September 2019, Telč, Czech Republic

Conference venue

facility of the Masaryk University

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MUNI UCT Univerzitní centrum Telč

Telč lies on the border of three territories – Moravia, Bohemia and Austria.

It is located 100 km from Brno and 150 km from both Prague and Vienna.

Taken from https://www.uct.muni.cz/media/3140349/skladacka_dl_en1_150dpi.pdf

TELČ - A UNESCO WORLD HERITAGE SITE

The town of Telč lies on the border of three territories – Moravia, Bohemia and Austria – in the southern part of the Bohemian-Moravian Highlands. Telč is first mentioned in historical sources dating to 1366. The first houses were built on the town square during the 14th century; however, the first stone buildings only appeared following the fire of 1386, gradually replacing the original early Gothic architecture. The town prospered most during the second half of the 16th century under the leadership of Zachariáš of Hradec. It was he who summoned Italian builders, plasterers and masons to renovate both the castle and the town square. Individual houses were thus decorated with various forms of sgraffi to, including the well-known letter patterns, and rustic work. The multi-storey houses with Renaissance gables and arcades surround the Telč square to this day.

The Renaissance château, the lookout towers of the Church of the Holy Spirit and St. James as well as eleven other churches and chapels are among some of the other sights well worth visiting. Thanks to the value of its historical monuments and the uniquely preserved town square, the town has been listed as a UNESCO World Heritage Site since 1992.

GREATER TELČ

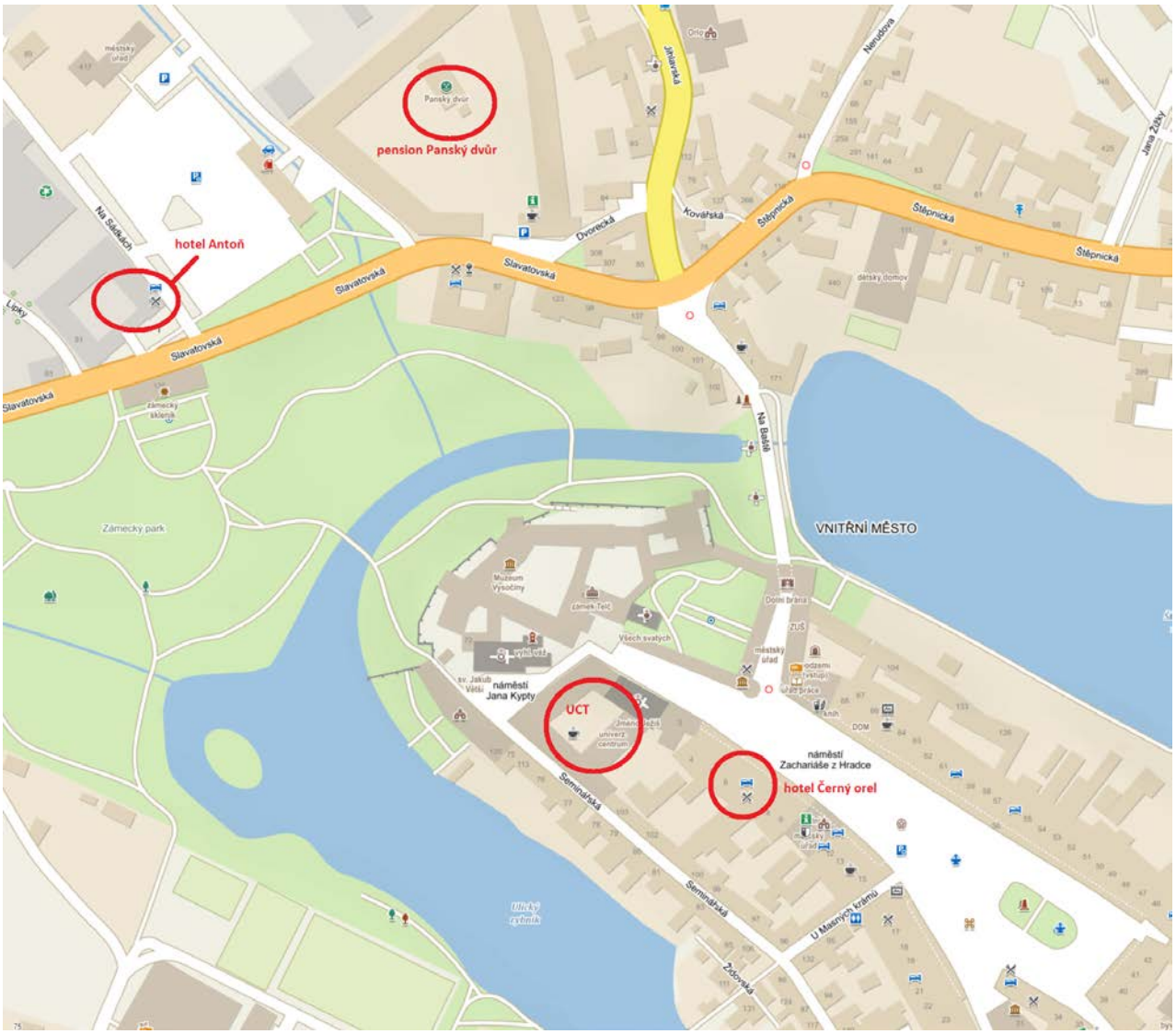
The vicinity of Telč offers many interesting places that are well worth a visit. Sightseers should not pass up a stop at the nearby gothic castle of Roštejn, or a hike up Javořice, the tallest peak in the region of Vysočina (837 meters above sea level). The town of Telč is set among the hills of the Vysočina National Geopark, an area of beautiful forests and lovely ponds. With its many hiking, biking and horse riding trails, the park is an ideal location for all those looking for shorter, less demanding outdoor trips.

JESUIT COLLEGE

The UCT resides in a complex formerly occupied by the Jesuit College in Telč. The foundation stone of the college building was laid in 1651 and construction of the three-wing two-storey edifice, positioned around an irregular courtyard, was fi nalized by 1655. The monumental structure stands out among the surrounding buildings both in terms of size and its simple, even austere appearance. A pharmacy was added in 1657 and a printer's shop several years later. Following the dissolution of the Jesuit order in 1773, the building was handed over to the state and – four years later – to the army, who used the site as barracks. A girls' burgher school was established on the premises in 1883 and subsequently replaced by a vocational secondary school in the second half of the 20th century. The complex was acquired by Masaryk University in 2002.

Telč is a regular venue for summer and winter music festivals and theatrical performances.

Taken from https://www.uct.muni.cz/media/3140349/skladacka_dl_en1_150dpi.pdf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hotel Antoň
UCT
hotel Černý orel
VNITŘNÍ MĚSTO
Slavatovská
Štěpnická
Jihlavská
Kovářská
Dvorecká
Na Baště
Zámecký park
náměstí Jana Kypty
náměstí Zachariáše z Hradce
Seminářská
Zdobrská
U Masných krámů

Program

Friday, September 6

19:00	**Welcome drink**	

Saturday, September 7

08:45-09:00		Welcome
09:00-09:40	Kafka	Citizen-scientists supporting binary star research
09:40-10:00	Zejda	Pro-Am collaboration in stellar astrophysics „Made in Czech Republic“
10:00-10:40	Kim	Professional-amateur programs at Chungbuk National Observatory
10:40-11:00	**Coffee/Tea Break**	
11:00-11:40	Teyssier	Symbiotic Binaries Monitoring
11:40-12:00	Olah et al.	The importance of studying active giant stars in eclipsing binaries - and the role of citizen scientists in finding them
12:00-12:40	Csizmadia	From CoRoT to PLATO: large photometric exoplanet space surveys for the planetary and binary star community
12:40-14:00	**Lunch**	
14:00-14:20	Forró	EBs hiding in the background: the Kepler Pixel Project
14:20-14:40	Mitnyan	Chromospheric activity of some bright contact binary stars
14:40-15:00	Rukmini et al.	Photometric study of 61 total eclipsing contact binaries from ASAS, OGLE, HATNet, AST3 and TESS databases
15:00-15:20	Hajdu et al.	Hierarchical triple star systems towards the Galactic Bulge through the OGLE's eye
15:20-15:40	Christopoulou et al.	What we can learn from Eclipsing Binaries in Large Surveys: The case of EA Catalina systems
15:40-16:00	**Coffee/Tea Break**	
16:00-16:20	Stevens & Zhou	A Binary of Ice and Fire
16:20-16:40	Lalounta et al.	An investigation of Low Mass Ratio EW systems from Catalina Sky Survey
16:40-17:00	Pawlak	Eclipsing Binaries in the ASAS-SN and APOGEE Surveys
17:00-17:20	Gazeas	Population of contact binaries in the solar neighbourhood
17:20-17:40	Zhou et al.	Photometric Observations of Extreme Mass Ratio Overcontact Binariy

17:40-19:00	Poster Presenters	Poster pitches (2-3 minutes)

Sunday, September 8

09:00-09:40	Pourbaix	Gaia binaries: get ready!
09:40-10:00	Siopis	Eclipsing binaries in the era of Gaia
10:00-10:40	Triaud	Binaries stars involving low mass stars, and planets
10:40-11:00	**Coffee/Tea Break**	
11:00-11:40	Brož	Modelling of complex stellar systems: the role of multiplicity (xi Tau) and circumstellar matter (beta Lyr)
11:40-12:00	Borkovits	(Not so) hierarchical stellar multiples with the eyes of Kepler, TESS and co.
12:00-12:20	Reggiani	Multiplicity constraints from direct imaging of massive binaries
12:20-12:40	Volkov	Search for invisible satellites in binary eclipse systems using photometric methods
12:40-13:00	Senavci et al.	Doppler imaging of the chromospheric active binary FF UMa
13:00-14:30	**Lunch**	
15:00-18:00		visit Telč castle
18:30		performance of the folklore ensemble Podjavořičan

Monday, September 9

09:00-09:40	Tokovinin	Close binaries in hierarchical stellar systems
09:40-10:00	Harmanec et al. (BRITE)	An improved model of delta Ori A
10:00-10:20	Harmanec, Mayer et al.	Massive quadruple sub-system with the eclipsing binary QZ Car
10:20-10:40	Zasche	Quadruple systems with two eclipsing binaries
10:40-11:00	**Coffee/Tea Break**	
11:00-11:20	Paunzen	Binary fraction of magnetic chemically peculiar stars
11:20-11:40	Mikulášek et al.	HD 34736 - an object containing two magnetic chemically stars
11:40-12:00	Zúñiga-Fernández et al.	An updated census of spectroscopic binary system in the young associations
12:00-12:40	Moe	The Formation of Binary Stars and Impact of Binaries on Planet Formation
12:40-14:00	**Lunch**	
14:00-14:40	Orosz	The KEPLER circumbinary systems

14:40-15:20	Martin	Circumbinary planets - now and into the future
15:20-15:40	Wilson et al.	Binary star analysis with intrinsic pulsation
15:40-16:00	**Coffee/Tea Break**	
16:00-16:40	Murphy	Pulsating stars in binaries
16:40-17:00	Sekaran et al.	An eclipse to build a dream on: Detecting g-mode period spacing patterns in eclipsing binaries with pulsating components
17:00-17:40	Mkrtichian	Eclipsing binaries with pulsating mass-accreting components
17:40-18:00	Johnston et al.	Calibrating core-masses of intermediate- and high-mass stars with pulsating binaries
18:00-18:20	Bahar et al.	Spot Migration on Eclipsing Binary KIC9821078
18:20-19:00		Posters

