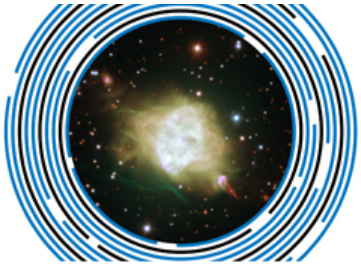

An ESO Workshop on

THE IMPACT OF BINARIES ON STELLAR EVOLUTION

03 – 07 July 2017 | ESO HQ, Garching, Germany

Poster Abstracts

Is VFTS 352 a Gravitational Wave Progenitor?

Michael Abdul-Masih
KU Leuven, Belgium

Nearly a quarter of all massive stars will merge during their lifetimes. The contact phase of massive binaries, preceding coalescence, is poorly understood due to a lack of observational constraints: only 7 O-type overcontact binaries are currently known. Stars in these systems may suffer from enhanced mixing due to rotation and tidal effects. Such enhanced mixing can induce chemically homogeneous evolution, a fundamentally different evolutionary channel where the 2 stars remain compact, preventing them from merging. Such a channel has recently been proposed as a viable way to create close and massive blackhole binaries that can explain the GW150914 gravitational wave event. However, the viability of this GW channel depends on the efficiency of the poorly-understood mixing processes. We use VLT/optical and HST/UV data of a LMC overcontact binary that shows evidence of enhanced mixing: VFTS 352 (O4.5V+O5.5V; P = 1.12d). We present new observational constraints on the physical parameters and surface abundances (He, C, N), compare them with binary evolution models, and discuss our results in the context of the future evolution of the system as a possible GW-progenitor.

Luminous Blue Variables with collimated winds

Claudia Agliozzo
Universidad Andres Bello, Chile

Interest in the role of binarity on massive star evolution has increased, creating a debate in the massive star community regarding the description of Luminous Blue Variables (LBVs). The mass-loss necessary to quickly expel their H-envelope before evolving as Wolf Rayet stars has to occur through intense line-driven stellar winds and violent eruptions. The role and the underlying mechanism of these eruptions has not been established. The majority of the known circumstellar LBV nebulae have a bipolar morphology, indicating an aspherical mass-loss. The cause is not determined but is usually hypothesized to be due to fast stellar rotation, presence of a companion star or magnetic fields. We gathered a multiwavelength dataset of some well-known LBVs, including ALMA, ATCA and VISIR observations. Our data reveal signatures of collimated winds, that seem related to the presence of a companion star and/or to fast rotation. The nebulae appear as helices formed by the precession of the collimated wind, enhancing the hypothesis that the mass-loss is influenced by a companion star.

The nature of the binary star HV Lup

Gustavo Aguayo
Universidad de Concepción, Chile

In this poster we present a spectroscopic and photometric study of the binary star HV Lup (HD 137518). Previous studies on this star (Waelkens, 1991) noticed photometric bi-periodicity and catalogued this object as a mass transfering binary where the gainer is being spun. The double-peaked emission in H-alpha yielded HV Lup to be considered as a Be star. Considering studies until 2013 about classical Be stars, there is a lack of evidence in binary systems with Be stars and companions filling Roche lobe. Also, binaries with mass transfer are excluded from the definition of classical Be stars due to the different origin of their circumstellar discs. The nature of this object remains unclear and whether this system contains or not a Be star may be solved with a new dataset of observations, combining photometry and spectroscopy. We are currently analyzing photometric data from ASAS V-band and 26 high resolution CHIRON spectra with a good coverage of the orbital phase. So far, we have found two photometric periods and we have disentangled the ligth curve; we present the ligth curve for long and short periods. Furthermore, we present the behavior of the spectra along the orbital phase showing complex and major variability. In future work we plan to disentangle the spectra and to obtain the RV curve. Afterwards we will model the orbital light curve in order to obtain the fundamental parameters and the evolutionary stage. We plan also to test if binary mass transfer is the origin for the circumstellar disc in this system.

Steller Evolution of Binary Stars from Detached to Contact Phase

Fahri Alicavus
Canakkale Onsekiz Mart University, Turkey

Star merge is one of the important phenomena to understanding the astrophysical process in beyond and statistic of single and multiple stars. Especially, contact binary stars have a crucial role to understand and compare of observational result for star merges. In this study, we produce evolutionary models for different type binary stars from detached to contact phase using with MESA. As a result, we show the effect on difference processes on the evolution and the statistical properties.

Comparison of Single and Binary Star Evolution Models for Selected Detached Binaries

Fahri Alicavus
Canakkale Onsekiz Mart University, Turkey

Eclipsing binary stars have a crucial role in finding absolute parameters in well sensitivity. This situation gets a significant advance to test evolution models of stars. For this aim, we choose a few detached binary stars which have sensitive spectroscopic and photometric data to find absolute parameters for checking differences between single and binary evolution models. In this study, we generate new models by using the MESA. Finally, we show effect and differences of rotation, binarity effects, mass loss and RLOF's in detail.

Eevidence of photometric and spectral variability for sdss j074625 + 423705

Metin Altan
Anadolu University, Yunusemre Observatory, Eskisehir, Turkey

8-night photometric observations were made at the TUBITAK national observatory and 306 images were recorded. As a result of the period analysis, the variability in the period of 1,271 hours was determined and discussed. Within the scope of 3559113446853287936 spectral ID reviews, the maximum density in the Fraunhofer H + K lines of ionized CaII determined within the scope of the spectral analyzes gave evidence that object is a star from the late G class. In addition, it was observed that the K-line was more intense than the H-line, and the triplet of magnesium was in the range of λλ 5169-83.

Observability of characteristic binary-induced structures in circumbinary disks

Roman Avramenko
Department for Theoretical Physics and Astrophysics at Kiel University, Germany

A substantial fraction of protoplanetary disks forms around stellar binaries. The binary system generates a time-dependent non-axisymmetric gravitational potential which leads to a change in basic physical properties of the circumbinary disk and in turn results in unique structures that are potentially observable with the current generation of instruments. Our goal is to identify these characteristic structures, to constrain the physical conditions that cause them, and to evaluate the feasibility to observe them in circumbinary disks. To achieve this we perform two-dimensional hydrodynamic and three-dimensional radiative transfer simulations. Based on the resulting density distributions as well as the re-emission and scattered light maps, we study the influence of various parameters, such as the mass of the stellar components, the mass of the disk and the binary separation on observable features in circumbinary disks. We find that the Atacama Large (sub-)Millimetre Array (ALMA) as well as the European Extremely Large Telescope (E-ELT) are capable of tracing asymmetries in the inner region of circumbinary disks which are affected most by the binary-disk interaction.

Eclipsing high-mass binaries

Angie barr
Universidad Católica del Norte, Chile

We report results from our photometric survey of high-mass eclipsing binaries. The monitoring campaign was performed with the robotic twin refractor (RoBoTT) at the Universitätssternwarte Bochum in Chile. We discovered six new eclipsing high-mass systems (HD319702, CPD 42 2880, CPD 24 2836, CPD 45 3253, Pismis24 4, GSC08173-00182) and confirm the eclipsing nature of four other high-mass systems (Pismis24 1, CPD 51 8946, CPD 26 2656, TYC8175-685-1). For all objects, we provide the first light curves and determine orbital periods through the Lafler-Kinman algorithm; apart from GSC08173-0018 (P = 19.47 days) all systems have orbital periods between one and seven days. We model the light curves within the framework of the Roche geometry and calculate fundamental parameters for each system component. The Roche lobe analysis indicates that seven systems have a detached geometry while three of them are near-contact systems. The deduced mass ratios q = M_2/M_1 reach from 0.4 to 1.0 with an average value of 0.7 suggesting that these high-mass binaries were created during the star formation process rather than by tidal capture.

CI Camelopardalis: The archetypal sgB[e]/X-ray binary almost 20 years on

Liz Bartlett
ESO, Chile

The evolution of massive stars ($M > 8M_{\odot}$) is subject to significant unknowns, being a sensitive function of initial mass, mass loss rate, metallicity, rotational velocity and binarity. There is mounting support for the idea that supergiant B[e] (sgB[e]) stars represent either interacting or newly formed, post- interaction binary systems. The recent association of Ultra Luminous X-ray source Holmberg II X-1 with a sgB[e] star (Lau et al. 2017) only highlights the need for further study of these stars. The sgB[e] star CI Camelopardalis (CI Cam) underwent a dramatic X-ray outburst in 1998, brightening by 5 orders of magnitude in a matter of hours before decaying to quiescence in less than 2 weeks. Such X-ray activity firmly establishes this source as a high mass X-ray binary (HMXB) but the nature of the compact object, as well as binary system parameters, still remain mystery almost 20 years on. Here I will present a long term study of CI Cam, from 2001 onwards, from modern X-ray missions including XMM-Newton, Swift and NuSTAR in an attempt to further understand this system, and the nature of the X-ray bright sgB[e] stars.

Old and New PhotometricObservations of P Cygni

Sopia Beradze
Ilia State University, Georgia

We found original observations by E.Kharadze and N.Magalashvili of P Cygni in the archives of the Abastumani Astrophysical Observatory, Georgia. These observations were carried out during 1951-1983 period. Initially they used 29 Cygni as comparison star and all observations of P Cygni were processed using this star. On the basis of their calculations, authors decided that P Cygni may be a W UMa type binary with orbital period of 0.500565, but this hypothesis was not confirmed. The observations of only 1951-1955 yy have been published in the Bulletin of the Abastumani Astrophysical Observatory. There is a whole observational data not only of P Cygni and 29 Cygni but in great majority of cases also those of 36 Cygni in the archives. So we recalculated all data (where it was possible) using 36 Cygni as comparison star. Also we are going to present the results of the new photometric observations of the P Cygni. New observations were obtained in 2014 using 48 cm Cassegrain telescope of the Abastumani Observatory. Some interesting behaviors of the light curves were revealed, so we are reporting also new results on the periodicity of P Cygni's variations.