Tuesday, September 10

09:00-09:40	Prsa	The brave new world of EB modeling
09:40-:10:00	Conroy	Upcoming Support for Triple Stellar Systems in PHOEBE
10:00-10:40	Wilson	An Analytic Self-gravitating Disk Model: Morphology and Logical Structure
10:40-11:00	**Coffee/Tea Break**	
11:00-11:20	Kochoska et al.	Beyond DC and MMC: new algorithms and approaches for fitting binary star light curves
11:20-11:40	Guzel & Ozdarcan	PyWD2015 - A new GUI for the Wilson - Devinney Code
11:40-12:00	Debski	Starspot trek: The motion picture
12:00-12:20	Zelinka	Artificial Intelligence in the Astrophysics
12:40-14:00	**Lunch**	
14:00-14:40	Renzo	The explosive life of massive binary systems
14:40-15:00	Icli et al.	Long and short-term photometric variations of selected X-ray binaries
15:00-15:20	Maqbool et al.	A stochastic propagation model to the energy dependent rapid temporal behaviour of Cygnus X-1 as observed by AstroSat in the hard state
15:20-15:40	Celedon	On the variations on the accretion disk on AU Monocerotis
15:40-16:00	**Coffee/Tea Break**	
16:00-16:20	Oomen et al.	Modelling the depletion in post-AGB binaries with dusty circumbinary discs
16:20-16:40	Dsilva et al.	Radial velocities of galactic Wolf-Rayet stars

16:40-17:00	El-Badry	Wide binaries as probes of stellar formation and evolution
17:00-17:20	Kiran et al.	Spectroscopic Observations of Eccentric Binary Systems
17:20-17:40	Kocak et al.	CBs in open and globular clusters
17:40-18:30		Posters

Wednesday, September 11

09:00-09:40	Sion (Kafka)	Probing the evolution of Cataclysmic Variables
09:40-10:00	Merc et al.	New online database of symbiotic variables
10:00-10:40	Griffin	The Good, the Bad and the Really Ugly: Composite-Spectrum Binaries
10:40-11:00	**Coffee/Tea Break**	
11:00-11:20	Miroshnichenko et al.	Binarity among objects with the Be and B phenomena
11:20-11:40	Nemeth & Vos	Composite spectra hot subdwarf binaries
11:40-12:00	Skarka et al.	Binary stars with an RR Lyrae component - new candidates
12:00-12:20	Pavlík et al.	Do star clusters form in a completely mass-segregated way?
12:20-12:40	Szász	Binarity of Population II stars
12:40-13:00		Wrap-up
13:00-14:00	**Lunch**	


invited


talk


poster

Saturday, 7th September 2019

Citizen-scientists supporting binary star research

Stella Kafka

American Association of Variable Star Observers, Cambridge, MA, USA

The AAVSO was formed in 1911 as an international group of observers acquiring data in support of professional astronomy projects. As such, this is the first International Astronomical Association that was focusing on citizen science, enabling citizen scientists worldwide to acquire, analyze and communicate scientific data. In its current form, the AAVSO is an International Organization with members and observers from both the professional and non-professional astronomical community, contributing photometry to a public photometric database of more than 30,000 variable objects, and using it for research projects. I will discuss the main aspects of the association and how it has evolved with time to become a premium resource for variable star researchers, focusing on the contributions of AAVSO observers in binary star research. I will also discuss the various means that the AAVSO engages its members in projects, building a stronger international astronomical community.

Pro-Am collaboration in stellar astrophysics „Made in Czech Republic“

Miloslav Zejda

Masaryk University, Department of Theoretical Physics and Astrophysics, Kotlářská 2, Brno, 61137 Czech Republic

The collaboration between Czech variable star observers and professional astronomers has a long tradition. We introduce several nowadays activities of Variable Star and Exoplanets Section of the Czech Astronomical Society which serve the whole community of astronomers around the world.

Profession-amateur programs at Chungbuk National University

Yonggi Kim

Chungbuk National University, Republic of Korea

Some efforts of the Chungbuk National University, Korea, for encouraging the amateur astronomers to participate in the astronomical observation will be presented. The Chungbuk National University Observatory opened the Jincheon station with a 1.0m optical telescope and 0.6m optical telescope, which we are using for researching and educating the students. Our observatory equipped with a fully automated observation and control system is trying to help other astronomical observatories in Korea for activating the astronomical observation as well as the astronomy education. Since the openning the University Observatory in 2008, we continue to develop the contact programs with amateur astronomers and the training programs for the astronomical observation. We will summarize our programs and our future plan concerning the profession-amateur programs in Korea.

Symbiotic Binaries Monitoring

Teyssier, F.

Astronomical Ring for Amateur Spectroscopy Group

Spectroscopic monitoring symbiotic binaries by amateurs around the world, in both the northern and southern hemispheres, is a fundamental activity of ARAS (Astronomical Ring for Amateur Spectroscopy) initiative. The group of volunteers demonstrates what can be accomplished with a network of independent, very telescopes (from 20 to 60 cm), furnished with spectrographs of different resolution, from R = 500 to 15000, and covering the range from 3400 to nearly 9000 angströms. The observing program concentrates on bright symbiotic stars (about 60 to date). The main features of the ARAS activity are rapid response to alerts, long term monitoring and high cadence. A part of the program involves collaborations based on requests from professional teams (e.g. CH Cyg, AG Dra, R Aqr, SU Lyn) for long time monitoring or specific events. Some examples of the evolution of basic observational parameters along outbursts and/or as a function of the orbital phase (e.g. radial velocities, equivalent widths or lines profiles) are presented. The spectra are gathered in the open access Eruptive Stars Database that has been used for several publications by professional teams.

Keywords: novae -- symbiotic stars -- spectroscopic database

The importance of studying active giant stars in eclipsing binaries - and the role of citizen scientists in finding them

Olah, K.[1)], Rappaport, S.[2)], Derekas, A.[3)], Vanderburg, A.[4)], +citizen scientists: Tom Jacobs[5)], Martti Kristiansen[6)], Daryll LaCourse[7)], Hans Martin Schwengeler[8)], Mark Omohundro[8)], Ivan Terentev[8)]

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2) Department of Physics, and Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA
3) ELTE Gothard Astrophysical Observatory, Szombathely, and Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences
4) Department of Astronomy, The University of Texas at Austin, 2515 Speedway, Stop C1400, Austin, TX 78712 NASA Sagan Fellow
5) Amateur Astronomer, 12812 SE 69th Place Bellevue, WA 98006, USA
6) 5DTU Space, National Space Institute, Technical University of Denmark, Elektrovej 327, DK-2800 Lyngby, and Brorfelde Observatory, Observator Gyldenkernes Vej 7, DK-4340 Tollose, Denmark
7) Amateur Astronomer, 7507 52nd Place NE Marysville, WA 98270, USA
8) Citizen Scientist, c/o Zooniverse, Department of Physics, University of Oxford, Denys Wilkinson Building, Keble Road, Oxford, OX1 3RH, UK

Red giant stars with deep convection zones and rapid rotation maintain a strong surface magnetic field which may alter their observable astrophysical parameters. The resulting lower surface temperature due to spots makes the inferred masses and ages from evolutionary tracks uncertain. Eclipsing binaries having an active giant component can help in finding the stellar mass independently. However, until the recent space missions it was nearly impossible to find such systems from the ground. Since the evolution on the giant branch is rapid, the number of binaries containing giant stars is low. The eclipses, if the inclination allows, are very shallow, on the order of the photometric accuracy from the Earth, due to the large brightness difference between a red giant

primary and its solar size or smaller secondary. And, the typically acquired data from the ground are not uniform or continuous. The problems of the accuracy and time coverage of observations are solved by the space telescopes (Kepler, TESS). However, the number of observed stars is huge, and to find the interesting objects among them is not an easy task. It is especially true when looking for small eclipses in longer period (days or weeks) systems with changing light curves. Here, citizen scientists play such an important role that, at least at present, there is no substitute for their visual surveys of the data. Our joint work has already resulted in a published paper of an eclipsing spotted giant star, observed by Kepler, as well as several more related systems that we are currently studying. In this talk I will present a few new eclipsing binaries with active giant components observed by TESS and discovered by citizen scientists, which we think are worthy of further studies.

From CoRoT to PLATO: large photometric exoplanet space surveys for the planetary and binary star community

Csizmadia, Sz.

Ultraprecise mass-photometry from space revolutionized the field of exoplanets and eclipsing binary stars. In this talk I review the capabilities, contents of the data products, photometric properties, main discoveries and expectations of the main surveys like CoRoT, Kepler, K2, TESS, and future CHEOPS and PLATO with their limitations from both exoplanet and eclipsing binary point of view. A summary of the main results, open issues and future expectations will be given.

Eclipsing binaries hiding in the background: the Kepler Pixel Project

Adrienn Forró

MTA CSFK, Budapest, Konkoly Thege Miklós út 15-17, Hungary

Abstract: 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.

Chromospheric activity of some bright contact binary stars

T. Mitnyan, T. Szalai, J. Vinkó, A. Bódi, B. Cseh, O. Hanyecz, L. Kriskovics, A. Ordasi, A. Pál, K. Vida

There are lots of contact binaries that show activity signals, and stellar activity can alter the formation and evolution of these systems. One of these signals is the emission excess observed in several ultraviolet and optical absorption spectral lines (Ca II H+K, Mg II, Halpha), which indicates ongoing chromospheric activity. As different systems have different physical and orbital parameters,

the strength of chromospheric activity can also be different, hence, it seems to be evident that there are some kind of relations between these quantities. To date, this topic has been investigated thoroughly only in the ultraviolet domain involving the Mg II line; these studies show that the strength of the chromospheric activity may correlate with several quantities, e.g. orbital period, B-V colour index, or the logarithm of the inverse Rossby-number. There is only one preliminary study in the literature based on the analysis of the optical Halpha-line of four contact binaries (Barden 1985). Our main objective is to extend these possible correlations between the strength of the chromospheric activity on contact binary stars and of their physical and orbital parameters found in the literature. For this purpose, we obtained a lot of spectra in the last 1.5 year with the 1m telescope located at Piszkés-tető Mountain Station, Hungary. We also observed a few nights with the 2m telescope of Rozhen Observatory in Bulgaria. After constructing models for every spectra, our data allow us to get a deeper insight in short-scale chromospheric variations and to perform an extended statistical analysis concerning the optical counterpart of chromospheric activity on contact binaries.

Photometric study of 61 total eclipsing contact binaries from ASAS, OGLE, HATNet, AST3 and TESS databases'

Rukmini J, Shanti Priya D, Raghu Prasad M and Ravi Raja P.

Contact binaries form an interesting class of binaries which not only show mutual interactions through gravitationally bound periodic close orbit but also show dynamical interactions through mass transfer, angular momentum loss and modulation of their orbits due to presence of tertiary components and magnetic activity. They are important sources as distance indicators and best laboratories to study stellar evolutionary models. The current work highlights photometric studies of 61 totally eclipsing contact binaries from ASAS, OGLE, HATNet, AST3 and TESS databases'. The physical parameters were derived using PHOEBE. The selected binaries fall in a range of short period (0.34-0.97d), low mass ratio (0.076-0.38), F-K spectral types and wide range of fill out factors (0.09-77 %). Based on the obtained fill out factors, 6 binaries were classified as marginal contact and 17 as deep contact. The absolute parameters are compared with large database of well-studied binaries and their possible evolutionary states are discussed, emphasizing their distribution across the galaxy.

Hierarchical triple star systems towards the Galactic Bulge through the OGLE's eye

Hajdu, T. et al.

Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Budapest, Hungary

Abstract: We report the result of eclipse timing variation (ETV) analyses of OGLE-IV eclipsing binaries (EBs). From our selected 80,000 EBs we have identified around 1000 potential triple (or multiple) system candidates. In addition, we determined the orbital parameters and we carried out statistical analyses on the properties of the candidates. We found that (i) the distribution of the outer eccentricity has a maximum around e2=0.3; (ii) in most cases the estimated outer mass ratio is lower than q2~0.5. Besides, we also present some systems that deserve special attention. (i) Based on our ETV solution one system has a third component with probably substellar mass. (ii) There are some systems where the perturbations of the third body are also significant therefore a combined

(dynamical and light-travel-time effect) ETV model was used. (iii) There are four triple candidates where ETV can be explained by the presence of a further companion.