Interaction between Massive Stars and the Interstellar Medium

Julia Bodensteiner
Technical University of Munich, Germany

We serendipitously discovered associations of main-sequence (MS) stars with IR nebulae in WISE 22 μm data. As single MS stars are not expected to produce dust, we expanded our search to a larger sample by visually inspecting WISE All Sky images at 22 μm around all ~3800 OBA stars in The Bright Star Catalogue for extended nebulosities surrounding the stars. We detected such associations for 7% of all stars, with a steep decline towards later spectral types. Because we found early-type stars with IR nebulae also at high Galactic latitudes, the associations cannot generally be chance coincidences of stars and intrinsic, clumpy ISM structures within the Galactic plane. Most of the nebulae are bow shocks arising from dynamical interactions between stellar winds and the ISM. The relative velocities crucial for the interaction are a combination of large-scale ISM motions and peculiar motions of stars. Some nebulae are more circular or elliptical in shape and may be bow shocks seen head- or tail-on. We discuss our findings in the context of various evolutionary paths of binary stars.

Know your partner: The mass ratio of binary systems in the H-R diagram

Henri Boffin
ESO, Germany

Binarity is now a well established quality affecting a large fraction of stars and recent studies have shown that the fraction of binaries is proportional to the mass of the star, with the vast majority of massive stars being member of a close binary system. By cross-matching TGAS with the SB9 database, we went one step further and derived the mass ratio distribution of binary systems as a function of the mass of the primary star. This, combined with the binary fraction, will provide very strong constraints on star formation and useful input for stellar population models.

IRC+10216 in high-resolution molecular lines

Michael Bremer
Institut de Radio Astronomie Millimetrique, France

During their TP-AGB phase, stars expell a thick dusty envelope, enriched in C and other processed elements. The stars stay hidden as the envelopes are opaque to optical and NIR wavelength, making the envelope morphologies and the mass loss process difficult to study. The advent of powerful mm-wave interferometers, such as the SMA, NOEMA and ALMA, which combine high angular and spectral resolutions with high sensitivity, enables us to penetrate into the deepest hidden layers and to study, through the observations of molecular lines, the envelope structure and velocity field. We will present the first such high resolution study of IRC+10216/CW Leonis, the archetype of TP-AGB stars and the closest one to the Sun. CW Leo is believed to be a double star, and its envelope exhibits a characteristic pattern of near-concentric shells. Based on new observations of CO, CN and C4H lines, made with the SMA, ALMA and the IRAM 30-m telescope with angular resolution down to 0.3 arcsec, we will show how we have reconstructed the 3 dimensional structure of the envelope from its edges to the innermost region and started to investigate CW Leo's mass loss history.

An Expansion of the Mass-Orbital Period Relation of sdBs from Stable Roche Lobe Overflow

David Brown
Specola Vaticana, Vatican City State

Hot Subdwarf B (sdB) stars are thought to be core-helium burning stars with core masses of about 0.5 Ms surrounded by thin hydrogen envelopes of less than 0.02 Ms. Although the precise mechanisms by which they are formed are not entirely determined, one of the binary formation channels modelled by Han et al. (2002, 2003) posits that some sdBs can result from one or two phases of stable Roche love overflow which produce sdB stars in binaries with long orbital periods, the distribution of which peaks at 100 d (Z=0.02). Observations suggest that the distribution of long-period sdB binaries with MS companion masses peaks at around 500 d-1000 d. Recent improvements by Chen et al. (2013) in the treatment of stable RLOF have yielded a mass-orbital period relation (for a given Z) for sdB stars, which yields a wider range of long-period sdB binaries of up to about 1100 d for sdBs produced via the first stable RLOF channel. This is consistent with the observed sdB orbital period distribution of long-period sdB binaries. In results presented here, the work of Chen et al. (2013) is expanded to include a great include a greater range of metallicities (Z=0.0001, 0.001, 0.02, 0.03, 0.04, 0.05).

Carbon enrichment in APOGEE disk stars as evidence of mass transfer process

Denise Castro
Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences, Poland

Analyzing a carefully selected sub-sample of 12.860 predominantly disk stars from the APOGEE DR12 catalog, we identified 120 stars with enhanced carbon abundance ([C/Fe] ~ 0.3). Theory does not predict such large carbon abundances in stars within the red giant branch phase of stellar evolution. We examined the possibility that these C-rich stars are members of binary systems in which mass transfer from a more evolved (AGB) primary companion was responsible for the enhancement of carbon abundances in the secondary stars observed by APOGEE. We determined that the frequency of stars with high radial velocity variability is much higher within the C-rich sample than in carbon normal stars within the same metallicity range, suggesting that mass transfer is a likely mechanism to explain carbon enhancement. We further characterised the C-rich sample in terms of their chemical compositions and ages. We briefly discuss the implications of our findings.

GSC 3152-1202 – massive eccentric eclipsing binary with a fast apsidal motion.

Drahomír Chochol
Astronomical Institute SAS, Slovakia

New UBVRIRcIc light curves of the eccentric orbit (e = 0.09) eclipsing binary GSC 3152-1202 (orbital period 2.09d), obtained at the observatories Stará Lesná (Slovakia), Mt Koshka and Nauchny in Crimea (Russia), were used to determine its basic physical characteristics. We estimated the masses of the components as 8 and 7 solar masses. Rapid apsidal rotation with the period of 44 years perfectly coincides with a theoretically expected value. A distinctive feature of the system is unusually large interstellar absorption Av = 5.3 mag in its direction. We suggest that the object, located in the Galactic plane and perhaps still surrounded by a dense pre-stellar envelope, is a young massive binary with rapid circularization of its orbit.

The Algol-type binaries RW CrA and DX Vel as multiple systems.

Drahomír Chochol
Astronomical Institute SAS, Slovakia

Our analysis of available and new multicolour light curves of the southern Algol-type binaries RW CrA and DX Vel allowed to determine their absolute parameters and classify them as detached and semidetached system, respectively. The times of primary eclipses of both binaries were used to construct eclipse time variation (ETV) diagrams and interpret them by a light-time effect. We determined the periods of their highly eccentric third body orbits to be 37.2 years for RW CrA and 78.9 years for DX Vel.

How bad are we at predicting DNS merger rates?

Martyna Chruślińska
Astronomical Observatory, University of Warsaw, Poland

Mergers of double compact objects are the main source of gravitational wave signals for the network of ground-based detectors. The first detection of the signal from merging double neutron stars (DNS) will hopefully become reality within the next observing runs of advanced LIGO. Both detection or further non-detection will allow to better constrain the limits on observational rates of DNS mergers, which in turn can be confronted with theoretical predictions derived from population synthesis studies. Such predictions suffer from many uncertainties due to a number of poorly constrained model parameters. Here we use the StarTrack code to study the the impact of various evolutionary assumptions on the formation and merger rates of DNS, in particular those associated with mass transfer phases and natal kick velocities. Our predictions, challenged by the aLIGO observations, will allow to narrow the range of possible models, bringing us closer to the better understanding of many aspects of the evolution of massive binaries.

On the orbital period of MAXI J1659-152: the shortest in a black hole candidate.

Jesus Corral-Santana
ESO, Chile

Black hole transients (BHTs) are binary systems formed by a black hole (BH) fed by a low-mass companion star usually through an accretion disc. They show sporadic outburst episodes followed by long quiescence stats. There are nearly 60 candidates of such systems to harbor a BH whereas only 18 have been dynamically confirmed so far. In this contribution, we will present the latest results on MAXI J1659-152, a BHT detected in 2010 during an outburst. During this phase, it showed X-ray dips with a periodicity of only 2.4h that was promptly pointed as the orbital period, the shortest obtained so far in a BHT. Here, we will the first optical confirmation of the orbital period in perfect agreement with the proposed with the X-ray data. In addition, we will also show evidence of the quiescent counterpart based on the Halpha emission, discarding the line-of-sight star scenario proposed in the context of the period/outburst amplitude relation.

Constraints on AGB nucleosynthesis based on Barium star observations

Borbála Cseh
Konkoly Observatory, Hungary

Barium stars belong to a binary system where the companion star has evolved through the AGB phase and transferred elements heavier than Fe produced by the slow neutron capture process onto the secondary star now observed. A new large set of homogeneous high resolution spectra of Barium stars makes it now possible to meaningfully compare the observational data with different AGB models. Here we present the preliminary results of such a comparison with the aim to constrain the physical processes responsible and affecting the neutron capture process in AGB stars.

Multi-epoch observations with high spatial resolution of multiple T Tauri systems

Gergely Csépány
Konkoly Observatory, Hungary

We have carried out a survey of multiple T Tauri systems with high spatial resolution at optical and infrared wavelengths. We have determined if the components are gravitationally bound and orbital motion is visible, derived orbital parameters and investigated possible correlations between the binary parameters and disk states. Our sample consisted of 18 T Tau multiple systems in the Taurus-Auriga star forming region from the survey by Leinert et al. (1993), with spectral types from K1 to M5 and separations from 0.22 arcsec (31 AU) to 5.8 arcsec (814 AU). We analysed data acquired in 2006-07 at Calar Alto using the AstraLux lucky imaging system, along with data from SPHERE and NACO at the VLT, and from the literature. We found ten pairs to orbit each other, five pairs that may show orbital motion and five likely common proper motion pairs, using data from the last 20 years. We investigated possible correlations between the stellar parameters and binary configuration, but we found no obvious correlation.

Comparison of the distribution of Symbiotic Stars in Milky Way and in M31

Katarzyna Drozd
Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences, Poland

We present the spatial distribution of Symbiotic Stars (SySt) and SySt candidates in the Milky Way (MW) and in M31. Since both galaxies are fairly similar in terms of size, structure, metallicity, and metallicity gradient, it is worth comparing their SySt populations. Roughly 250 SySt are known in the MW although not all distances are determined. Additionally, most objects observed in the MW occupy a small fraction of the Galaxy. On the other hand, the sample in M31 is smaller (35 objects from Mikołajewska et al. 2014, more than 100 yet to be published) yet the distance to the Andromeda Galaxy is well known. On top of that, we can see the entire host galaxy which gives us an unbiased brightness limited distribution. Therefore, both samples are statistically significant and one can compare: the total expected numbers of objects, the C/M giant ratio as a tracer of metallicity, the possible membership to the disk/halo/bulge populations, and other characteristics.