What we can learn from Eclipsing Binaries in Large Surveys: The case of EA Catalina systems

Christopoulou P-E.[1)], Athanasios Papageorgiou[2)], Márcio Catelan[3)], Andrew J. Drake[4)] and S. G. Djorgovski[4)]

1) University of Patras, Greece
2) Millennium Institute of Astrophysics, Santiago, Chile and Pontificia Universidad Católica de Chile, Facultad de Física, Instituto de Astrofísica, Santiago, Chile
3) Pontificia Universidad Católica de Chile, Facultad de Física, Instituto de Astrofísica, Santiago, Chile & Millennium Institute of Astrophysics, Santiago, Chile
4) California Institute of Technology, 1200 East California, USA

With the recent availability of large-scale multi-epoch photometric datasets, we were able to study EBs en masse. Large samples are useful to determine not only statistical properties but for finding strange and curious systems that no one had ever studied before, binaries with peculiarities that may reveal physical significance. We present an updated and more detailed catalog of 4680 Northern EAs in the Catalina Sky Survey (CSS). This work includes, new systems, revised period determination and ephemerides, system morphology classification based on machine learning techniques, computation of principal physical parameters with the EBAI (Eclipsing Binary via Artificial Intelligence) and detection of eclipse timing variations. We identify several groups of interesting systems including those with low mass K and M dwarfs, systems with longterm modulation of the maximum brightness, systems with longterm period modulation, potential triple systems and systems with magnetic activity. We also present the current status and future prospects of the analysis in contact eclipsing binary systems from large astronomical surveys.

A Binary of Ice and Fire

Daniel J. Stevens, George Zhou

Many surveys for companions around intermediate-mass (B- and A-dwarf) stars are not sensitive to very low mass and flux ratios. However, recent transit surveys of hot stars provide a novel opportunity to discover such eclipsing systems serendipitously. I will present the KELT discovery of an eclipsing binary composed of a late-B star and an M-type companion in a ~3.6-day orbit. By jointly analyzing the photometric and spectroscopic transits, RVs, and the spectral energy distribution, we find that the M star's mass is consistent with a fully convective interior, making it one of the smallest stars known to eclipse an intermediate-mass star. I will also evaluate the accuracy of analytic prescriptions for ellipsoidal variations and Doppler beaming by comparing the results from analyzing the out-of-eclipse TESS phase curve to those from the aforementioned joint analysis.

An investigation of Low Mass Ratio EW systems from Catalina Sky Survey

Lalounta E., Papageorgiou A., Christopoulou P.-E., Catelan M.

Astronomy Laboratoty, Dept of Physics, University of Patras, Greece

We have conducted a survey of overcontact binary systems (EW) with mass ratio ≤ 0.25 from Catalina Sky Survey (CSS) that are considered strong candidates mergers and are probable progenitors of FK Com-type stars and blue stragglers. The discovery of such extreme mass ratio overcontact binaries is vital to resolve the critical mass ratio to merge ambiguity, the mass loss process, and refine the current theoretical models. So far only a few tens of such systems have been identified. To increase this sample we selected and derived the physical parameters (q, incl, T2/T1, R2/R1, fillout-factor) and their uncertainties, of 92 newly discovered totally eclipsed Low Mass Ratio (LMR) EW systems based on their Vcss band light curve, using PHOEBE-0.31a scripter and Monte Carlo method respectively. In this talk, I will present the procedure that it has been followed to select the sample and discuss the preliminary results from our analysis.

Eclipsing Binaries in the ASAS-SN and APOGEE Surveys

Michal Pawlak

I present the catalog of 1924 periodic variables identified among more than 258000 APOGEE targets including 430 eclipsing and ellipsoidal binaries. 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 0.3dex than that of the overall APOGEE sample. Eclipsing binaries and ellipsoidal variables are shifted to a lower median [Fe/H] by 0.2~dex. Eclipsing binaries and rotational variables exhibit significantly broader spectral lines than the rest of the sample.

The population of contact binaries in the vicinity of solar neighborhood

Kosmas Gazeas

National and Kapodistrian University of Athens, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, University of Athens, GR 15784 Zografos, Athens, Greece

Contact binaries belong to the old population of our Galaxy, while their metallicity is close to solar. Their physical properties, kinematics and spatial distribution, reflect the properties of their stellar progenitors. This study focuses on the spatial distribution of contact binaries in our solar neighborhood within a 500 pc radius, using a combined astrometric, photometric and spectroscopic determination of their stellar parameters. The sample is carefully selected, in order to fulfill certain criteria and have well defined metallicity and distance parameters. H-R diagram, as well as similar correlation plots (Mass-Radius and Mass-Luminosity) show that the primary (more massive) components in such systems are located close or below the ZAMS region, while secondary ones are seem to be evolved, as a result of their common envelope geometry. Some outliers are still prominent, which are carefully examined, in order to judge about the environmental properties and

evolution in certain locations of the Milky Way. It is found that the metallicity is not correlated with distance, but there is a weak correlation between metallicity [M/H] and evolution state, as it is expressed by the location of the systems in H-R diagram, the type of binary (A or W), temperature.

Photometric Observations of Extreme Mass Ratio Overcontact Binary

Xiao Zhou, Boonrucksar, Soonthornthum, Shengbang, Qian

Stellar mergers are estimated to be common events in the Galaxy. Theoretical models predict that a contact binary system will merge around q ~ 0.07–0.09. The minimum mass ratio can even fall up to q = 0.05 and it depends on the mass and structure of primary star. So far, only a handful number of these transients have been noted in the Milky Way: V4332 Sgr, V838 Mon, V1309 Sco, and OGLE-2002-BLG-360. And V1309 Sco is the best studied stellar merger case to date. The discovery of the luminous red nova V1309 Sco (Nova Scorpii 2008) and the fact that its progenitor is an extreme mass ratio overcontact binary system with a rapidly decreasing orbital period makes the research on binary stars to be frontier research again. In the present work, we will give a brief introduction about the optical telescopes we can get access to in National Astronomical Research Institute of Thailand (NARIT) and Yunnan Observatories (YNOs), Chinese Academy of Sciences (CAS). Then, we will display the light curves of an extreme mass ratio overcontact binary system CSS_J135012.1+272259 observed with the 2.4 meter telescope at Thai National Observatory (TNO) and give out its photometric solutions determined with the Wilson-Devinney (W-D) program. Then, the statistical information on extreme mass ratio overcontact binary systems with $q < 0.15$ are shown and the targets will be long term monitored with facilities at NARIT and YNOs. Their period variations are also investigated, which will reveal interior/exterior dynamic interactions of these binary systems. These targets will give us a better understanding on pre-outburst state of contact binaries, and enrich our knowledge on the mechanism of binary merger.

Sunday, 8th September

Gaia binaries: get ready!

Dimitri Pourbaix

Since mid-2014, Gaia has been repeatedly observing the whole sky, collecting positions, spectra, and photometry. That has led so far to two data releases (more than one billion of parallaxes, proper motions, magnitudes, colours!) but no binary star result yet. The situation will drastically change with Gaia Data Release 3, anticipated for the second half of 2021. Millions of orbital solutions (astrometric, spectroscopic, eclipsing, ...) will become available for everybody to play with. Get ready!

Eclipsing binaries in the era of Gaia

Christos Siopis

Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles

The ESA mission Gaia is expected to detect on the order of 10^5-10^6 eclipsing binaries, most of them hitherto unknown. We present an outline of the processing of these objects in the Gaia pipeline with an emphasis on the estimation of their orbital and physical parameters, including a comparison with cases of eclipsing systems with known solutions in the literature.

Binaries stars involving low mass stars, and planets

Amaury Triaud

School of Physics & Astronomy, University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom

Measuring the masses and sizes of fully convective stars has proved difficult until the advent of transiting planet experiments. Stars with masses under 0.2 Msol have similar radii and luminosities to many of the hot Jupiters. I will describe a 10 year long effort by WASP (the Wide Angle Search for Planets), called the EBLM project. Our goal is to catalog single line binaries, measure their properties, notably masses and sizes, parameters that are crucial to the study of planets orbiting ultra-cool dwarfs, such as TRAPPIST-1. I will show recent results of the EBLM project, and describe the next stage of our survey, involving TESS. In addition, the EBLM sample of eclipsing low mass binaries is now at the core of an ambitious new radial-velocity survey seeking circumbinary planets. I will details some of the aspects of the BEBOP search for circumbinary planets.

Modelling of complex stellar systems: the role of multiplicity (xi Tau) and circumstellar matter (beta Lyr)

Miroslav Brož

Charles University, MFF UK, V Holešovičkách 2, Praha, Czech Republic

We constructed an advanced N-body model for interacting multiple stellar systems in which we compute all trajectories with a numerical integrator, namely the Bulirsch-Stoer from the SWIFT package. We can derive various observables: astrometric positions, radial velocities, minima timings (TTVs), eclipse durations, interferometric visibilities, closure phases, synthetic spectra, spectral-energy distribution (SED), and even complete light curves. To this point, we used a modified version of the Wilson-Devinney code. A joint chi-square metric and an optimisation algorithm allow to search for a global minimum and construct robust models of stellar systems. We present an example of the quadruple system xi Tauri (Nemravová et al. 2016; Brož 2017) showing dynamical effects that can be studied and also discuss systematic errors that may affect results.

For systems with circumstellar matter, the problem is even more complicated. In order to compute lightcurves, spectra, SED, as well as interferometric observables (i.e. V^2, $|T^3|$, arg T^3, differential visibilities Delta |V| and differential phases Delta arg V) we prepared a model based on Shellspec (Budaj 2011; Mourard etal. 2018). As a 1-D radiative-transfer code, it has some limitations, e.g. LTE, optically-thin scattering, only simple shadowing, prescribed rho and T radial profiles, or geometry of two components and CSM. Nevertheless, it is capable to compute all observables, respective chi2 terms and perform an optimisation of parameters. Because the Fourier transforms of synthetic images and computations of high-res synthetic spectra are demanding, the code runs on multiple cores (OpenMP). We present an example of beta Lyrae A, a well-known binary with an accretion disk, for which we obtained CHARA/MIRC data in Halpha and He 7065 lines.

(Not so) hierarchical stellar multiples with the eyes of Kepler, TESS and co.

Borkovits, T.

Due to the era of Kepler, TESS and their mates, the several months (or even years) long quasi continuous monitoring of thousands of known and previously mostly unknown eclipsing binaries has led to the discovery of hundreds of compact hierarchical triple (and multiple) star systems. Many of them produces spectacular observational effects that were never (or at least, rarely) seen before, for example: extra, outer eclipses (having complex structure); third-body perturbations dominated, large amplitude, non-sinusoidal eclipse timing variations (ETV); rapid eclipse depth variations, etc. Successful modelling of these phenomena means a great challenge, however, it does offer substantial astrophysical benefits. In this talk I review our groups' two different answers for these challenges: one of them is based on the analytical theory of the third-body perturbations and applied exclusively to the ETVs, while the other is a complex, numerical, spectro-photodynamical modelling of all the available observations of such systems. I discuss some most recent results obtained for K2 and TESS systems.

Multiplicity constraints from direct imaging of massive binaries

Maddalena Reggiani

The formation of massive stars remains one of the most intriguing questions in astrophysics today. Several formation theories have been proposed, each claiming different multiplicity properties of massive stars. There are observational challenges preventing us from discriminating between the formation scenarios: massive stars are rare and found at relative large distances from us, they form on short timescales and evolve in multiple stellar systems within the gas-rich environment from which they are born.

Taking advantage of the extreme-AO capabilities of VLT/SPHERE, we observed more than 100 O stars in the Carina nebula and the galactic field, aiming at characterizing their multiplicity properties.

SPHERE offers unprecedented imaging contrast which allows us to detect even the faintest companions around massive stars. The comparison between the outcome of our study and the predictions of companion statistics from massive star theories will help us to discriminate between the different formation scenarios.

Here, we present the first results from the survey and describe the potential consequences of our findings.