The Nature and Origin of the Helix Disk - Binary post-AGB disk or Remnant Kuiper Belt

Steve Ertel
University or Arizona, Steward Observatory, United States

Due to its relative proximity and high luminosity, the Helix central star is the best target to probe for circumstellar dust as part of a planetary/planetesimal system around a (pre-)white dwarf. Spitzer observations revealed the presence of mid- to far-infrared excess emission that could be well disentangled from the nebula's bulk emission. These data are consistent with the presence of a massive Kuiper belt. Such dust disks are important components of main sequence planetary systems and commonly used to infer the systems' architectures. If confirmed, this is the first Kuiper belt found around a white dwarf and will make the Helix be a benchmark object to study the post-main sequence evolution of planetary systems. We analyzed new ALMA data, archival Herschel data, and ancillary photometry to determine the disk's nature. Surprisingly, our modeling demands the presence of small dust grains that are not consistent with dust production in a collisional cascade from larger bodies, but with dust released by evaporating comets. We may be seeing heavy cometary activity as a result of the disruption of a planetary system during the stellar post-main sequence evolution.

Spectroscopic identification of INTEGRAL high-energy sources using VLT/ISAAC

Francis Fortin
AIM, France

INTEGRAL has been observing the gamma-ray sky for 15 years and discovered over 900 high-energy sources of various nature (Bird et. al 2016). They are mostly AGNs (369) and X-ray binaries (348). However, more than 200 of them still lack a precise identification. We aim to better constrain their nature in order to improve the census on binaries, which can then be compared with population synthesis models. We performed near-infrared photometry and spectroscopy with VLT/ISAAC in July 2012 on 15 INTEGRAL sources, and identified them by comparing their spectral features to nIR atlases (Kleinmann et. al 1986, Hanson et. al 1996,2005). Deriving the spectral type of donor stars allowed us to constrain the exact nature of several binaries. Our sample is mostly composed of AGNs (5) and Cataclysmic Variables (5), along with X-ray binaries (2 BeHMXB and 2 LMXB). In particular, some of the CVs we found appear to have a companion star which may have depleted its atmosphere. These results are the first step to further studies which will focus on deriving various parameters in binaries using spectral modelisation.

Tertiary Tides: A Novel Mechanism with Potential Implications for the Evolution of Some Binaries

Yan Gao
Yunnan Observatories, Chinese Academy of Sciences, China

A certain tidal effect, by which the existence of a tertiary can potentially drastically reduce the separation of an inner binary, is introduced. For various reasons, this effect has previously been overlooked. We study this phenomenon using a number of tidal models, most notably viscoelastic models, and provide the conditions in which it is significant.

Rapid mass transfer in binaries and its application in common envelope evolution

Hongwei Ge
Yunnan Observatories, Chinese Academy of Sciences, CHINA

Whether the mass transfer is dynamically stable or not is one of the basic question in binary evolution. Recently, many different authors have made progress on it by different methods. We have found that the main sequence donor stars with a radiative envelope will suffer a delayed dynamically unstable mass transfer if the initial mass ratio is too large; the local thermal timescale and the global dynamical timescale of the donor stars on the first or asymptotic giant branch have nearly the same order of magnitude. So the response to both thermal and dynamical timescale mass transfer of these donor stars is important. We build the adiabatic and the thermal equilibrium mass loss model to study the response of the donors to dynamical and thermal timescale mass loss. Our results show mass transfer tends to be more stable than we thought before, including both MS/HG stars and RGB/AGB stars. We can use the total energy of the star during the rapid mass transfer process to limit the outcome of Common Envelope evolution; the core of intermediate- and massive stars will expand and affect the binding energy a lot comparing with initial model.

Binary stars in Galactic globular Clusters observed with MUSE

Benjamin Giesers
Institut für Astrophysik Göttingen, Germany

Globular clusters provide a unique fossil record of the dynamical and chemical conditions during the formation and early evolution of galaxies. Binary stars have a strong influence on the core collapse in a globular cluster and are therefore important for their overall evolution. Since 2014 we are observing over 20 Galactic globular clusters with the integral field spectrograph MUSE at the VLT. MUSE gives us the possibility to extract spectra of some thousand stars per exposure. With different epochs on a specific globular cluster, we use the radial velocity method to find variable stars. There are several aspects of variable stars that are worth to examine. One is the statistical approach on how the binary fraction differs in various spatial or stellar parameter regions. For example a study of Blue Stragglers in binary systems could help to get a better understanding on the link between the stellar and dynamical evolution of globular clusters. Another aspect is the study of single binary systems to learn more about period and mass distributions of host and companion stars in specific globular Clusters.

The crucial role of binary interactions for energetic explosions of massive stars

Avishai Gilkis
Technion - Israel Institute of Technology, Haifa

Common envelope evolution spins up the core of a massive star before it explodes. I show the decisive effects of a high rotation rate on the dynamics of core-collapse supernovae using detailed three-dimensional simulations including core deleptonization and approximate neutrino transport. The simulations indicate that the collapse of rapidly-rotating massive stellar cores leads to super-energetic supernovae with strong asymmetry. Due to non-spherical mass ejection during the common envelope evolution phase, the scenario I present establishes a strong connection between super-energetic supernovae and their interaction with a bipolar massive circumstellar medium.

Binary stars as seeing by Speckle Interferometry

Carlos Alberto Guerrero Peña
Observatório Nacional/MCTI, Brazil

In this talk I will present a short review of Speckle Interferometry and how it has impacted our knowledge of binary statistics. I will also discuss some interesting results related to the binary fraction of open clusters.

Post-mass Transfer Delta Scuti/Gamma Doradus Stars in Close Binaries

Zhao Guo
Nicolaus Copernicus Astronomical Center, Poland

It has been shown that binary star evolution can form different types of pulsators, including Cepheids variables, RR Lyrae stars, white dwarfs, Delta Scuti stars and Gamma Dor stars (e.g., the formation of EL CVn stars). Through two case studies, I will demonstrate the assets of studying post-mass transfer pulsators in close binaries. In particular, pulsations of high-frequency p-modes of the primary star in KIC8262223 suggest it has been rejuvenated, which is a direct result of the mass-transfer from its companion. This formation channel may explain the overabundance of high-frequency Delta Scuti stars observed in the Kepler field. The prograde dipole g-modes in KIC9592855 can reveal the interior rotation of this Gamma Dor/Delta Scuti hybrid, shedding lights into the angular momentum transfer in this circularized and synchronized binary.

The Photometric Evolution of V723 Cas (Nova Cas 1995) from 2006 - 2016

Catrina Hamilton-Drager
Dickinson College, USA

We present photometric data of the classical nova, V723 Cas (Nova Cas 1995), over a span of ten years (2006 through 2016) taken with the 0.9-m telescope at the National Undergraduate Research Observatory (NURO) in Flagstaff, Arizona. A photometric analysis of the data produced light curves in the optical bands (Bessel B, V, and R filters). The data analyzed here reveal an asymmetric light curve, the overall structure of which exhibits a decrease in magnitude and change in color from year to year. In 2016, we observed the system to exhibit an abrupt change in both magnitude, color, and shape of the light curve. This corresponds to the end of the SSS phase.

Binary Evolution and Type Ia Supernovae

Zhanwen Han
Yunnan Observatories, the Chinese Academy of Sciences, China

Binary evolution plays a crucial role in many aspects of astrophysics and Type Ia supernovae (SNe Ia) are believed to result from binary evolution. In this talk, I will show how binary evolution would change the results of SNe Ia study. I will discuss the effect of stability of mass transfer, the nonconservation of mass transfer, common envelope evolution, mass accretion process of a white dwarf component on the production of SN Ia progenitors (including both single degenerate scinario and double degenerate scenario).

Automatic determination of eclipsing binary period, geometric-model and quality ranking in Gaia data

Berry Holl
Observatoire de Genève, Switzerland

Binary systems can have periods from a fraction of a day to many years, and occur in a large variety of possible configurations at various evolutionary stages. About 2% are oriented such that photometric eclipses can be observed. This talk will focus on the analyses of the millions of eclipsing binaries that the all-sky multi-epoch ESA Gaia mission is expected to observe, allowing for detailed statistical studies of these systems. Despite Gaia's very good photometric epoch precision (mmag to tens of mmag level from V<14 to V=20), the time sampling is rather sparse with an average of about 70 epochs over the 5 year nominal mission. We present a configurable scheme that can quickly identify the period, best-fit geometric model, and 'quality' rank of eclipsing binaries in hundreds of millions Gaia time-series. We demonstrate its performance on OGLE-III eclipsing binaries and Gaia-resampled Kepler data. Though the results will focus on single band data, multi-band data and radial velocity data are planned to be included too. The scheme can easily be configured to run on other large photometric surveys like: LINEAR, super-Wasp, NGTS, and future LSST, TESS and PLATO.

HD 96446: a long-period binary with a strongly magnetic He-rich component with beta Cep pulsations

Swetlana Hubrig
Leibniz-Institut fuer Astrophysik Potsdam, Germany

The star HD 96446 (V430 Car) is a well-known magnetic B2p He-strong photometric variable with a strong magnetic field of the order of kG. More recently, the star was discovered to be a beta Cep pulsator with a period of 2.23 hours. Since pulsating early B-type stars with very strong magnetic fields are rather rare, we gathered an intensive dataset of high S/N high-resolution spectra to which we added archival spectroscopy and archival and new spectropolarimety to study this interesting target in detail. Our spectroscopy revealed HD 96446 to belong to an eccentric binary with an orbital period of ~799 days and led to the first derivation of the rotation period of 23.4 days, allowing the first reliable estimation of the magnetic field model parameters of the star with a dipole field strength of 4.60±0.84 kG. It is also found that Helium is concentrated towards the negative pole and the metals are more abundant in the opposite stellar face. Moreover, we identified the dominant pulsation mode as a radial mode and we discovered a second pulsation mode. This target is the only known He-rich pulsator in a long period binary with such a strong magnetic field of the order of kG a

Upper main sequence binaries with magnetic components

Swetlana Hubrig
Leibniz-Institut fuer Astrophysik Potsdam, Germany

Surveys of the presence of a magnetic field in components of upper main sequence binary systems have the potential to uncover the field generation mechanism and to learn about the impact of the magnetic field on the binary evolution. Due to the obvious lack of magnetic components in binaries with short orbital periods, a merging scenario for the origin of Ap stars was suggested. Indeed, only two close binaries with a magnetic Ap component are currently known. Importantly, the magnetic field behaviour in these Ap components is closely related to the position of the companion. Also the inhomogeneous surface element distribution appears to be affected by the presence of the companion. In our talk we present the results of our study of a few recently detected systems with magnetic components and discuss the implication for the origin of their magnetism.

The spotted active binary UX Arietis

Christian Hummel
ESO, Germany

UX Arietis is one of the most active members of the RS CVn class of binaries in which spin-up of a sub-giant/giant star by a close companion led to the creation of magnetic fields which in turn are responsible for the radio and X-ray flares of UX Ariestis as well as its photometric variability. We observed this binary with the MIRC beam combiner at the CHARA array and made images of a single large spot rotating in and out of view over a month in 2012. A precise orbit was derived using the Wilson-Devinney code to account for the effect of the spot on the measured visibilities. Archival and new radial velocities taken at the NOT were also corrected for spot activity and allowed us to determine precise stellar masses and luminosities for the components. Consistency with the predicted locations in the HR-diagram is achieved after a careful analysis of the effect of spots. The orbit can be used to establish the relative locations of the stellar components at times when radio observations by Ros and Massi (2007) with the VLBA detected two radio components moving around each other. We tentatively conclude that radio emission in UX Arietis flows along magnetic flux tubes between the stars.

Velocity of the MSP is an important probe of the binary evolution

Andrei Igoshev
Radboud University, The Netherlands

The millisecond radio pulsars (MSPs) are considered to be promising tools to detect the gravitational wave background. That is why recently the precise measurements were performed for distances and proper motions of multiple MSPs. According to the binary stellar evolution, the MSP can be only formed in binaries which stay bound after the primary supernova explosion and go through the second mass transfer to spin-up the old NS. Such a binary receives a composite kick consisting of the part caused by the instantaneous mass loss and the NS natal kick. The primary star in this binary goes either through the core collapse SN explosion (strong mass loss and natal kick) or the electron capture SN explosion (small mass loss and negligible natal kick). According to the galactic dynamic, the present equilibrium velocity distribution of the local MSP ensemble is strongly anisotropic because the Galactic gravitational potential has a pronounced disk component. Namely, the expected vertical velocity dispersion appears to be two times smaller than the radial velocity dispersion. In my talk, I show what we can learn about the binary stellar evolution from the present velocities of MSPs.

An investigation of the peculiar photometric dips in the WDMS binary SDSS J1021+1744

Puji Irawati
National Astronomical Research Institute of Thailand, Thailand

A few white dwarf stars have been recently observed to display dimmings in their light curves, which have been attributed to obscuring materials such as planetesimals or to flare-related mass ejections. SDSS J1021+1744, a post common-envelope binary found in the Catalina Sky Survey, is one such system in which we detected multiple secondary dips consistent with a Lagrange L5 point location. These secondary dips disappeared within 15 months after our first detection. We report now on additional recent observations made with the 2.4m Thai national Telescope using the ULTRASPEC camera. We have detected a new series of dips, coincident with a flare episode. These findings support our previous conclusion that the long-lived dips in this system are caused by the flares/prominences from its main sequence M2 companion. Additionally, we also see shallow dips on the Lagrange L4 in this binary, confirming our hypothesis that the materials ejected from the flare are actually trapped on the two Trojan points.

New Binaires from infrared surveys

Valentin Ivanov
ESO, Germany

We have mined the recent VISTA and UKIRT infrared surveys for nearby binary stars using their high proper motion to identify any co-moving companions to known nearby stars. Here we report some new binaries and their spectroscopic follow up.

Exploring low and intermediate-mass binary properties in the young cluster Westerlund 2 using HST

Chris Johnson
Space Telescope Science Institute, USA

We present preliminary results of an HST photometric and astrometric campaign aimed at probing the unexplored population of low and intermediate-mass binaries (periods of ~2 days to several hundred years) in the young, massive cluster Westerlund 2 (Wd2). Over the next 3 years, we have a total of 45 orbits using the HST WFC3 instrument. We will be able to measure, for the first time, the separation, flux ratio and the angle of barely resolved short, intermediate and long period binaries in Wd2. Our sample closely represents the properties of the primordial binary population in star clusters. We will discuss the properties of binary systems immersed in an environment that resembles the conditions of stellar density and UV radiation found during the early evolution of starburst galaxies and globular clusters and how the main orbital properties of the binary population in Wd2 can be used to constrain models of star and cluster formation and evolut
ion.

Asteroseismology of close binary pulsators

Cole Johnston
KU Leuven, Belgium

Stellar evolution is driven by the physical processes occurring deep in the stellar interior, by the dynamics in the outer stellar envelope, and in the case when a star is in a binary or multiple system, by the tidal interactions between the components. While these physical processes are understood in a general sense, theoretical calculations involving them are largely unconstrained in modern stellar evolution codes. Particularly in massive stars, which drive the dynamical and chemical evolution of galaxies and the interstellar environment, theoretical evolution codes cannot match observationally determined stellar parameters and use artificially adjusted physical parameters such as convective core overshooting and/or chemical mixing. Here we discuss the synergistic use of asteroseismology with binary modeling as a necessary observational constraint to cross calibrate the internal physics that govern stellar evolution such as rotational mixing, overshooting, and angular momentum transport. We provide several examples of suitable binaries to perform calibrations for stellar modeling, covering a wide range in masses and evolutionary

Evolution of Binaries Containing a White-Dwarf

Belinda Kalomeni
University of Ege, Turkey

The evolution of binary systems containing white dwarf accretors such as cataclysmic variables, AM CVn systems, and supersoft X-ray sources will be discussed. The evolution calculations were carried out using the stellar evolution code MESA. Evolution tracks of 56,000 initial models are examined in the orbital period -- donor-mass plane in terms of evolution dwell times, accretion rate, and chemical composition at the center and surface of the donor star. In addition, in the orbital period and donor-mass plane, we will discuss where gravitational radiation signatures may be found with LISA, and where the accretion disks tend to be stable against the thermal-viscous instability.

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

Karczmarek Paulina
Warsaw Astronomical Observatory, Poland

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

Chemical analysis of binary and non-binary dwarf stars in the young stellar association AB Doradus

Orlando J. Katime Santrich
Instituto de Astronomia, Geofísica e Ciências atmosféricas, Universidade de São Paulo, Brazil

We have done a high-resolution spectroscopic study of binary and non-binary dwarf stars within AB\,Doradus. This association is one of the 11 nearby young stellar associations identified in the SACY project (Torres et al. 2003a, b). The stellar atmospheric parameters and chemical abundances were calculated using the LTE hypothesis by means of the Kurucz atmospheric grids and spectral code MOOG. We have found important differences in two stars reported as multiple-systems, mainly due to the fact that these stars present a decrease of the depth in the absorption lines, called veiling, reported in Yellow Straggler Stars (Sales Silva et al. 2014). This fact is reflected on the projected rotational velocities (V\,$\sin$\,i), stellar atmospheric parameters, and chemical abundances. Binary nature is assigned to these systems due to abundance deviations relative to non-binary stars in AB\,Doradus.

On the Binarity and the Possible Pulsations of P Cygni

Nino Kochiashvili
Ilia State University, Georgia

LBVs represent pre-SN evolutionary states of massive stars. Evolutionary scenarios of massive stars were revised after finding the unusual blue progenitor of SN 1987A and after detecting the more massive stars than the accepted 120 $M_\odot$ maximum limit of stellar masses. Now there exist different models of massive stars which predict pulsational variability that may be associated with the microvariations of LBVs. According some of them in some circumstances the Eddington limit is exceeded periodically in the pulsation driving region of the stellar envelope, accelerating the outer layers, and perhaps initiating mass loss or the LBV outbursts. On the basis of long-duration UBV observations of LBV star P Cygni it is clear that it has undergone reddening and we are witnessing of its evolutionary changes. If the rate of P Cygni's reddening will be the same, then the star will have the next eruption (or even supernova explosion) in near future. According to the behavior of UBV light curves, we suggest that P Cygni could pulsate. Hypothesis of binarity of the star is also valid.

Dynamical Masses of young visual binaries as test for pre-main-sequence evolutionary models

Rainer Koehler
Universität Innsbruck, Austria

The mass is the most important parameter for the structure and evolution of a star. Therefore, empirical mass determinations are crucial for our understanding of stellar astrophysics. In particular, this is the case for low-mass pre-main-sequence stars, for which a number of evolutionary models with different mass predictions exist. Binary stars are one of only two ways to measure stellar masses directly, without relying on theoretical models. They are therefore valuable test cases for theoretical pre-main-sequence tracks. We are monitoring a number of young visual binaries that were discovered in the 1990s. Many of them show significant orbital motion by now, and it was possible to determine the orbit for some. The largest uncertainty for the mass derived from the orbit is the distance from Earth, which will be greatly reduced once reliable Gaia-parallaxes for binaries are available. We will present first results and show some interesting systems.

Tidally excited oscillations in the context of stellar evolution

Gloria Koenigsberger
UNAM- Instituto de Ciencias Fisicas

A connection between tidal interactions and enhanced activity around periastron passage has recently been demonstrated by the observation of a distinct pattern of photometric variability in a number of eccentric binary systems. These so-called heartbeat stars show a brightness increase around periastron together with tidally excited oscillation frequencies that are harmonics of the orbital period. We use the TIDES code to study the time-dependent response of the stellar surface as it is perturbed by the binary companion in these systems. This provides insight into to physical processes causing the variability. We outline possible consequences of these processes on the evolution of binary stars.

Binary Fraction from Hyper Suprime-Cam Deep Imaging Survey for the Local Group Dwarf Galaxies

Yutaka Komiyama
National Astronomical Observatory of Japan, Japan

We have carried out an imaging survey for Local Group dwarf galaxies using Hyper Suprime-Cam (HSC) which is a newly-built 1 Giga pixel CCD camera with 1.5 degrees field of view attached to the prime focus of the 8.2-m Subaru Telescope. We show the result for the dwarf spheroidal galaxy Ursa Minor (UMi) for which HSC covers out beyond the nominal tidal radius down to ~2 mag below the main sequence turn-off point. The fraction of binary stars of UMi is investigated from the morphology of the main sequence following the method described in Sollima et al. (2007) and Milone et al. (2010). The CMDs of binary systems can be calculated by making use of the isochrone of the representative stellar population (i.e., age and metallicity), the initial mass function, and the binary mass distribution of the system. By comparing the simulated CMDs of different binary fractions with the observed CMD, the fraction of binary stars in UMi is estimated to be ~0.4. The value is consistent with those estimated for the other Local Group dwarf spheroidal galaxies based on the radial velocity measurements, but slightly higher than those derived for the most Galactic globular clusters by the same method.