Search for invisible satellites in binary eclipse systems using photometric methods

Volkov, I.M.

Institute of Astronomy of the RAS, Moscow, Russia

Using several eclipse systems as an example, a number of which has been well studied, it is shown how the photometric method used by us for the complex study of double eclipsing systems has led to the discovery of additional components. The actual presence of these additional components over time was confirmed by the periodic deviations in the ETV diagrams.

Doppler Imaging of Chromospheric Active Binary FF Ursa Majoris

Senavci, H.V., Bahar, E., Ozavci, I.

We present the first Doppler Imaging (DI) study of the chromospherically active RS CVn type binary FF Ursa Majoris. The mid-resolution (R ~ 13500) time series spectral data used in this context were acquired using the echelle spectrograph attached to the 0.4 m Kreiken Telescope at the Ankara University Kreiken Observatory. In addition, we applied spectral subtraction technique to the H? line to reveal the chromospheric activity behavior of the system along with the orbital phase. The results derived from DI and spectral subtraction analyses show that both components of FF UMa system shows photospheric and chromospheric activity. The time series spectral data also enable us to obtain the most recent radial velocity curve of the system and therefore revised physical parameters.

Monday , 9th September

Close binaries in hierarchical stellar systems

Tokovinin, A.

Cerro Tololo Interamerican Observatory

Many (although not all) close binaries are inner subsystems in triple and higher-order hierarchical systems. It has been suggested that formation of close binaries is related to the outer components, for example by a combination of Kozai-Lidov cycles with tides. However, recent study indicated that only a fraction of solar-type close binaries could be formed this way and that many close binaries form even before stars contract to the main sequence. Moreover, statistics of compact triple systems shows that their orbits are too close to coplanarity to cause Kozai-Lidov oscillations. Yet, the correlation between close binaries and hierarchies is firmly established observationally. We explore alternative formation mechanism where initially wider pairs migrate inward by accretion during accumulation of stellar mass. In this scenario, tertiary companions form from the same accretion flow.

Testable predictions of this scenario are outlined.

An improved model of delta Ori A

P. Harmanec, A. Oplištilová, P. Mayer, P. Zasche, M. Šlechta, H. Pablo, A. Pigulski, the BRITE Team

We shall present an improved model of delta Orionis A, a triple star, which belongs to the multiple-star system delta Orionis (Mintaka) and consists of an eclipsing binary with the orbital period P = 5.732436 d and a distant tertiary with an orbital period of the order of several thousands of days. For the first time we were able to disentagle the very weak spectral lines of the secondary in the blue parts of the optical spectrum and derive a reliable mass ratio. Along with a light-curve solution, based on photometry from the astronomical satellites SMEI, MOST and BRITE we obtained improved physical elements of the system.

Massive quadruple sub-system with the eclipsing binary QZ Car

P. Harmanec, P. Mayer et al.

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QZ Car is a quadruple system composed from a 6 d eclipsing binary and 20 d spectroscopic binary revolving around each other with as yet not precisely known period, perhaps some 50 years. Using several new sets of electronic spectra and photometric observations, and compiling and homogenising all available earlier photometry and radial-velocity measurements, we derived improved geometrical and physical elements of this massive system.

Quadruple systems with two eclipsing binaries

P. Zasche

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Two eclipsing binaries as parts of more complex multiple systems are being studied for the last 10 years. We present our new findings on this relatively new group of objects. Detection methods, distribution of parameters, resonances, and also interesting distribution on the sky.

The binary fraction of magnetic chemically peculiar stars

E. Paunzen

The magnetic chemically peculiar (mCP) stars are upper main sequence objects (spectral types early B to early F) whose spectra are characterized by abnormally strong absorption lines that indicate peculiar surface elemental abundances in the presence of a stellar magnetic field. They constitute about 10% of all upper main sequence. Their atmospheres are enriched by elements such as Si, Cr, Sr, or Eu and exhibit photometric variability as a result of rotational modulation because of stellar spots. These stars are excellent and unique astrophysical laboratories for investigating effects of convection, magnetic fields, atomic diffusion, and rotation. What do we know about the binary fraction of mCP stars? The answer is astonishing. There is a large discrepancy of the actually detailed investigated systems and the statistical numbers given in the literature. It is often stated that the overall rate of mCP binaries is not abnormally low: Carrier et al. (2002, A&A, 394, 151) give 43%; Mathys (2017, A&A, 601, A14) gives 51%. The population of mCP binary stars is dominated by long period systems with a significant deficiency of systems with periods in the order of days to tens of days with complete lack of binaries with periods below 2.9 days (Carrier et al. 2002; Mathys, 2017). On the other hand, a conspicuous lack of binaries among mCP stars has been described in the literature (Leone & Catanzaro, 1999, A&A, 343, 273). In fact, only very few double-lined spectroscopic binaries comprising a mCP star have been identified (Hubrig et al., 2014, MNRAS, 440, L6). I will review the literature and present new radial velocity observations of candidate systems.

HD 34736 - an object containing two magnetic chemically stars

Z. Mikulášek et al.

Department of Theoretical Physics and Astrophysics, Faculty of Science, Masaryk University, Brno

A detailed analysis of 17925 highly accurate TESS data surprisingly showed that the light of the well-known magnetic chemicaly peculiar star HD 34736 is modulated by periodic light variations attributable to another mCP star.

An updated census of spectroscopic binary system in the young associations

S. Zúniga-Fernández, A. Bayo, P. Elliot, C. Zamora, M. F. Sterzik, C. A. O. Torres, X. Haubois, N. Huélamo, G. R. Quast, J. Olofsson, and J. M. Corral-Santana

The young associations offer us one of the best opportunities to study the properties of young stellar and sub-stellar objects thanks to their proximity (< 200 pc) and age (~ 5 - 150 Myr). We update the spectroscopic binary fraction of the SACY (Search for Association Containing Young stars) sample using rotational broadering and higher-order cross-correlation features (CCFs). Using high-resolution spectroscopic observations we obtain 1375 CCFs for our calculation of radial and rotational velocities, these values were cross-matched with previously published values. Out of 427 objects, we flagged 68 potential spectroscopic multiple (SB) systems. The results of our new radial velocities determinations and SBs candidates are particulary relevant for membership revision of targets in young stellar associations. Our results show that the three highest spectroscopic binary fractions correspond to three youngest associations (Etha-Cha: 0.23, TW Hydrae: 0.20 and Beta-Pic:0.23). We comment on the significance of the resulting SB fraction for futher investigations and the implications on companion migration beyond ~20 Myr.

The Formation of Binary Stars and Impact of Binaries on Planet Formation

Moe, M.

University of Arizona

First, I will review the statistical properties of multiple stars in the context of the two dominant modes of binary star formation: disk fragmentation on small scales and core fragmentation at wider separations. Disks become more prone to fragmentation with higher accretion rates and lower opacities, and so the close binary fraction increases with primary mass and decreases with metallicity. Alternatively, wide binaries that form via core fragmentation are metallicity invariant. Close binaries accrete from a circumbinary disk, leading to a uniform mass-ratio distribution and small excess twin fraction, while wide binaries that form via core fragmentation are weighted toward small mass ratios. The mutual inclinations of triple stars provide further support for two formation channels: most compact triples are in nearly coplanar configurations while wide tertiaries have random orientations with respect to the inner binaries. Second, I will highlight the increasing evidence that stellar companions within a < 50 AU substantially sculpt and even suppress planet formation, either by increasing turbulence in the disk, truncating the disk, and/or accreting disk material on timescales faster than the planets can form. I will present a meta-analysis of the various surveys, demonstrating 43% of G-dwarf primaries in magnitude-limited samples cannot host close planets because they already have close stellar companions. The influence of binaries on planet formation has important implications for the inferred planet occurrence rates and trends with host mass and metallicity.

The Kepler Circumbinary Systems

Jerome A. Orosz

Closely orbiting around eclipsing pairs of stars, the transiting circumbinary planets discovered by Kepler are fascinating and challenging systems. The circumbinary planets are subjected to much stronger gravitational perturbations than planets in single-star systems. This creates a dynamic environment that challenges our planet formation and migration theories. The task of parameter estimation can be daunting owing to the large number of free parameters and, in many cases, the presence of confounding signals due to star spots. The reward one reaps is large, however, since very precise system parameters can be determined.

To date, 13 planets in 11 systems have been discovered and characterized using the Kepler data. Although relatively few in number, the sample is large enough that interesting trends are emerging regarding the planets' radii, orbits, host-binary star periods, and proximity to the habitable zone. In this talk I will discuss the set of the Kepler circumbinary planets and their trends, present the latest discoveries and candidate systems, and comment on the necessity and benefits of full "photodynamical" modeling.

Circumbinary planets - now and into the future

David Martin

Department of Astronomy and Astrophysics, University of Chicago, 5640 South Ellis Avenue, Chicago, IL 60637, USA

The Kepler mission opened the door to a bonafide sample of a dozen circumbinary planets. Some initial trends have been identified and used to challenge our theories of planet and binary formation. However, the Kepler sample is not only small but highly biased. I will present the next step in circumbinary planets, now and into the future. This talk will cover the BEBOP radial velocity survey to get mass-based detections, the latest TESS transit mission and the key changes needed with respect to Kepler, and a new technique to dig out additional, smaller planets in the existing Kepler data.

Binary Star Analysis with Intrinsic Pulsation

R. E. Wilson[1)], W. Van Hamme[2)], Geraldine J. Peters[3)]

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Strategies are introduced for coherent measurement of pulsational waveforms, amplitudes, periods, and period change rates, where 'coherent' means that the model stars actually pulsate, with no artificial alternation between pulsation without binary effects and binary effects without pulsation. Capabilities of the more advanced EB light curve models are in place, such as simultaneous solutions of multiband data and radial velocities, tides, mutual irradiation, and proper datapoint weighting. Color information from two or more bands allows geometric and radiative pulsational behavior to be compared with structural pulsation computations. An application to the Algol-type EB V1352 Tau exhibits possibilities.

Pulsating Stars in Binaries

Simon J Murphy

University of Sydney, Australia

Binaries anchor many of the fundamental relations we rely upon in our analyses. Masses and radii are rarely constrained better than when measured via orbital dynamics and eclipse depths. Pulsating binaries have so 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. And when their orbits are eccentric, oscillations can be excited tidally, informing our knowledge of tidal dissipation and resonant frequency locking. I will present an overview of these themes in light of both observational and theoretical developments recently made possible by space-based photometry.

An eclipse to build a dream on: Detecting g-mode period spacing patterns in eclipsing binaries with pulsating components

Sanjay Sekaran, Andrew Tkachenko, and Cole Johnston

Eclipsing binaries are valuable objects of study as the masses and radii of the individual components can often be observationally determined to a precision of ~1% or better. This synergises well with asteroseismology, which enables the derivation of stellar internal properties through the study of stellar pulsations. Combining the information derived from binarity and asteroseismology allows for the simultaneous confrontation of models derived from both stellar structure and evolution, and pulsational excitation theory. We have identified three F-type eclipsing binaries from the Kepler Eclipsing Binary Catalog (Prsa et al. 2011) that also display g-mode period spacing patterns that are required for asteroseismic modelling: a very rare combination. In particular, we have identified that the eclipsing binary KIC9850387 displays multi-mode period spacing patterns in the Fourier transform of an unprecedented length. Here we present the statistics of our eclipsing binary sample, specifically the orbital and pulsational properties, and our methodology for the analysis of eclipsing binary pulsators.

Eclipsing binaries with pulsating mass-accreting components

Mkrtichian D.

I will give a review of the basic properties and a current status of works related to a class of mass-accreting pulsating components in semi-detached Algol systems (oEA stars).

The effects of the mass transfer/accretion on pulsations will be discussed and observational confirmations will be demonstrated on the examples of well-studied Algol-type systems. The results of spectroscopic observations of oEA stars will be compared with the results of 3D hydrodynamic simulations of mass transfer.

I will review briefly a new asteroseismic methods for studies of short-term processes in binaries, in particular acceleration/braking of rotation of mass-gaining component under a high mass-trasfer epizodes. The results of high-resolution spectroscopic survey, showing the existence of high-degree non-radial pulsations in oEA systems will be presented.

I will also overview the results of photometric survey of southern Algol stars which is based on TESS light curves and led to detection of more than three tens of new oEA pulsators.

Calibrating core-masses of intermediate- and high-mass stars with pulsating binaries

Cole Johnston, Andrew Tkachenko, Kresimir Pavlovski, Conny Aerts, Dominic Bowman

Institute of Astronomy, KU Leuven, Belgium

For decades, eclipsing binary systems have been heralded for their capacity to provide high-precision constraints on stellar modelling. Indeed, with their ability to provide model-independent (or dynamical) masses and radii, eclipsing binary systems serve as calibrators for distances, ages, and theoretical models of stellar structure and evolution. As such, eclipsing binaries are often used in studies to investigate the poorly understood processes of chemical and angular momentum transport in stellar interiors, particularly for intermediate- to high-mass stars born with convective cores. The most glaring difference between theory and observations is the so-called mass discrepancy between evolutionary and dynamical masses. This mass discrepancy problem is often solved by increasing the core mass of the star in the stellar models by introducing additional near-core-boundary mixing, via rotation, overshooting or penetration, or a combination thereof. However, there is much debate as to what the proper physical description and scaling of such mechanisms should be. In this talk, we review the results of using binaries to constrain such interior mixing processes and their effect on the resulting core masses and ages. We discuss the phenomena of rotation, overshooting, penetration and internal gravity waves as mechanisms to induce interior chemical mixing and angular momentum transport, as well how binary modelling can critically constrain such processes. We also showcase the potential of combining contemporary binary and gravity-mode asteroseismic modelling to provide independent cross-constraints for the calibration of interior transport processes. Finally, we point out how binary asteroseismology based on space-based photometry, in combination with the Gaia astrometry in future data releases, can lead to precise predictions of He-core masses and ages at the end of the main-sequence.

Spot Migration on Eclipsing Binary KIC9821078

Engin Bahar; İbrahim Özavci, Hakan Volkan Şenavcı

High precision and continuous light curves obtained from Kepler Space Telescope provide significant information about the behavior of cool star-spots. In this study, we obtain the surface maps of the eclipsing binary KIC9821078 with the help of the light curve inversion method to reveal longitudinal spot migration behavior, using Kepler Short Cadence (SC) light curves. We also present up-to-date light curve solution of the system using light and radial velocity curves. The inversion results show that there are at least two dominant spot regions migrating from higher to lower longitudes as a consequence of solar-like differential rotation.

Tuesday, 10th September

The Brave New World of EB Modeling

Andrej Prsa

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Over the last decade, the precision of photometric and spectroscopic data used in eclipsing binary modeling witnessed a surge that revealed an incredible complexity of the observed sources. We are routinely talking of ppm photometric precision and m/s radial velocity measurements. Yet the codes to model these observations were never designed for such ultra-precise observations and, in consequence, systematics abound. In this review I will discuss the limitations imposed by the currently existing codes, and the efforts to overcome them. In particular, I will discuss the impact of discretizing stellar surfaces, of frequently implied assumptions regarding limb darkening, gravity darkening and Doppler boosting, the caviats related to model atmospheres and reflection, and I will outline common pitfalls when fitting observed data to obtain fundamental stellar parameters (masses and radii). I will conclude with a brief overview of the new physics currently being implemented in PHOEBE, most notably pulsations and many-body dynamics.

Upcoming Support for Triple Stellar Systems in PHOEBE

Kyle Conroy

Villanova University, Astrophysics & Planetary Sciences, Villanova PA, United States

Eclipsing binary stars allow for the direct measurement of stellar parameters and distances and are therefore an important tool in the calibration of stellar relationships. In benchmark cases, we can achieve a precision of 2-3% in fundamental stellar parameters. Due to tighter constraints caused by mutual eclipse events, systems with additional companions allow achieving precision as low as 0.5%. Triple systems have also been proposed as a mechanism for explaining an overabundance of short-period tight binaries. Despite all of this, we do not yet have a complete model for these multiple star systems that include tight binaries. In order to precisely and accurately model these complex systems, we must take into account several considerations, including: light time effects, perturbations to orbital elements, and this distortion of the stellar surfaces. Including all of these into a comprehensive treatment of triple and higher order systems within PHOEBE is currently under development and planned for an upcoming release.

An Analytic Self-gravitating Disk Model: Morphology and Logical Structure

R. E. Wilson

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The foundations of an analytic Accretion-Decretion (*A-D*) disk model for mass-transfer binaries, based on equipotential theory, are examined. Gravitation of stars 1 and 2 and the disk, as well as disk and star rotation, are included and relevant morpholology is explored. Expected applications are

to disks with morphologically significant mass and substantial optical thickness, although possibly with semi-transparent edges. Specific targets include classical novae, nova-like variables, and W Serpentis binaries, with the concept invoking knowledge about B_e stars and the classically strange binary β Lyrae. The model's ideas and resulting character differ from those usually applied to optically thick disks -- for example there is no need to truncate the model arbitrarily at an outer or inner limit, as it closes naturally at both places. It is a volume emitter with attenuation of internally generated light. Computations intrinsically produce phenomena that are characteristic of circumstellar disks in binaries - in particular tidal and rotational gravity brightening and an outer effective gravity null point that do not occur in the common axi-symmetric disk model. Impersonal analysis in terms of the model (Least Squares criterion) is applied to light curves of recurrent nova CI Aquilae.

Beyond DC and MCMC: algorithms and approaches for fitting binary star light curves

A. Kochoska, K. Conroy, A. Prsa

Villanova University, Astrophysics & Planetary Sciences, Villanova PA, United States

The parameter space of binary star light curve models is highly complex and degenerate, thus basic fitting approaches often fail to yield a good (and correct) estimate of the parameter values and their uncertainties. I will demonstrate the problems that this gives rise to when using the most common methods, namely DC or NMS for quick and MCMC for more advanced modeling, in particular when the solution is not well-constrained. On the other hand, we have an increasingly large number of fitting and sampling algorithms available that can be relatively easily interfaced with open-source eclipsing binary packages, like PHOEBE 2. I will showcase several fitting methods and their associated python packages, including nested sampling, differential evolution and PRISM, as well as discuss their performance on fitting a light and RV curve model with PHOEBE 2.

PyWD2015 - A new GUI for the Wilson - Devinney Code

Ozan Güzel, Orkun Ozdarcan

Ege University, Bornova, Izmir, Turkey

In this work, a new, modern GUI for 2015 version of the Wilson - Devinney (WD) code is developed. PyWD2015 is written in Python 2.7 and uses Qt4 interface framework. At its core, the GUI generates lcin and dcin files from user inputs and sends them to WD, then reads and visualizes the outputs in a user friendly way. It also includes some useful tools for the user, which makes technical aspects of modeling process significantly easier. While multiple sky surveys and space missions generate, reduce and categorize large amouts of observational data, it's up to the dedicated studies to analyze peculiar or anomalous systems and make further progress in the field of physics of eclipsing binaries. We believe PyWD2015 will be a great "dedicated study" suite for such systems.

Starspot Trek. The motion picture

B. Debski

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This work is focused primarily on the starspot migration in contact binary stars of the W UMa-type. With the power of the Light Curve Morphology Analysis applied to the data from Kepler Spacecraft it was possible to easily trace the spot migration in our sample of objects with the EW- and EB-type light curves. The same method allowed obtaining the unique insight into the physical properies of the studied binary systems. Here we show some of the findings: how to machinely detecting the spot migration, trace the spot migration, learning the direction of the migration; the relative temperature of the migrating spot, proof that spots tend to form 'tilted polar caps' and much more.

Artificial Intelligence in the Astrophysics

Ivan Zelinka

This paper discusses the mutual combination of the unconventional algorithm (in this case evolutionary algorithms), deterministic chaos and modelling by neural networks on real data from astrophysics. Symbolic regression with the selected evolutionary algorithm is used to synthesize suitable models and then verify them on the real astrophysical data sets.

The explosive life of massive binary systems

Mathieu Renzo

Massive stars are one of the key drivers of Galactic evolution and exist mostly as members of binary (or higher multiplicity) systems. Therefore, any observed sample of massive stars will necessarily be significantly influenced by the effects of binarity. The presence of a companion on a short period orbit can significantly alter the life and final outcome of a massive star, allowing for a variety of outcomes from stellar mergers, runaway and walkaway stars, X-ray binaries, and gravitational waves mergers. Binarity might also contribute to the solution of the long-standing problem of the explosion mechanism for core-collapse supernovae and enhance the number of transients of stellar origin in the sky. These explosions have also a dramatic impact on the kinematics and orbital motion of the binaries, with consequences for the rate of formation of X-ray sources and gravitational waves. In this talk, I will focus on the most common processes in massive binary evolution and how they impact the death of the stellar companions. I will highlight the most uncertain physical ingredients (mass transfer efficiency, natal kicks, etc.) and possible ways to constrain them using present and upcoming observational samples. In particular, I will emphasize the outcomes of binary evolution that are robust against variations in the input physics, and what are instead rare and unusual evolutionary paths.

Long and short-term photometric variations of selected X-ray binaries

Tugçe Içli, Dolunay Koçak, and Kadri Yakut

University of Ege, Department of Astronomy and Space Sciences, Bornova, Izmir, Turkey

In this study, long and short-term photometric variations of the selected low mass (LMXBs) and high mass X-ray binaries (HMXBs) are discussed. The long and short term new VRI multicolours observations of some selected X-ray binaries were observed between 2015-2019 with 60cm and 100cm telescopes at the TÜBITAK National Observatory (TUG). We obtained new light variations for HZ Her, ScoX-1, PSRJ1023+ 0038, BQ Cam, SAXJ2103.5 + 4545, XTEJ1946 + 274, X Per, V934 Her. The new orbital period of some systems has been determined, and long and short-term light variations have been discussed and presented in this study.

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A stochastic propagation model to the energy dependent rapid temporal behaviour of Cygnus X-1 as observed by AstroSat in the hard state

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We report the results from analysis of six observations of Cygnus X-1 by Large Area X-ray Proportional Counters (LAXPC) and Soft X-ray Telescope (SXT) on-board AstroSat, when the source was in the hard spectral state as revealed by the broad band spectra. The spectra obtained from all the observations can be described by a single temperature Comptonizing region with disk and reflection components. The event mode data from LAXPC provides unprecedented energy dependent fractional root mean square (rms) and time-lag at different frequencies which we fit with empirical functions. We invoke a fluctuation propagation model for a simple geometry of a truncated disk with a hot inner region. Unlike other propagation models, the hard X-ray emission (> 4 keV) is assumed to be from the hot inner disk by a single temperature thermal Comptonization process. The fluctuations first cause a variation in the temperature of the truncated disk and then the temperature of the inner disk after a frequency dependent time delay. We find that the model can explain the energy dependent rms and time-lag at different frequencies.

On the variations on the accretion disk on AU Monocerotis

Lientur Celedon

University of Concepcion, Victor Lamas, 1290, Concepcion, Chile

AU Monocerotis is a well studied interactive binary star, member of a group called double periodic binaries, which principal characteristic is the existence of a long photometric cycle roughly 33 times the orbital period. Here I present the preliminary results of variation in the accretion disk of the primary star in the system which are related to this long photometric cycle.