Constraining the parameters of massive eclipsing binaries in the Local Group

Michalis Kourniotis
IAASARS, National Observatory of Athens, Greece

We aim to increase the number of hot, massive stars with well-constrained parameters resolved from the study of eclipsing, double-lined systems in the Galaxy and the LMC. The diversity in metallicity will assist in constraining the evolutionary models in different environments. Our study is carried out over different spectral regimes and resolutions: moderate-resolution near-infrared spectroscopy with VLT for five obscured binaries in the galactic, massive Danks clusters and high-res optical spectroscopy with Du Pont of eight luminous systems in the LMC. Our analysis so-far has yielded an O-type main-sequence system with components of mass 22-25 Mo with an accuracy 4% and radii ~9 Ro, accurate to 1%. Preliminary results indicate systems containing high-mass components in both Danks and LMC. The accurate radii have allowed a direct distance measurement to the Danks 2 cluster with a precision of 2%. We aim for a new precise measurement of the distance to the LMC using early-type systems, thus contributing towards the direct calibration of the extragalactic distance scale. We compare our results to the theoretical predictions and evaluate them in the context of stellar encounters.

Tomographic method and its application to the detection of binarity.

Kateryna Kravchenko
Institut d'Astronomie et d'Astrophysique (Universite Libre de Bruxelles), Belgium

We present a tomographic method allowing to recover the velocity field at different optical depths in a stellar atmosphere. It is based on the computation of the contribution function to identify the depth of formation of spectral lines in order to construct numerical masks probing different optical depths. These masks are cross-correlated with observed spectra to extract information about the average shape of lines forming at a given optical depth and to derive the velocity field. We apply this method to red supergiant atmospheres and compare to existing 3D dynamical simulations of stellar convection. The detection of binarity in Mira stars is also explored through the tomographic method. The pulsations of these objects cause radial velocity variations, making the detection of binarity challenging. The cross-correlation of masks probing the deepest atmospheric layers (less affected by pulsations) with observed Mira spectra will potentially help to detect the binarity of Miras.

Are long-term periodicities and giant outbursts in BeXRBs driven by Kozai-Lidov oscillations?

Eva Laplace
IAAT Tübingen, Germany

Understanding the long-term evolution of Be/X-ray binaries (BeXRBs) is especially relevant today as they represent an evolutionary phase that is thought to be crucial for progenitors of Gravitational Waves sources. Recently, we found indications for long-term periodicity (~21 yr) in the occurrence of giant outbursts and orbital phase shifts for the BeXRB EXO 2030+375. This allowed us to successfully predict an orbital phase shift to occur (Laplace et al. 2017). We propose Kozai-Lidov (KL) oscillations of the Be disk, which result in a periodic exchanges of the disk's eccentricity and inclination, as an explanation for the observed recurrences. To investigate this hypothesis, we have undertaken a systematic study of giant outbursts in BeXRBs using archival and current monitoring X-ray data. In part of our sample, we find recurring giant outbursts with a similar time-scale to that of KL oscillations. Our findings suggest that the evolution of binary systems can be strongly affected by the presence of disks. This potentially has large implications for their further evolution and final fate.

Rapid photometric variability of the unique binary system AE Aquarii during 2013-2016

Georgi Latev
Institute of Astronomy and NAO

We present the results of multicolor (UBVRI) optical photometry of the rapid (flare) variability of the cataclysmic binary AE Aquarii during 2013-2016. We measure the amplitude, duration, and colors (u-b, b-v, r-i, v-i) of the flares and its physical parameters (temperature, size, mass included etc.) obtained according to Pearson's (2003, 2005) theoretical model. Some statistical dependencies between the basic flare parameters have been found and discussed.

The Rossiter effect in Algol-type systems

Holger Lehmann
Thueringer Landessternwarte Tautenburg, Germany

We investigate time series of high-resolution spectra of oscillating Algol-type systems. The Rossiter effect is studied using a new computer code, with the aim to draw conclusions about the occurrence of episodes of rapid mass transfer.

A Hottest White Dwarf SDSS J134430.11+032423.1 with a Planetary Debris Disk

Lifang Li
Yunnan Observatories, P.R. China

We discover a debris disc around a white dwarf SDSS J134430.11+032423.1. The effective temperature ($T_{\rm eff}=26,465\,$K), surface gravity (g=7.86$), and mass ($M=0.57{\rm M_{\odot}}$) of this object have been derived through an analysis of its SDSS spectrum. It is found that SDSS J1344+0324 is a hottest white dwarf with a debris disc at present. Meanwhile, two spectra of this object observed by SDSS at different times show that this object is similar to SDSS J1617+1620 with variable N-IR Ca II triplet emissions from a gaseous disc. Meanwhile, it is found that the debris disc around SDSS J1344+0324 has a lowest temperature in all debris discs around WDs, and that its inner and outer radii are close to the tide radius of this WD, implying that this debris disc might be newly formed disc because of the tidal disruption of a rocky planetary body which had just entered the tide volume of this WD.

The interaction of core-collapse supernova ejecta with a companion star

Zhengwei Liu
Argelander-Instituts für Astronomie (AIfA), Universität Bonn

The progenitors of many core-collapse supernovae (CCSNe) are expected to be in binary systems. After the SN explosion in a binary, the companion star may suffer from mass stripping and be shock heated as a result of the impact of the SN ejecta. If the binary system is disrupted by the SN explosion, the companion star is ejected as a runaway star, and in some cases as a hypervelocity star. By performing three-dimensional hydrodynamical simulations of the collision of SN ejecta with the companion star, we investigate how CCSN explosions affect their binary companion stars. It is found that the impact effects of Type Ib/c SN ejecta on the structure of main-sequence companion stars, and thus their long-term post-explosion evolution, is in general not dramatic. We find that at most 10% of their mass is lost and their resulting impact velocities are less than 100 km/s.

Binarity: the clue to understand the LBVs behaviour and their surrounding environment?

Christophe Martayan
ESO, Chile

We report on the results from multi-technique and multi-wavelength observations of LBVs and other massive stars regarding their binarity and the shaping of their circumstellar environment. We present in particular a few cases with specific nebular structures and propose an explanation of their origin.

The Kepler Swift Survey (KSS): active stars as possible FK Com descendants

Elena Mason
INAF-OATS, Italia

The Kepler-Swift Active Galaxies and Stars (KSwAGS) survey has allowed the identification of 20 X-ray bright stars. Our spectroscopic follow up and Kepler light curves analysis show that many of them are cool (spectral type: late F to mid K) evolved (luminosity class: IV-III to III) active stars; while several appear to be rapidly rotating. We speculate that these rapidly rotating active and evolved stars might be descendant of the FK Com type stars, resulting from the merging of W UMa type binaries.

The impact of binarity on the Luminous Blue Variable phenomenon

Andrea Mehner
ESO chile, Chile

The role of mass loss, especially episodic mass loss, in evolved massive stars is one of the outstanding questions in stellar evolution theory. During the Luminous Blue Variable (LBV) phase, stars can lose several solar masses. There is no established mechanism yet to explain this large mass loss. Numerous hypotheses have been proposed, one of them is binary interactions. We will review the current state of the literature regarding the impact of binarity on the LBV phenomenon.

Interacting binaries of intermediate mass showing long-cycle photometric periods

Ronald Mennickent
Universidad de Concepción, Chile

Interacting binaries of intermediate mass showing long-cycle photometric periods. Short Contributed Talk Abstract: We review the phenomenon of Double Periodic Variables from the observational point of view placing them in the context of the evolution of close interacting binaries of the Algol and β Lyrae type. A timeline presents the development of the field in the last 13 years, with emphasis on spectroscopic and photometric monitoring and light-curve models of selected objects. Bizarre cases are identified which place constrains on competing models for the long-cycle variability. We give special consideration to the recently published hypothesis for the long cycle based on a magnetic dynamo driven by the Applegate mechanism acting in the donor star.

The hunt of close-orbit companions of Galactic Cepheids

Antoine Merand
ESO, Germany

Cepheids are famous standard candles for the extragalactic distance scale, but also fundamental laboratories for studying the pulsation and evolution of intermediate-mass stars. With high-accuracy space- and ground-based instruments (Gravity, MOST, Gaia, ...), new physical phenomena are revealed. High-accuracy measurements provide strong constraints on stellar parameters, critical to our understanding of stellar evolution and pulsation. However, the most fundamental parameter, the mass, is still in debate. So far there is only one Cepheid with a measured mass, otherwise they are derived using stellar evolution or pulsation model, which differ by 10-20%. Binary Cepheids offer the unique opportunity to make progress on this mass discrepancy. But there are two problematics: 1) the Cepheid brightness, outshining the hot companions, and 2) the close orbit of the companions, <40mas, preventing astrometric measurements from single-dish telescopes. A technique able to reach high spatial resolution and high-dynamic range is long-baseline interferometry. We are engaged in a long-term program that aims at detecting, monitoring and characterizing physical parameters of the Cepheid companions.

Complex photodynamical analysis of the close hierarchical triple systems KIC 6525196 and KIC 8043961

Tibor Mitnyan
Department of Optics & Quantum Electronics, University of Szeged, Hungary

We performed a complex analysis of light, radial velocity (RV) and eclipse timing variation (ETV) curves of the close hierarchical triple systems KIC 6525196 and KIC 8043961 using our newly developed photodynamical code. The program numerically integrates the orbital motion and the rotation of the components of such kind of multiple systems, and, therefore, takes into account the effects of dynamical perturbations caused by the third body during the simultaneous fitting of the light and RV curves. This method allows us to determine the physical parameters (e.g. masses) of the components, as well as the 3 dimensional configurations of the systems with a high precision.