Modelling the depletion in post-AGB binaries with dusty circumbinary discs

Glenn-Michael Oomen, Hans Van Winckel, Onno Pols, Gijs Nelemans

Post-asymptotic giant branch (post-AGB) stars are transition objects between the AGB and planetary nebula (PN) evolutionary phases. A large fraction of post-AGB stars in our Galaxy turn out to be binaries in orbits with periods in the range 100 – 3000 days, often with non-zero eccentricity. It is now well established that these binaries are surrounded by a stable circumbinary disc of gas and dust. Many of these ‘disc-type’ post-AGB stars are also chemically peculiar in a particular way: the photosphere shows underabundances of refractory elements that scale with condensation temperature. This phenomenon, also called depletion, is expected to be the result of accretion of clean gas from the dusty disc in which the refractory elements were removed by dust formation. In this contribution, we provide the first models of depletion in post-AGB stars using the advanced stellar evolution code MESA. These models are compared to a sample of 58 observed disc-type post-AGB stars in our Galaxy with chemical abundance data. We find that large initial accretion rates (?3e-7 Msun/yr) and large initial disc masses (~1e-2 Msun) best reproduce the observed depleted post-AGB stars. These high accretion rates can have a strong effect on the evolution of the star, as the evolution timescale of post-AGB stars can be significantly extended by factor 2 - 5. Furthermore, because of the slow evolution of the lower-luminosity stars, we find that these low-luminosity systems can become depleted at lower effective temperatures (<5000 K). We conclude that our models of accretion from a circumbinary disc successfully account for the chemical peculiarity of post-AGB stars.

Radial velocities of galactic Wolf-Rayet stars

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Massive stars ?are key drivers in the evolution of galaxies, responsible for a plethora of astrophysical phenomena such as supernovae, pulsars, black holes and gravitational waves. It is now well established that the majority of massive stars form and evolve in the presence of one or more companions with which they will interact during their lifetime. Stars that are massive enough will eventually reach the classical Wolf-Rayet (WR) phase that is characterized by strong winds and hydrogen depletion. However, the fraction of WR stars that may form via binary interaction is

unclear. Knowledge of the true multiplicity of WR stars is crucial for understanding the impact of binarity on the evolution of massive stars and predicting the frequency of observed supernovae and gravitational wave events. However, no systematic studies attempting to derive the bias-corrected binary fraction of the Galactic WR stars were so far performed. Here we present the results of a pilot study; a multi-epoch, radial-velocity (RV) survey of galactic WR stars with high-resolution spectra observed with the HERMES spectrograph mounted on the Mercator telescope. Using an advanced cross-correlation method, we obtain precise RV measurements with errors of ~3 km/s, roughly a factor 5-10 better than previously attained. In my talk, I will illustrate the sample, methods, and preliminary results towards the first bias-corrected determination of the binary fraction of galactic WR stars.

Wide binaries as probes of stellar formation and evolution

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The Gaia mission has revolutionize the wide binary field, making it possible to assemble large, homogenous, and pure catalogs of wide binaries with a well-understood completeness function. I will discuss recent discoveries about the Galactic wide binary population enabled by these catalogs, including (a) the onset of metallicity dependence in the binary fraction at a < 200 AU, (b) evidence for weak stellar "kicks" during the AGB phase that unbind the widest binaries, and (c) detailed mapping of the mass ratio distribution over 0.1 < M_1/M_sun < 3 and 50 < s/AU < 50,000. Most intriguingly, I will present the recent unexpected discovery of an excess population of equal-mass "twin" binaries at very large separations, out to 10,000 AU. Such a population is not predicted to exist in commonly accepted binary formation models and challenges our understanding of the star formation process.

Spectroscopic Observations of Eccentric Binary Systems

Evrim Kıran, Hicran Bakış, Volkan Bakış

Eccentric eclipsing binaries (EEBs) are part of detached binary stars and most of the EEBs show apsidal motion effect. The fundamental physical parameters of EEBs allow us to test stellar evolution models and to estimate the internal stellar structure constants through apsidal motion analysis. At the UBT60 telescope of Akdeniz University located in TUBITAK National Observatory, we started a programme to study EEBs spectroscopically. In this study, we present orbital parameters of some selected eccentric eclipsing binary stars.

Close Binary Stars in Open and Globular Clusters

Dolunay Koçak, Tugce Içli, Kadri Yakut

University of Ege, Department of Astronomy and Space Sciences, Bornova, Izmir, Turkey

Abstract: Open and globular star clusters are very important laboratories for understanding and test stellar evolution theories. By using stellar parameters of a binary system, we can construct theoretical models to test current models and try to understand some of the poorly understood astrophysical phenomena like mass loss, mass transfer, physical parameter variations during the evolution, angular momentum problem, etc. In this study, we obtained high precision new multi-colour observations of close binary systems in the open cluster M35, M67, and globular cluster M71. New observations obtained by using the 1m and 0.6m telescopes at the TUBITAK National Observatory (TUG). We have observed M67 during four nights in VRI filters, M35 during nine nights in VRI filters and M71 during ten nights in VR filters. We analyzed multi-colour light curves of the close binaries and also determined new orbital and physical parameters for the binaries that member of the clusters. Besides, period variation analysis of the selected systems was done using all times of mid-eclipse available in the literature and those obtained in this study. Finally, we discuss the possible evolutionary scenario for the binary systems.

Acknowledgments This study was supported by the Turkish Scientific and Research Council (TUBITAK 117F188) and the TUBITAK National Observatory (18CT100-1422, 19AT60-1470). We would like to acknowledge the contribution of COST (European Cooperation in Science and Technology) action CA15117 and CA16104. The current study is a part of PhD thesis of DK.

Tuesday, 11th September

The Good, the Bad and the Really Ugly: Composite-Spectrum Binaries

Elizabeth Griffin

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Composite-spectrum binaries (containing a cool giant primary and a hot dwarf secondary) should be an answer to a theoretician's prayer. Because of their luminosity difference, both spectra are visible in the near UV, a region that include several valuable luminosity and temperature indicators. If we just measure the RV of the secondary at different dates, and construct an SB2 orbit, we immediate get the mass ratio of the component stars. A guess of the mass of the dwarf, and one thence obtains the mass of the cool giant - a unique and immensely valuable method. But "just" measure a hot dwarf's RV?? It raises many problems, mostly caused by the nature of the star: a hot (late-B or early-A) dwarf has few lines, they are weak, they can be very blurred by rotation, and they get hidden by the crowded spectra of the giant. Spectral subtraction works a treat in separating the two spectra, but the residue is inevitably rather noisy. Nevertheless, results from well over half of the 45 brightest northern composite-spectrum binaries have been published, and have revealed that about 1 in 6 are actually triple systems, and a few have characteristics that defy any theoretician to explain (though one tried to do so by altering the data!). Quite a number are `"bad" ones have such unique giant components that separation by subtraction is troublesome, while the "really ugly" include an Am star in a simple SB2 binary with a period of 75 years, a pair of early-A dwarfs in a 3-day orbit with amplitudes of ~100 km/s and which show absolutely no rotational broadening at all, and another whose secondary (apparently a single star) is more that twice as massive as its primary giant. But 8 of the sample are also eclipsing, and manifest the hugely important phenomenon of chromospheric absorption - those are the "really good" systems. I will show examples of each kind.

Binarity among objects with the Be and B[e] phenomena

A.S. Miroshnichenko, S.V. Zharikov, D. Korcakova, N. Manset, R. Mennickent, S.A. Khokhlov, S. Danford, A. Raj, O.V. Zakhozhay

Many B-type stars have been found to exhibit two phenomena, Be and B[e]. The former one refers to the presence of a circumstellar gaseous disk, while the latter one also implies the presence of circumstellar dust. Although the nature of both phenomena are not fully understood, there is growing evidence that binarity of the underlying stars plays an important role in their creation. Recent results on Be and B[e] binaries along with methods of their discovery will be reviewed. Possible evolutionary connections of these objects and ideas for finding them at earlier and later phases of the phenomena will be briefly discussed.

Composite spectra hot subdwarf binaries

Peter Nemeth, Joris Vos

Spectral disentangling is a fundamental method to work on double-lined spectroscopic binaries or to remove spectral contamination in crowded fields. Disentangling based on the Fourier method is a powerful tool to separate the contributions of the members to composite spectra. The method is general and provides a solution even if the binary members are of very similar type. However, it requires a good coverage of the orbital period by observations, as well as the condition that precise radial velocities can be measured. Typically this occurs in short period binaries with cool components. We work, however, on the opposite end, with long orbital period (400d < P < 2400d) hot subdwarf binaries with main sequence (F-G-K) components, where obtaining high signal-to-noise spectra is much easier than getting an orbital coverage. Exploiting that the binary members have very different spectra, a decomposition becomes possible from a single observation, simply by appropriately combining synthetic spectra. This method can also be generalized to systems with multiple components. I will describe our approach, the systems we work on and the results that came from this project, which may be the key to understand the yet mysterious formation of hot subdwarf stars.

Binary stars with an RR Lyrae component - new candidates

Skarka, M., Prudil, Z., Liška, J.

There is a significant lack of binary stars with the RR Lyrae component. In fact, only one binary star is known among 200 thousands of catalogized RR Lyrae stars. Currently, there are about one hundred candidates. The binarity of most of them is deduced from the periodic variations of their pulsation periods which are interpreted as the Light Travel Time Effect. We introduce 20 such new candidates with expected orbital periods between 3 and 15 years, which we found in data of the Galactic bulge survey of the Optical Gravitational Lensing Experiment (OGLE). We will briefly discuss the possible reasons for what we observe and the issues in searching for binary stars with an RR Lyrae component.

Do star clusters form in a completely mass-segregated way?

Václav Pavlík, Pavel Kroupa, and Ladislav Šubr

ALMA observations of the Serpens South star-forming region suggest that stellar protoclusters may be completely mass segregated at birth. Independent observations also suggest that embedded clusters form segregated by mass. As the primordial mass segregation seems to be lost over time, we aim to study on which timescale an initially perfectly mass-segregated star cluster becomes indistinguishable from an initially not mass-segregated cluster. As an example, the Orion Nebula Cluster (ONC) is also discussed. We used N-body simulations of star clusters with various masses and two different degrees of primordial mass segregation. We analysed their energy redistribution through two-body relaxation to quantify the time when the models agree in terms of mass segregation, which sets in only dynamically in the models that are primordially not mass segregated. A comprehensive cross-matched catalogue combining optical, infrared, and X-ray surveys of ONC members was also compiled and made available. The models evolve to a similar radial distribution of high-mass stars after the core collapse (about half a median two-body relaxation time, t_rh) and become observationally indistinguishable from the point of view of mass segregation at time ?_v ?

3.3 t_rh. In the case of the ONC, using the distribution of high-mass stars, we may not rule out either evolutionary scenario (regardless of whether they are initially mass segregated). When we account for extinction and elongation of the ONC, as reported elsewhere, an initially perfectly mass-segregated state seems to be more consistent with the observed cluster.

Binarity of the Population II stars

Gabriel Szász

Since the HST WFC/ACS survey (Milone et al. 2011) has revealed that the total fraction of binaries in nearby globular clusters is significantly smaller than the one we observe in the field stars, the observed binarity distribution in Population II stars remains a mystery. In this review talk, we summarize the current state of the research on this topic, discuss the outcomes of the ACS survey, and compare existing evolutionary studies on binary populations in the globular clusters.

Probing the Evolution of Cataclysmic Variables

Edward M. Sion, Villanova University, USA (presented by S. Kafka)

A number of critically important questions about cataclysmic variables (CVs) remain to be answered: What is the genesis of CVs; what is the outcome of their evolution through thousands of nova explosions; do the accreting white dwarfs accrete more mass than they lose via classical novae explosions: are CVs with massive white dwarfs (M_wd > 1.0 Msun) viable Supernova Type Ia progenitors. This review will primarily highlight what we know about the above questions through the analysis of far ultraviolet spectroscopy with Hubble, FUSE and IUE. Special Emphasis will be given recurrent novae, classical novae and the ER Ursa Majoris dwarf novae with extremely short outburst cycle times.

New Online Database of Symbiotic Variables

Jaroslav Merc[1,2)], Rudolf Gális[1)], Marek Wolf[2)]

1) Institute of Physics, Faculty of Science, P. J. Šafárik University in Košice, Slovakia

2) Astronomical Institute, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Symbiotic variables belong to an interesting class of interacting binary stars. Since the beginning of this century, the systematic search for these objects has begun and such surveys in the Milky Way and the Local Group resulted in discoveries of many new objects and dozens of candidates. As the latest catalog of symbiotic binaries is almost two decades old, we decided to prepare a new database of the galactic and extragalactic symbiotic systems which is presented in this work. Our database is available online, allowing it to be up-to-date and available to the community at any time. The database also includes a web portal that allows easy data access without the necessity for any additional software or formatting of the data.

Posters (28)

Back projections of the light curves of the RU Monocerotis binary

V. Bahyl[1)], M. Kodrík[2)]

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The poster presents the result of our mathematical experiment with the light curves of the variable RU Monocerotis which has high value of the apsidal motion. We have treated older and our photometric data for the different positions of the longitude of the periastron of the studied binary with our reconstruction algorithms. We have obtained very interesting result – picture of the primary and secondary minima projections representing the value of the apsidal motion of the system.

Light curve modelling of close eclipsing binaries

Fedurco. M., Čokina M., Parimucha Š.

Research on stellar oscillations in close eclipsing binaries requires a robust numerical model able to produce light curves of such objects, where presence of eclipses and tidal distortion of the components is taken into an account. Therefore, we present, easy to use, software package fully written in Python designed for light curve modelling of close eclipsing binaries. Software provides full treatment of Roche geometry and irradiation effects utilizing symmetries of tidally deformed stellar surfaces and eccentric orbits in order to reduce overall computational time. Additionally, software package allows modelling of spots and low amplitude radial and non-radial pulsations.

Temporal evolution of the eclipsing binary system DV Psc

Sofia Palafouta, Kosmas Gazeas

National and Kapodistrian University of Athens, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, GR 15784 Zografos, Athens, Greece

The existence of a magnetic activity for the eclipsing binary system DV Psc is known for almost two decades. However, no evidence of periodic behavior relevant to this activity has been found until recently. In this study, long-term photometric observations of DV Psc between 2005-2017 are used to analyze its magnetic activity, seek a possible magnetic cycle and determine the orbital and physical parameters of the system. The combination of photometric and spectroscopic observations resulted in a unified model that describes the system throughout the years, as a result of the variable spot activity. A total of 71 new times of minimum light are calculated through the entire time span of observations and combined with the 123 bibliographic ones since 1997, increasing significantly the existing sample. As a result an accurate astronomical ephemeris and an updated O-C diagram were constructed for a total span of 19 years (1997-2017) of the system. An intense magnetic activity, which is shown through the strong asymmetries on the light curves (O' Connell effect) and the periodic variation of the O-C diagram are combined to explain the system's behavior. The existence of a third body, orbiting the eclipsing binary in an eccentric orbit, as well as a magnetic cycle are the

most likely scenario. The absolute physical parameters of DV Psc are calculated for the unified model, while the evolution state of the system is studied through the mass-radius and temperature-luminosity (H-R) diagrams.

The Radial Velocity Revolution

Elizabeth Griffin

Measuring stellar radial velocities was a skilled operation, but fraught with difficulties even one became expert at it. The problems were not in the actual measurements of recorded spectra but in the way the spectrograph had been designed and operated, and many presented systematic errors that belied one's best efforts to be accurate. All that changed when Roger Griffin successfully introduced a technique of physical cross-correlation into the focal plane of the spectrograph, not only speeding up measurements hugely to about 10 minutes per 9-mag star (compared to measuring 3 stars PER DAY) the conventional way with a travelling microscope), not including telescope time to record the whole spectrum first. Systematic errors were determinable too. Roger's next element of "revolution" was a paper in 1974 that foresaw a way round the last of the obstacles, by replacing the error-prone comparison spectrum with one that was in-line with the stellar spectrum, progressing from telluric lines to a hydrogen fluoride cell (poisonous!) and culminating in the iodine cell. That sparked a population of highly stable spectrographs that could discern RVs as small as a few (tens of) metres per second, and gave birth to the highly popular sub-discipline of exoplanets. Roger's series of SB orbits in The Observatory Magazine may have come to an end, but I am taking this opportunity to recall to you the magnificent

K dwarf triples and quadruples in the SUPERWIDE catalog of 90,000 nearby wide binaries

Zachary Hartman, Sebastien Lepine, Gerard van Belle

Lowell Observatory, Flagstaff, AZ, United States; Physics and Astronomy, Georgia State University, Atlanta, GA, United States

The SUPERWIDE catalog is an all-sky catalog of ~90,000 wide binaries with projected orbital separations ~100 AU-100,000 AU, most of them located within 500 pc of the Sun. These consist of common proper motion (CPM) pairs of high proper motion stars (>40 mas/yr); a Bayesian analysis using positions, proper motions and distances from Gaia DR2, shows these pairs to have probabilities >99% of being gravitationally bound systems. Here, we examine the wide binaries where the primary star is a K dwarf. This allows us to identify unresolved higher-order systems because the K dwarf main-sequence is narrow in this part of the H-R diagram, and unresolved systems are easily identified as over-luminous. We identify several hundred systems where at least one of the common proper component is over-luminous, and are thus higher-order systems (triples and quadruples). We examine how metallicity appears to affect the colors of K dwarfs, complicating the identification of over-luminous objects. Taking these effects into account, we calculate the higher-order multiplicity fraction as a function of the color/mass of the K dwarf primary.

Contact binary atmospheres with STARGRIT

A. Kochoska, M. Horvat, T. Zwitter, A. Prsa

Villanova University, Astrophysics & Planetary Sciences, Villanova PA, United States

The modeling and analysis of contact binaries is crucial for the studies of stellar formation and evolution, in particular interactions and orbital dynamics in binary and multiple systems. Many studies use photometric data of contact binaries to probe mass transfer models and progenitor scenarios for objects such as blue stragglers and red nova explosions. However, there is an inherent shortcoming when modeling them with any currently available eclipsing binary code, due to the lack of contact binary atmosphere tables. I will present the basic principles and design of STARGRIT, a new, 3D, true-geometry radiative transfer code that is capable of computing CB atmospheres, whose development was motivated by this issue. I will discuss the current status of the code, as well as its integration with existing hydrodynamical models and binary star analysis software. This is the first and most crucial step towards significantly improving future analyses of these systems from archival and upcoming data.

35d cycle of X-ray binary HZ Her/Her X-1

D. A. Kolesnikov, N. I. Shakura, K. A. Postnov, I. M. Volkov, I. F. Bikmaev, T. R. Irsmambetova, R. Staubert, J. Wilms, E. Irtuganov, P. Shurygin, P. Ju. Golysheva, S. Ju. Shugarov, I. V. Nikolenko, E. M. Trunkovsky, G. Schonherr, A. Schwope, D. Klochkov

We studied X-ray binary system HZ Her/Her X-1 with a 1.7-day orbital period in which disc accretion occurs from the optical donor star (HZ Her) onto a neutron star (Her X-1). On top of orbital variability and pulsating X-ray emission with about one second period from rotating neutron star, a 35-day X-ray modulation of emission is observed. The 35-day variability is due to a tilted precessing accretion disc periodically screening X-ray emission from the neutron star. The disc precesses in the direction opposite to the orbital motion and is determined by the joint action of the tidal torque from the donor and dynamical torque from the gas streams. Several ten thousand broadband UBV photometric observations of HX Her has been obtained since 1972.

The form of the orbital light curves of HZ Her also changes withe the 35-day cycle phase. The orbital variability can be reproduced in a model including a tilted precessing and warped accretion disc around a freely precessing neutron star. The disc is warped near its inner edge due to interaction with the rotating neutron star magnetosphere. The magnetic torque depends on the precessional phase of the neutron star. The X-ray emission flux from the neutron star also depends on the free precession phase which modulates the X-ray illumination of the optical star atmosphere and the intensity of gas streams. We demonstrate that this model is able to well reproduce both optical observations of HZ Her and the behavior of the 35-day X-ray cycle.

WHOO! - White Hole Observatory Opava

Hana Kučáková

Faculty of Philosophy and Science, Silesian University, Opava, Czech Republic

Introduction of the Observatory of Institute of Physics, Faculty of Philosophy and Science, Silesian University in Opava.

KMTNet variable star catalog

Lee, Chung-Uk

Korea Astronomy and Space Science Institute, Daejeon, South Korea

Almost 0.5 billion stars have been being observed and monitored during Bulge season using the Korea Microlensing Telescope Network (KMTNet) of Korea Astronomy and Space Science Institute to search for exoplanets using microlensing method in the Galactic bulge area from 2015. Because KMTNet consists of three identical 1.6m wide-field telescopes and 324M pixel Mosaic CCD camera having 2 x 2degree FOV at Chile, South Africa and Australia, the 24-hour uninterrupted high cadence light curves are easily obtained on the ground. After the appearance of KMTNet the observation paradigm in the microlensing science field has been apparently changed by omitting follow-up observation. It is true that we are producing remarkable science results in the microlensing science fields, however the other light curves obtained in the Galactic Bulge regions are still buried in the disk storage. In this presentation, the variable star catalog of KMTNet will be introduced with some sample light curves showing the excellent continuity and high cadence. Any suggestion or comment to increase the usage of KMTNet variable star catalog is always welcome.

Physical Parameters of Low Mass Contact Binaries, very close to the orbital period cut -off

Georgia Loukaidou & Kosmas Gazeas

University of Athens, Zografou, Athens, Greece

Research on dwarf Main Sequence stars with low mass and low temperature, is particularly interesting and highly important in understanding stellar evolution in evolved stellar systems in our solar neighborhood. This type of systems host stars, which are one step before their final coalescence, having a substantial part of their mass and angular momentum already exhausted due to their long evolution. The purpose of this study is to investigate this type of contact binaries, by correlating their physical parameters with other known similar binaries. Consequently, we present a photometric investigation of low temperature and low mass stars, that simultaneously have orbital periods very close to the period cut-off of 0.22 days. The scientific approach was obtained by utilizing photometric observations of contact binary stars, in order to determinate their physical and geometrical parameters (i.e. mass, radius, temperature and luminosity). The sample was selected from the SWASP survey, on which follow-up photometric observations were carried out with larger telescopes and a proper optical filter set, such as the 2.3m telescope at Helmos Observatory and the 1.2m telescope at Kryoneri Astronomical Station (both at the National Observatory of Athens) and the 0.40m telescope at the University of Athens Observatory (UOAO).

Astroserver research services

Peter Nemeth

Spectroscopic investigations are essential to understand stars. With binary stars the challenge is more than doubled, because one must pay attention to the interactions of the binary members. These can be tidal or radiative interactions, or due to stellar intrinsic variability, as well as orbital variability, etc. Such features make binary spectral modeling a challenging task. Astroserver provides online stellar spectral analysis tools and services on-demand to help researchers in this field.

On some strange features in KEB lightcurves

Nuspl, János[1)], Hajdu, Tamás[1)], Hegedüs, Tibor[2)]

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We have scrutinized in details the compiled around 3 thousand eclipsing binary light curves of Kepler-I mission and found several typical and repeated common artifacts. We will present some of them pointing out their origin and give methods of how one can get rid of them.

Speckle Observations of Binary Stars with Telescopes of Observatorio Astronómico Nacional

Valeri Orlov

Regular speckle observations of double stars on OAN telescopes have been carried out since 2008.

Circumbinary brown dwarfs in Kepler eclipsing binaries

V. Kudak, P. Gajdoš, Š. Parimucha, M. Fedurco

Our study of O-C variations of eclipsing binaries observed with high precision photometry by Kepler satellite revealed systems, that indicate low amplitude O-C variations. These period changes can be interpreted as a ligh-time effect caused by the presence of the third, low mass bodies in the systems. We have separated binaries where variations correspond to the upper mass of brown dwarf (70 masses of Jupiter) and we determined their orbital parameters.