Exploring the orbital diversity of post-AGB binaries

Glenn-Michael Oomen
KU Leuven, Belgium

We present a homogeneous analysis of all orbital elements available for post-AGB stars (some 40 systems). These objects are in a transition phase to become a hot central star that will ionise material that is expelled near the end of the AGB. All our systems evolved to long-period binaries (100-2000 days) and often with non-zero eccentricities. This comes as a surprise as these binaries are expected to strongly interact when the progenitor is in the AGB phase. Mass transfer for an AGB star is always unstable. Models predict that this results either in post-common envelope systems, or in systems that barely interact (P > 10000 days). However, the observed systems seem to have exactly the periods which are least predicted. All post-AGB binaries harbour a circumbinary disc formed by interaction with the companion during the phase of intense mass loss by the AGB star. Metal-poor gas from the disc is reaccreted onto the post-AGB star, causing depletion of refractory elements. In this contribution, we investigate how strong accretion can affect the evolutionary timescale. The goal of this work is to evaluate whether feedback from a disc can impact the post-AGB evolution.

Runaway Stars in Supernova Remnants

Anna Pannicke
Astrophysical Institute and University Observatory Jena, Germany

The majority of massive stars is part of a multiple system. After the core collapse supernova (SN) of the more massive component the formed neutron star is ejected by the SN kick whereas the companion star either remains within the system and is gravitationally bounded to the neutron star, or is ejected with a spatial velocity comparable to its former orbital velocity. Such stars with a large peculiar space velocity are called runaway stars. We present our observational studies of the supernova remnants G74.0-8.5, G119.5+10.2 and G184.6-5.8. The focus of this project lies on the detection of low mass runaway stars. We analyze the spectra of a number of candidates and discuss their possibility of being the former companions of the SN progenitor stars.

Are sdAs He-core stars?

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Univ. Fed. do Rio Grande do Sul/Brazil, Brazil

Stars with a helium core can be formed by mass exchange interaction with a companion or by strong mass loss. Their masses are smaller than 0.5 Msun. In the database of the Sloan Digital Sky Survey, there are several thousand stars which were classified by the SDSS pipeline as dwarf A and B stars. Considering the lifetimes of these classes on the main sequence, typically smaller than 2 Gyr, and their distance modulus (m-M)>14.5 at the SDSS bright saturation, if these were common main sequence stars, there would be a considerable population of young stars very far from the galactic disk. Their spectra are dominated by Balmer lines and suggest effective temperatures ~10000K. Many show surface gravity in intermediate values between main sequene and white dwarf (4.75<log(g)<6.5), hence they have been called sdA stars. Their physical nature and evolutionary history remains a puzzle. We propose the sdAs are not H-core main sequence stars, but He-core stars.

Mass determination for SB1 systems with pulsating components and the RaveSpan software.

Bogumil Pilecki
Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences

Double-lined spectroscopic (SB2) eclipsing systems offer a possibility
to accurately derive physical parameters of their components. If lines of only one component are seen in the spectra in general only some limits can be derived. We show that it is possible to determine quite accurately the physical parameters (including masses) of both components in eclipsing single-lined binary (SB1) systems if one of the component is a radially pulsating star. This result is very important for the unbiased study of Cepheids in eclipsing binaries as the majority of them exists in SB1 systems. We explain the method and present a solution for one such system. Additionally we present RaveSpan, an open-source graphical software for radial velocity measurement and analysis.

Tides in binary, differentially-rotating, cool stars

Vincent Prat
CEA Saclay, France

A large fraction of low-mass stars have stellar or planetary companions. For short-period systems, this leads to potentially strong tidal interactions that impact the orbital and the rotational evolutions of their components. In the case of stable binary stars or star-planet systems, the dissipation of tidal waves excited in stellar interiors contributes to the circularisation of the orbits. If the star rotates as a solid body, inertial waves can propagate in the entire convective region and an important dissipation can be obtained through resonances with applied tidal forces. However, turbulent convection is able to sustain latitudinal differential rotation as in the case of the Sun. This modifies the propagation domain of the waves and allows for corotation resonances. In this work, I will first present the results obtained on free inertial modes in presence of latitudinal differential rotation, using an analytical asymptotic approach combined with numerical simulations. Then, I will show how the numerical study of tidally-forced modes allows us to compute dissipation spectra, as well as frequency-averaged dissipation rates that can be used in stellar and orbital evolution codes.

The Spatial Distribution of Type Ia Supernovae in their Host Galaxies

Chris Pritchet

Dept of Physics and Astronomy, Canada

Do Type Ia Supernovae (SNe Ia) follow disk light, bulge light, neither, or both? What are the implications for progenitor models of SNe Ia? To answer these questions we use a sample of SNe Ia discovered by SDSS II. Host galaxies are assigned for the brightest 297 of these SNe, and the 2D surface photometry of these hosts is fitted by seeing-convolved bulge plus disk profiles using the program GIM2D (Simard et al.). The distribution of SNe Ia follows disk light, but not bulge light. Even for bulge-dominated systems there is a strong deficit of SNe in the inner regions relative to bulge light profiles. Some implications of this results are discussed.

The distribution of orbital periods and eccentricities for close solar-type binary stars

Andrej Prsa
Villanova University, USA

NASA's Kepler and K2 missions provide us with an opportunity to study period and eccentricity distributions for eclipsing binary stars. These data can be used to deduce the underlying binary population period and eccentricity distributions by an iterative process that builds a synthetic sample of binaries in the Kepler/K2 fields and compares it to observations. The parameters adjusted during the iterative process determine the properties of the overall population of binaries, not just eclipsing systems. This allows us to assess detection efficiency for ongoing missions such as Gaia and planned surveys such as LSST.

The spin of the second-born black hole in coalescing double black hole binaries

Ying Qin
Geneva University, Switzerland

Since the first gravitational event GW150914 was discovered by LIGO, various double Black Hole (BH) formation channels have been proposed. In the binary evolution channel, the formation of the second BH is preceded by the evolution of a BH and a helium star in a close binary, which can significantly affect the spin of the second-born BH. In order to study this phase in detail, we updated the relation between tidal coefficient E2 and the fractional radius of the convective core, and then ran an extensive grid of BH-He star binary evolution tracks, for different initial component masses, orbital periods and metallicities, keeping track of the angular momentum evolution of the He star. For a He star with a compact object (BH or Neutron stars: NS) companion in a close orbit, tides can be efficient only when the orbital period is < ~2 days. Based on the direct-collapse model, we find that the spin of the second-born BH covers the whole range of the BH's spin (i.e. from 0 to 1), and a weak inverse correlation between the timescale of the merger and the spin of the second-born BH. For the GW150914 event, we give a possible explanation for the observation of the low of the second-born BH.

The BBC survey: unbiased reporting of the 30 Doradus' B-star binaries

Oscar Hernán Ramírez Agudelo
UK Astronomy Technology Centre, United Kingdom

Massive stars enrich their local environment through their violent deaths as supernovae. While true, it glosses over the facts that the enriching supernovae are dominated by the B-type population, not just "massive stars" in general, and that we currently do not fully know the final fate of many B-type stars, nor the exact frequency and nature of their supernovae. To address these important questions we have carried out the B-star Binary Characterisation (BBC) survey. This is a comprehensive study of 30 FLAMES/GIRAFFE observations of about 100 B-type binaries in the 30 Doradus region. In addition, BBC has also observed the high-mass X-ray binary system VFTS 399, the only known X-ray binary in 30 Doradus to date. We will introduce the survey and focus on this interesting system.

Possible Tidally Excited Pulsations in the eta Carinae binary Revealed from BRITE photometry

Noel Richardson
University of Toledo, United States

We observed the massive binary eta Carinae with the BRITE-Constellation nanosatellites and found three coherent pulsations in the data. One of these frequencies was also present for many years during a previous ground-based monitoring campaign. The time-scales involved seem to represent tidally-excited oscillations as seen in several highly eccentric binaries (the "heartbeat" stars) observed with Kepler and K2. Further, the photometric variability of eta Car near periastron is reminiscent of these systems. If proven true with further planned observations, eta Car will represent the longest period and highest mass member of the heartbeat class discovered to date.

X-ray and Optical Variability of the colliding winds binary gamma2 Velorum

Noel Richardson
University of Toledo, United States

We have initiated optical and X-ray variability campaigns on the bright WC+O binary gamma2 Velorum. In the optical, we have collected BRITE-Constellation precision time-series photometry and simultaneous high-resolution spectroscopy. These results show the effects on the optical spectrum and photometric behavior. Further, we have collected four new XMM spectra across a recent periastron passage, leading to new constraints on the shocks in the colliding winds and the processes leading to its X-ray production. All observations are being compared to numerical simulations of the shock cone with great success.

Characterizing Short Period Eclipsing Binaries in the Field of NGC 2362

Tyler Richey-Yowell
Dickinson College, USA

We present light curves of seven previously unknown and two scarcely-covered eclipsing systems in the field of the young (t ~ 5 Myr) cluster NGC 2362. These light curves represent binaries of the Algol, Beta Lyrae, and W Ursa Majoris types. Some of these stars show signs of the O'Connell effect, caused by either hot spots or circumstellar material. If this circumstellar material is shown to be present in a light curve, we can calculate the density of the material to predict the change in magnitude for future data. The light curves have been modeled in Binary Maker 3.0 and have been used to determine the characteristics of these binary systems (i.e. mass ratio, temperature, fillout, disk and spot parameters) for stars of each type. The results of the models support current evolutionary theories regarding eclipsing binary star systems and shed light onto sources of the O'Connell effect and why it is seen most in certain evolutionary stages.

The class of Jsolated stars

Efrat Sabach
Technion - Israel Institute of Technology, Israel

I will present a novel scenario for the formation of super-energetic core-collapse supernovae (CCSN) that involves the merging of two massive giant stars. The two stars start close in mass, such that the post-main sequence phase of the two stars overlap. The two stars merge while being giants, and form a common envelope composed of two dense carbon-oxygen (CO) cores and an extended and massive envelope. The two CO cores spiral-in, merge and eject the hydrogen-rich, and in many cases the helium-rich, envelope. The new core is massive, rapidly rotating, and hydrogen and helium poor. It explodes as super-energetic CCSN (SESN) with no hydrogen and possibly helium, e.g., SESN Ic or Ib. This scenario requires very massive stars, above about 30 solar masses, close in mass. Such binary systems seem to be more common in low metallicity environments.