About the dependency of the spin maxima on orbital phase in the intermediate polar MU Cam

Š. Parimucha, P.A. Dubovský, I. Kudzej, V. Breus

Long term monitoring of intermediate polars is performed at Astronomical Observatory on Kolonica Saddle as a part of the InterLongitude Astronomy campaign (Andronov et al. 2003). High quality and long-time series observations allow us to investigate fine effects on complex light curves. In the case of MU Cam, we have investigated the periodic modulation of the spin phases with the orbital phase. This dependency was already described by Kim et al. (2005). As an explanation, they proposed inhomogeneous accretion flow from the secondary. However, based on our new data we can propose a simple explanation as the influence of orbital sidebands in the periodic signal produced by intermediate polar. This explanation is supported by the fact that the changes in spin maxima phase are observed mainly when the sideband frequency is dominant in the periodogram.

The enigmatic highly peculiar binary system HD 66051

E. Paunzen, S. Hubrig, E. Niemczura, P. K. Szymański

The spectroscopic binary system HD 66051 (V414 Pup) consists of a highly peculiar CP3 (HgMn) star and an A-type component (Niemczura et al. 2017, Nat. Sci. Rep. 7, 5906; Paunzen et al., 2018, A&A, 615, A36). It also shows out-of-eclipse variability that is due to chemical spots. The components have

effective temperatures of 12 500 K and 8 975 K, respectively. The orbital solution and the estimates from the isochrones are in excellent agreement with the estimates from the spectroscopic study. The system is very close to the zero-age main sequence and younger than 120 Myr. However, Kochukhov et al. (2018, MNRAS, 478, 1749) challenged the nature of the components for this system. Using a set of high-resolution spectropolarimetric observations, they discovered a weak magnetic field on the primary and found intrinsic, element-dependent variability in its spectral lines resembling a CP2 object. The secondary is claimed to be a metallic-line star showing neither a strong, global magnetic field nor intrinsic spectral variability. All other fundamental parameters are in excellent agreement with the former published ones. We present new photometric and spectroscopic observational results also using the TESS light curves in order to shed more light on the true nature of this object.

Characterization of evolved giants in symbiotic systems

D. Pieńkowski, C. Gałan, J. Mikołajewska

Symbiotic stars are binary systems composed of a red giant, and a hot, compact companion, usually white dwarf or neutron star, surrounded by ionized nebula. Despite of their long periods, which reach up to dozens of years they strongly interact via wind or Roche-lobe overflow, which places symbiotic stars among the most variable stars. Moreover, in the past, when the present compact object was going through AGB phase mass flowed in opposite direction which left a mark in the chemical composition of its companion – the present red giant. Study of chemical composition of symbiotic giants are essential to fully understand their evolution as well as many others related objects involving red giant stars at any phase of their life. To study chemical properties of the symbiotic giants, we collected many low-resolution near infrared spectra for objects from northern and southern hemisphere. By measuring equivalent widths of Na, Ca and CO features in K-band region of spectra and by comparing them with synthetic ones, we tried to find the effective temperatures, metallicities and chemical composition of these giants.

Stellar and Disk Characteristics of Young Visual Binary Components

L. Prato, K. Lindstrom, S. Graham, K. Sullivan, G. Schaefer, M. Simon

Properties of the individual stellar components and their primordial circumstellar disks in young binaries provide insight not only into the formation and evolution of the stars but also that of the surrounding planet-forming raw material. Objects in multiple systems with separations of a few to a few hundred AU are subject to the same local conditions, thus removing the variable of environmental impact. It is therefore possible to isolate the stellar and binary properties that most impact circumstellar disk, and hence young planet, formation and evolution. We present the initial results of a multi-year survey of 100 pre-main sequence binary systems in the Taurus, Ophiuchus, and other nearby star forming regions. Heterogeneous disk evolution around stars of similar mass may point to a dominant role of initial cloud core conditions. Ultimately, spectra and higher-level products of our analysis will be publicly available to the community at http://jumar.lowell.edu/BinaryStars/ (currently in beta version). Support for this research was provided in part by NSF award AST-1313399 and by NASA Keck KPDA funding.

Apsidal motion in the massive binary HD 152248

Sophie Rosu, Gregor Rauw, Eric Gosset, Jean Manfroid, Pierre Royer

The eccentric massive binary HD 152248, which hosts two O7.5 III(f) stars, is the most emblematic eclipsing O-star binary in the very young and rich open cluster NGC 6231. Measuring the rate of apsidal motion in such a binary system gives insight into the internal structure and evolutionary state of the stars composing it. In this context, from a set of optical spectra of HD 152248, we reconstruct the individual spectra of the stars and establish their radial velocities using a disentangling code. Combining radial velocity measurements spanning seven decades, we show that the system displays an apsidal motion at a rate of 1.750° per year. We further analyse the reconstructed spectra with the CMFGEN model atmosphere code to determine stellar and wind properties of the system. The optical light curve of the binary is analysed with the Nightfall binary star code to constrain the Roche lobe filling factors of both stars to a value of about 0.86 and derive an orbital inclination of 68.6°. Absolute masses of 28.9 and 29.1 solar masses are derived for the primary and secondary star respectively.

A Comprehensive study of SdB+dM binary TYC 3315-1807-1

Rukmini J, Shanti Priya D, Jishnu P and Vinay Kumar G

Subdwarf (sdB) stars are core helium burning stars with a very thin hydrogen envelope that lie at the blue end of horizontal branch (or Extreme Horizontal Branch {EHB}). The object TYC 3315-1807-1 is a SdB+dM first reported by Kawka et al (2010). Photometric data from the archives indicate the presence of a secondary companion causing a large reflection effect. Spectroscopic observations of the object were carried out from Vainu Bappu Observatory, Kavalur; to probe into the nature of secondary companion as well as to understand the Post Common-Envelope evolution of such objects. The Equivalent Widths (EW) of lines exhibits orbital phase dependent variations, indicating the probable contribution of secondary. Period variation study of the object was carried out using Times of Minima obtained from the literature suggesting a decrease in period. The evolutionary state of the system was evaluated on the basis results obtained and is discussed.

The discovery of the first delta-Scuti-like pulsating Ap star in an eclipsing binary system

Skarka, M., Kabáth, P., Paunzen E., Žák, J.

We introduce HD 99458, which is a peculiar binary system that shows interesting contradictory effects. The primary component is the first Ap star ever detected in an eclipsing binary system. It exhibits the second shortest known orbital period (2.7 days) for spectroscopic binary systems including an Ap component. It was also found that HD 99458 is a delta Scuti type pulsator. Again, it is for the first time, when this type of pulsations is observed in an Ap star. We briefly discuss the discovery and characteristics of this interesting object as well as which astrophysical theories can be tested with it.

MAVKA: Choosing the statistically optimal approximation using various methods

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We study statistical properties of the parameters determined using the software MAVKA (2019OEJV..197...65A) for determination of characteristics of extrema: moment of extremum

(recently abbreviated to ToM=Time of Minimum/Maximum), magnitude and their statistical errors. This program realizes the application of 9 basic functions for approximation of the extrema: algebraic polynomial in a general form, "symmetrical" algebraic polynomial, abrupted Taylor series of the "New Algol Variable" function (2012Ap.....55..536A), and that of prof. Z. Mikulášek (2015A&A...584A...8M), "Asymptotic Parabola" (1996OAP.....9..127M, 2015OAP....28..158A), "Wall-Supported Parabola", "Wall-Supported Line", "Wall-Supported Asymptotic Parabola" (2017OAP....30...57A) and "Parabolic Spline of defect 1". We made numerous tests of all these methods which consist of two parts, and in the second part - real observations of different variable stars. In the first part, the most important parameters we have investigated are the deviation between generated and determined values of moment of extremum and its magnitude, as well as the execution time for different shapes of extrema and other parameters. In the second part, we determined moments of extrema for many variable stars using photometric CCD and visual observations from different databases. The results obtained using proposed methods are compared.

Apsidal motion in Alpha CrB

Volkov, I.M.

Our long-term studies of the star finally led to reliable measurement of the velocity of apsidal rotation in this binary elliptical system. Our earlier measurements showed slow apsidal rotation in the system. The new refined value indicates a better agreement with the theory, although there is a slight slowdown of the apsidal rotation, which can be attributed to the inclination of the rotation axis of the main component to the orbital moment of the system. A comparison is made with other independent determinations of the apsidal rotation speed using satellite observations in the x-ray range.

New orbit of spectral and eclipsing double star BD-20 4369

Volkov, I.M., Kravtsova, A.S., Pribulla, T.

Our new multicolour photometrical observations of the southern eclipsing variable BD-20 4369 combined with earlier radial velocity curve enabled us to construct the reliable model of the binary. The details of a method for decoding spectra and processing photometric data obtained on large air masses are discussed.

Possible companions in low-mass eclipsing binaries

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Abstract: We present the next results of our long-term observational project to analyze the variations in the orbital periods of low-mass eclipsing binaries. New precise mid-eclipse times recorded with a CCD were obtained for several eclipsing binaries with short orbital periods. Observed-minus-calculated diagrams of the stars were analyzed using all reliable timings, and new parameters of the light-time effect were obtained. We derived for the first time or improved the short orbital periods of possible third bodies and calculated minimum masses of the third components. This research is part of an ongoing collaboration between professional astronomers and the Czech Astronomical Society, Variable Star and Exoplanet Section.

Eclipsing binary research made by minitelescopes

Zejda, M.

Bright variable stars became neglected in the epoch of the CCD cameras. Bright stars are not measurable also in the most of surveys apart from specialized projects like BRITE. We present a cheap solution accessible to students, small observatories and amateur astronomers and show some results.

Substellar and stellar companions in eclipsing binaries

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One of the best known methods for detecting period variation mechanisms in eclipsing binaries is based on the detection and analysis of the eclipse timing variations (ETV) of the binary (also known as Observed-Cacluated times of minima). Here, we present an extensive analysis of O-C diagrams constructed by previously published times of minima and updated by photometric observations from Mythodea Observatory (Astrophysics Laboratory, Department of Physics, University of Patras) for the post-common envelope binaries NSVS 14256825, NSVS 07826147 and the over-contact (W UMa type) binary system TZ Boo, in search of evidence for circumbinary companions (Light-Time Effect, LITE) or magnetic activity cycle (Applegate mechanism). The best-fitting model for NSVS 14256825 reveals a sub-stellar companion of mass M3~15MJup (for coplanar orbit) with a moderately elliptical orbit e3~0.17 and orbital period P3~10years, while in the case of NSVS 07826147 the indication of a downward trend reveals a sub-stellar companion of mass M3~4MJup and orbital elements e3~0.44, P3~32years, however, more data through next years are necessary in order to confirm the trend. The period analysis of TZ Boo confirmed the spectroscopically detected existence of a third star which according to the best-fitting model has mass M3~0.9Ms (for coplanar orbit), a very wide orbit e3~0.7 and orbital period P3~35years. A second companion with orbital parameters e4~0.3, P4~23years and mass M4~0.49Ms is indicated by the circular trend in the residuals

Dynamical masses of nearby pre-main sequence binary systems: Refining the orbit of HD98800 B using VLTI observations

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HD 98800 is a young (~ 10 Myr old) and nearby (44.9 pc) quadruple system, composed of two spectroscopic binaries orbiting around each other (AaAb and BaBb). The BaBb component harbours a proto-planetary disk that has very recently been spatially resolved with ALMA (Kennedy et al. 2019). The AB and BaBb components have orbital solutions in the literature, and the ALMA observations revealed that the disk is in a polar configuration with respect to the BaBb orbital plane. In our effort towards obtaining a full characterisation of the HD 98800 binary components, we have recently been awarded time for the NAOMI+PIONIER science verification (SV) to refine the BaBb orbital solution and obtain a first point for the AaAb orbit. The preliminary results will be presented and the implication on the dynamics of the binary system with respect to the circumbinary disc will be discussed. Finally future work on full orbit characterization for the AaAb component of the quadruple system will be presented.