QZ Lib: a period bouncer

Linda Schmidtobreick
ESO Chile, Chile

We will present time resolved optical and NIR spectroscopy and photometry for different epochs to study the evolution of the SU UMa system after its 2004 super-outburst. We study the accretion process using trailed spectra and Doppler Tomography. A comparison of the orbital period with the superhump period indicates a strong possibility of this system being a period bouncer - one of those cataclysmic variables which during its evolution reached the minimum orbital period where the secondary star becomes degenerate and which is now evolving towards longer periods. Although predicted by theory, no such system could be confirmed so far. From the X-Shooter data an upper limit for the mass of the secondary is derived which is inconsistent with any main sequence star. The secondary must be a Brown Dwarf which - together with the orbital period - implies that the system is on the evolutionary track of a period bouncer.

A systematic study of the connection between binarity and overabundances in HgMn stars

Markus Schoeller
European southern Observatory, Germany

The phenomenon of late B-type stars showing HgMn anomalies seems to be intimately linked with their multiplicity. In a study with NACO, we were able to demonstrate that more than 90% of the HgMn stars in the sample displayed evidence for a companion. Strikingly, most late-B-types stars in binaries with certain orbital parameters become HgMn stars. Following the NACO observations, we started to study a sample of 80 HgMn stars with PIONIER on the VLTI in 2014. Of the 40 objects observed so far, ~25% were resolved. Together with spectroscopic data, we will be able to determine the three-dimensional orbit of these systems, the masses for both objects and their distance. From these values, we can fix the age and initial metallicity of the systems, determine the individual stellar diameters, and finally study their rotational behavior. For 41 Eri, this has already been demonstrated. I will give an overview about what we have learned so far on HgMn stars, studying them with various methods.

An outburst powered by the merging of two stars inside the envelope of a giant

Ron Schreirer
IIT

We conduct three-dimensional hydrodynamical simulations of energy deposition into the envelope of a red giant star as a result of the merger of two close main sequence stars, and show that the outcome is a highly non-spherical outflow. Such a violent interaction of a triple stellar system can explain the formation of 'messy', i.e., lacking any kind of symmetry, planetary nebulae (PNe). The ejection of the fast hot gas and its collision with previously ejected mass are very likely to lead to a transient event, i.e., an intermediate luminosity optical transient (ILOT).

HD 202664: a new HgMn star?

Semenko Evgenii
Special Astrophysical Observatory, Russian Academy of Sciences

In this poster, the discovery of a new spectroscopic binary SB2-type system is reported. HD 202664 consists of two almost identical stars orbiting each other with a period of 11.27 days in a circular orbit. Projected masses ($M\sin^3 i$) obtained from the radial velocity solution correspond to 2.085 and 1.890 Msun. Neither of the components has a measurable longitudinal magnetic field. Together with similarities in spectra, these facts point to the HgMn nature of the star.

Binary mass-transfer does not dominate the formation of Wolf-Rayet stars in the Magellanic Clouds

Tomer Shenar
University of Potsdam, Germany

Classical Wolf-Rayet (WR) stars are evolved, hydrogen-poor stars characterized by powerful, radiation-driven stellar winds. Massive stars reach the WR phase after having shed much material via either stellar winds or mass-transfer in binary systems. Because stellar-wind mass-loss scales with metallicity, current evolutionary models predict that the majority of WR stars at the low metallicity environments of the Magellanic Cloud form in binaries. Using the PoWR code, we performed a non-LTE spectral analysis of the complete population of Wolf-Rayet binaries in the Small and Large Magellanic Clouds (SMC and LMC), testing mass-luminosity relations against orbital masses, and constraining evolutionary channels for each system using the BPASS and BONNSAI tools. We find that the initial masses of most WR stars observed in the Magellanic Clouds significantly exceed the minimum mass needed for a star to enter the WR phase intrinsically, i.e. via stellar wind mass-loss. A comparison with evolutionary tracks reveals that, while mass-transfer in binaries may have played a role in their detailed evolution, it does not dominate the formation of WR stars in the Magellanic clouds.

The Gaia HR diagram of S stars.

Shreeya Shetye
Universite Libre De Bruxelles, Belgium

In this contribution we present the HR diagram of S-type stars based on their Gaia parallaxes. S stars are late-type giants whose most noticeable characteristics are the appearance of ZrO bands, overabundances showing signature of s-process nucleosynthesis, and a C/O intermediate between that of M and carbon stars. Technetium-rich (Tc-rich) intrinsic S stars are objects evolving along the Thermally-Pulsing Asymptotic Giant Branch (TPAGB) while in Tc-poor extrinsic S stars, the mass transfer is thought to be responsible for the enhancements of carbon and s-process elements. We consider all S stars with TGAS parallaxes affected by error smaller than one third of the parallax value itself. Obtaining a reliable HR diagram of S stars is challenging because their complex atmospheres make the determination of effective temperature and surface gravity difficult. We determine the stellar parameters by comparing high-resolution spectra (from the HERMES spectrograph mounted on the MERCATOR telescope) with MARCS model atmospheres for S stars. We determine accurate chemical abundances of intrinsic S stars which help us to constrain the nucleosynthesis operating along the TPAGB phase.

Simulating the Grazing Envelope Evolution (GEE)

Sagiv Shiber
Technion, Israel

Simulating the Grazing Envelope Evolution (GEE)
Short Contributed Talk Abstract: In the grazing envelope evolution the secondary star orbits the giant star at its surface and launches jets. I will present new simulations where for the first time the secondary star spirals-in while launching the jets. I will discuss the flow structure, the jets-envelope interaction, and the outflow properties. The jets create hot, low-density bubbles which escape through the less dense areas behind the secondary. Inside the envelope these bubbles are unable to escape and the common-envelope evolution (CEE) commences. I will also show simulations of our newly proposed mechanism of post-common envelope grazing evolution, where jets are launched by the secondary star when it exits the CEE from inside, and the jets remove the circum-binary flat envelope. I will suggest that the orbital energy released mainly inflates the envelope and does not remove it completely. Instead, a large part of the envelope removal is due to jets.

The role of the circumbinary disc in shaping the orbital parameters of Ba stars

Lionel Siess
Universite Libre de Bruxelles, Belgium

Several families of long period low- and intermediate-mass binaries like barium stars show surface enrichments in s-process elements. This peculiar composition is thought to be the result of mass transfer from a past asymptotic giant branch star which is now an extinct white dwarf companion. What still remains a puzzle is the observed distribution of these s-process enriched binaries in the period-eccentricity diagram which reveals that a large fraction of systems are able to maintain a significant eccentricity, at odds with current tidal theories that predict circularisation. In this talk, I will present recent binary stellar evolution calculations of the progenitors of barium stars and discuss the effects of a circumbinary disc in shaping the orbital parameters.

The decisive role of jets in determining the outcome of strong binary interaction

Noam Soker
Technion, Israel

I will bring arguments for the decisive role of jets in some violent interaction phases of binary evolution, including powering intermediate luminosity optical transients (ILOTs) and the removal of the common envelope. In extreme cases the jets can efficiently remove the envelope and prevent all together the common envelope phase. Instead, a grazing envelope evolution takes place. In most cases the jets are not observed as the interaction takes place in optically think environment. However, the imprints of some of the jets are seen in LBVs such as Eta Carinae, in planetary nebulae, and in supernova remnants. The physics of the jet interaction with the stellar envelope and circumstellar matter connects different kinds of strongly interacting binary systems to each other, and these to core collapse supernovae. For example, I will present my new idea that most of the progenitors of Type IIb supernovae (those with very little hydrogen) result from grazing envelope evolution of massive stars.

A new approach to unravel the formation history of nearby black hole x-ray binaries

Mads Sørensen
Observatory of Geneva, Switzerland

(1) Combining all available observational data on individual black hole (BH) X-ray binaries (XRBs), such as binary properties and proper motions, can provide important constraints on how these systems formed. We developed a method, first used on LMC X-3 (Sørensen et.al. 2017), to infer the past properties of the system at the onset of Roche lobe overflow (RLO), at pre and post supernova (SN), and at the zero age main sequence (ZAMS). Further we estimate the most probable asymmetric kick during SN. We achieve this by combining grids of detailed stellar structure and binary evolution models of the XRB phase with approximate population synthesis models from ZAMS to onset of RLO, including models for kicks and mass loss during SN. We now focus on two Galactic BHXRBs, GRS1915+105 and V404 Cyg, for which we have proper motions which tightens further the constraint on natal kicks, as well as revisit the formation history of XTE J1118+480 and GRO J1655-40 (Willems et al. 2004; Fragos et al. 2009). Knowledge of the BH XRBs' evolutionary histories is crucial for understanding paths of compact object formation and discriminating threads that are different between BH and neutron star formation.

The formation of massive close binaries via accretion

Observations have revealed that most stars are in multiple star systems. However there are mostly open questions with respect to how these systems form. In particular how the distribution of proto-binary seeds transforms into the main sequence (MS) population of binaries we observe. A key process in shaping binary systems is accretion of gas onto a proto-binary. As it accretes, the proto-binary alters its orbital separation and mass ratio. Hence a fraction of pre-MS stars will undergo mass transfer and some will merge. Knowing the initial conditions that lead to mass transfer or merging is thus needed, in order to understand the formation of binaries and stars in general. Our derived family of analytic models of accreting binaries which account for the change in mass ratio and orbital separation is incorporated into a 1D stellar evolution code to study different accretion scenarios, the effect of mass transfer in pre-MS binaries, and infer boundaries. Our models fit excellently with the MS binary population, suggesting that accretion plays a significant role in binary formation. Combined with mass transfer modelling, we can also explain the observed population of twin binaries.

Early-type eclipsing binaries in the LMC

Mónica Taormina
Nicolaus Copernicus Astronomical Center

Our main goal is to establish a firm empirical calibration of the surface brightness - color relation for early type stars based on high quality spectroscopic and infrared observations of nine early-type detached eclipsing systems in the LMC. Our calibration will allow distance determination accurate to about 2.5 % to a single object located well beyond the Magellanic Clouds, which will let us calibrate other important distance indicators. Apart from this we will obtain precise physical parameters of about 20 early-type stars, which can be used for a detailed study of their evolution. Here we present theresults from the analysis of one B-type system, OGLE-LMC-ECL-22270.

Weighing Melnick 34: The most massive eclipsing binary?

Katie Tehrani
University of Sheffield, UK

The massive WN5ha star Melnick 34 (Mk34) was included in a recent Chandra X-ray imaging survey (T-Rex). It was found to be the brightest X-ray source in 30 Doradus, with an X-ray luminosity of 10^35.2 erg/s, and a colliding wind X-ray binary with a 155-day period. We present an orbital solution to the double lined spectroscopic binary from VLT/UVES observations, revealing it as potentially the most massive binary system known to date. This work uniquely permits the calibration of masses from spectroscopic models for very massive stars.

Search for binaries in large spectroscopic surveys using t-SNE reduction of spectral information

Gregor Traven
University of Ljubljana, Faculty of Mathematics and Physics, Slovénie

Peculiar spectra and objects to which they belong are relatively abundant among targets of general all-sky surveys such as RAVE, Gaia-ESO, and GALAH. Detection of such objects is important because the automatic evaluation of their stellar and chemical properties might turn out to be very challenging and therefore introduces a complication in achieving scientific goals such as galactic archaeology. On the other hand, the nature of peculiar objects can be quite intriguing and might include cataclysmic variables, symbiotic stars, stars with massive outflows or inflows, stars exhibiting chromospheric emission, different binary systems, and others. We employ the novel dimensionality reduction technique t-SNE (t-Distributed Stochastic Neighbor Embedding) to alleviate the discovery and overview of distinct morphological types of spectra, with the focus on double-lined spectroscopic binaries (SB2s). Classification of spectra from aforementioned surveys/datasets will be presented, together with a user-friendly utility called t-SNE Explorer, which provides a convenient overview of the results of our method. Special emphasis will be put on detected SB2 systems and their physical properties.

(1) A Binary Progenitor for the Type IIb Supernova 2016gkg
(2) Searching for Companions of the Binary Progenitors of Supernovae

Schuyler Van Dyk
Caltech/IPAC, USA

(1) We present our analysis of SN 2016gkg in NGC 613, classified as Type IIb. Our hydrodynamical modeling of the observed optical light curves and determination of the nature of the progenitor object, identified in pre-explosion Hubble Space Telescope (HST) images and confirmed with recent HST observations, both point to a supernova quite similar in properties to the well-studied SN 2011dh in M51 and to an interacting binary star origin. We present our model for the binary system and discuss its implications. Support for program GO-14115 was provided by NASA through a grant from STScI,
which is operated by AURA, Inc., under NASA contract NAS 5-26555.
(2) Direct identification of the progenitor, or progenitor system, of a supernova is one constraint on the nature of the star that has exploded and on our knowledge of stellar evolution in general. For the most common hydrogen-rich supernovae, we are confident that these arise from massive stars which end their lives in the red supergiant phase. However, for the so-called "stripped-envelope" supernovae, i.e., those events which show indications spectroscopically for little or no hydrogen, we are less certain about the progenitor systems. Although several Type IIb supernovae appear associated with envelope-stripped supergiants in presumed interacting binary systems, there is only one identified Type Ib progenitor and no identified progenitor for the hydrogen- and helium-less Type Ic supernovae. An alternative means of constraining the progenitor system is to identify a putative companion to the primary star which has exploded, long after the supernova has faded. Here we present our constraints for the Type Ic SN 1994I in M51 and the broad-lined Type Ic SN 2002ap in M74.

EM Cep

Manana Vardosanidze
Ilia State University, Georgia

EM Cep is a Be star with unstable light curves. Sometimes it shows flare activity. On the basis of UBVR photometric data, obtained at the Abastumani Observatory unusual flare of the star has been revealed – it brightened in R band and decreased its brightness in U band simultaneously. EM Cep was considered as a close binary, but according to the new spectral data of Bulgarian astronomers it seems that EM Cep is a single star. So, it should pulsate, but we have clear evidence of presence of two minima on its light curves and accordingly, additional observations are needed for finding the true nature of variability of the star.

Using wide sdB binaries to constrain binary interaction theory

Joris Vos
Universidad de Valparaiso, Chile

Hot subdwarf-B (sdB) binaries are evolved core-He burning stars with very thin hydrogen envelopes. The only way to form these stars is through binary interaction, making them very useful objects to study binary evolution.

sdB stars in wide binaries (P = 2-3 years) are formed through stable Roche-lobe overflow (RLOF) when the sdB progenitor is at the tip of the red giant branch. These binaries are found to have eccentric orbits even though current binary evolution theory predicts these systems to circularise before the onset of RLOF. This observation is not limited to sdB binaries, also post-AGB binaries and central binaries in planetary nebula show signs of eccentric orbits. Eccentricity pumping through binary interaction is necessary to explain these observations.

By analyzing the orbital and spectral parameters of wide sdBs, a test sample for binary evolution theory is constructed. As wide sdB binaries are double lined binaries of which the canonical mass of the sdB component is known, these systems can provide strong restrictions on binary population synthesis studies that can not be achieved by other types of post mass-loss systems.

VLTI-AMBER monitoring of Eta Car's wind-wind collision zone

Gerd Weigelt
MPI for Radio Astronomy, Bonn

The VLTI allows us to study stellar winds of massive stars with unprecedented angular resolution in the infrared. Eta Car is a unique object for studying the massive stellar winds in a wind-collision binary during the LBV phase. We present observations at many orbital phases (0.85 - 0.1). The observations show the variation of the spectrum, the velocity-dependent diameter of the wind-collision zone, and the velocity-dependent photocenter shift with a spectral resolution of 12000. The strongest changes were observed in 12 nights near periastron passage (phases 11.991 - 12.022). The good uv coverage of the 2014 observations enabled us to reconstruct aperture-synthesis images with a spatial resolution of 6 mas or 14 au (A&A 594, A106, 2016). We present images reconstructed in more than 100 different spectral channels distributed across the Brackett Gamma emission line. The velocity-resolved intensity distributions suggest that the obtained images are the first images of the innermost wind collision zone. The observations provide time- and velocity-dependent image structures that can be used to test models of the massive interacting winds of Eta Car.

The origin of the Ultraluminous X-ray Sources

Grzegorz Wiktorowicz
University of Warsaw, Poland

Recently, several ultraluminous X-ray (ULX) sources were shown to host a neutron star (NS) accretor. We perform a suite of evolutionary calculations which show that, in fact, NSs are the dominant type of ULX accretor. Although black holes (BH) dominate early epochs after the star-formation burst, NSs outweigh them after a few 100 Myr and may appear as late as a few Gyr after the end of the star formation episode. If star formation is a prolonged and continuous event (i.e., not a relatively short burst), NS accretors dominate ULX population at any time in solar metallicity environment, whereas BH accretors dominate when the metallicity is sub-solar. Our results show a very clear (and testable) relation between the companion/donor evolutionary stage and the age of the system. A typical NS ULX consists of a ~1.3 M_sun NS and ~1.0 M_sun Red Giant. A typical BH ULX consist of a ~8 M_sun BH and ~6 M_sun main-sequence star. Additionally, we find that the very luminous ULXs (Lx > 10^41 erg/s) are predominantly BH systems (~9 M_sun) with Hertzsprung gap donors (~2 M_sun). Nevertheless, some NS ULX systems may also reach extremely high X-ray luminosities (Lx > 10^41 erg/s).

V766 Cen (=HR 5171 A): A luminous red supergiant with a close companion

Markus Wittkowski
European Southern Observatory, Germany

V766 Cen (=HR 5171 A) was originally classified as a yellow hypergiant. The star is known to have a wide companion (HR 5171 B) at a separation of 9.7 arcsec, which was classified as type B0 Ib. Chesneau et al. (2014) found evidence that V766 Cen (=HR 5171 A) itself has a low-mass companion that is very close to the primary star, possibly in the common envelope phase. Here, report on new AMBER observations of V766 Cen. We find that V766 Cen is a high-luminosity source of effective temperature ~4300 K and radius ~1500 Rsun, located in the Hertzsprung-Russell (HR) diagram close to both the Hayashi limit and Eddington limit; it is consistent with a 40 Msun evolutionary track and current mass 27–36 Msun. It shows strong extended molecular (CO) layers, Na I in emission arising from a shell of radius 1.5 Rphot, and a dusty circumstellar background component. We conclude that V766 Cen is a red supergiant located close to the Hayashi limit instead of a yellow hypergiant already evolving back toward warmer effective temperatures as discussed in the literature. We also present new preliminary aperture synthesis images of this system obtained with the VLTI/PIONIER instrument.

Long-term photometric monitoring of the selected binary systems with compact objects

Kadri Yakut
University of Ege, Turkey

In this study, we present long term VRI monitoring of some of the selected binaries with black hole and neutron star components. New observations obtained at the TUBITAK National Observatory (TUG). Using one-year multicolor photometric data long-term light variations of these systems will be discussed in this poster.

The origin of the Ultraluminous X-ray Sources

Miloslav Zejda
University of Warsaw

Recently, several ultraluminous X-ray (ULX) sources were shown to host a neutron star (NS) accretor. We perform a suite of evolutionary calculations which show that, in fact, NSs are the dominant type of ULX accretor. Although black holes (BH) dominate early epochs after the star-formation burst, NSs outweigh them after a few 100 Myr and may appear as late as a few Gyr after the end of the star formation episode. If star formation is a prolonged and continuous event (i.e., not a relatively short burst), NS accretors dominate ULX population at any time in solar metallicity environment, whereas BH accretors dominate when the metallicity is sub-solar. Our results show a very clear (and testable) relation between the companion/donor evolutionary stage and the age of the system. A typical NS ULX consists of a ~1.3 M_sun NS and ~1.0 M_sun Red Giant. A typical BH ULX consist of a ~8 M_sun BH and ~6 M_sun main-sequence star. Additionally, we find that the very luminous ULXs (Lx > 10^41 erg/s) are predominantly BH systems (~9 M_sun) with Hertzsprung gap donors (~2 M_sun). Nevertheless, some NS ULX systems may also reach extremely high X-ray luminosities (Lx > 10^41 erg/s).