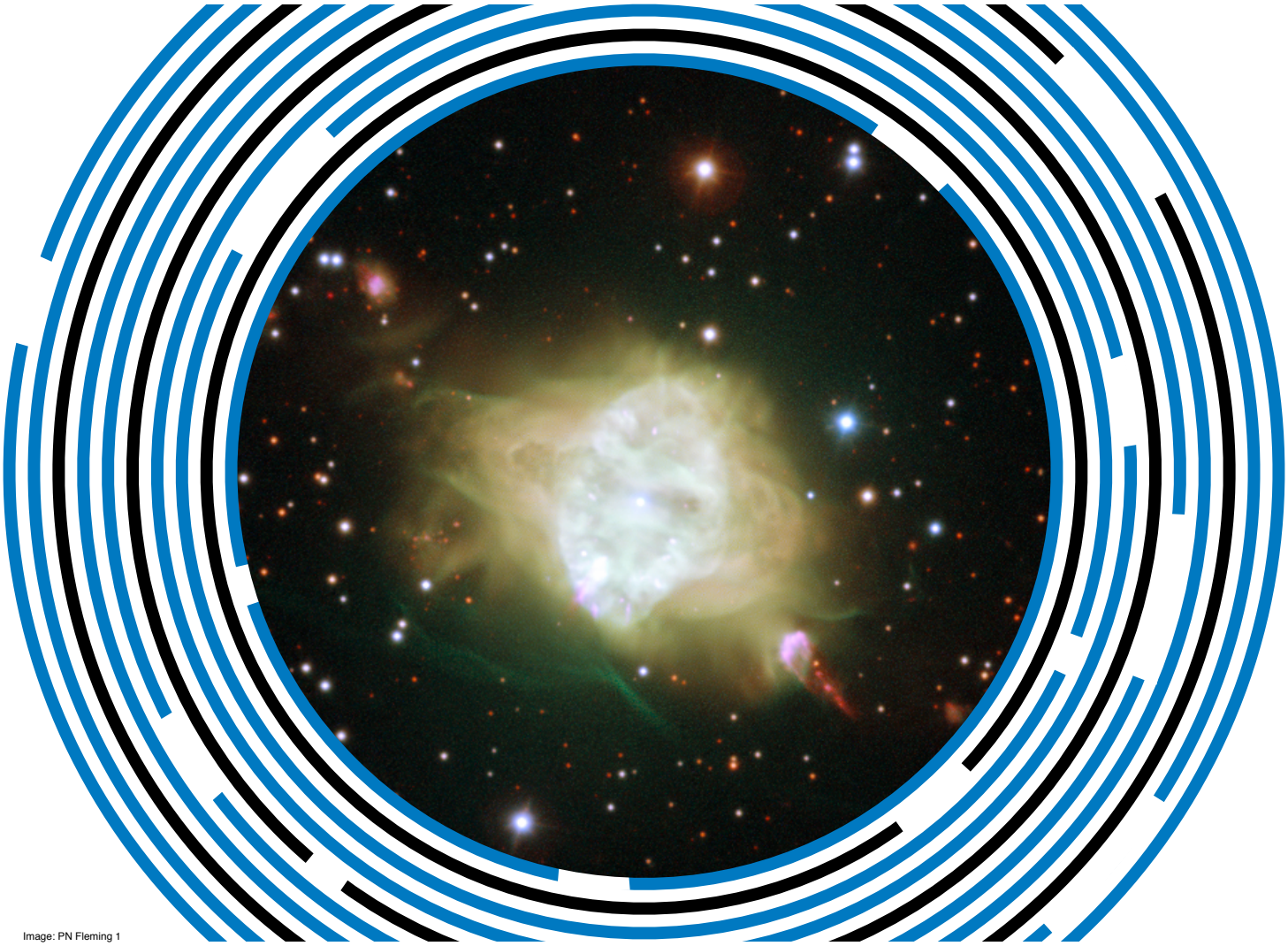
An ESO Workshop on

THE IMPACT OF BINARIES ON STELLAR EVOLUTION

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



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Booklet

SOC:

- Giacomo Beccari (co-Chair, ESO, Germany)
- Henri Boffin (Chair, ESO, Germany)
- Romano Corradi (GTC, Spain)
- Selma de Mink (Amsterdam, the Netherlands)
- Monika Petr-Gotzens (ESO, Germany)
- Antonio Sollima (Bologna, Italy)
- Christopher Tout (Cambridge, UK)
- Sophie Van Eck (Brussels, Belgium)

Programme

Invited speakers are indicated in **bold**.
Invited talks are 25 min (+10 min for Q&A) and contributed talks are 15+5 min.

MONDAY 3 July 2017

08:30	REGISTRATION	
09:15	**H.M.J. Boffin**	**Welcome and introduction to the conference**
09:50	**M. Moe**	**Statistics of Binary / Multiple Stars**
10:25	J. Winters	The nearby M dwarfs and their dance partners
10:45	COFFEE	
11:15	**C. Clarke**	**Multiplicity at birth and how this impacts star formation**
11:50	C. Ackerl	Multiplicity among 3500 Young Stellar Objects in Orion A
12:10	**P. Kroupa**	**The impact of binary systems on the determination of the stellar IMF**
12:45	LUNCH	
14:15	**M. Salaris**	**Low- and intermediate-mass star evolution: open problems**
14:50	P. Beck	Oscillation double-lined binaries as test cases for understanding stellar evolution
15:10	X. Chen	Formation of low-mass helium white dwarf binaries and constraints to binary and stellar evolution
15:30	A. Dervisoglu	Constraining thermohaline mixing in Algol systems with the surface carbon-nitrogen abundance ratio
15:50	TEA	
16:20	**O. Pols**	**Mysteries in the formation of chemically polluted binaries**
16:55	L. Whitehouse	The binary fraction of dwarf carbon stars and their possible role as CEMP progenitors
17:15	A. Escorza	To Ba or not to Ba: observational constraints to the formation and evolution of Barium stars
17:35	D. Karinkuzhi	When binaries keep track of a recent nucleosynthesis: The Zr–Nb pair as an s-process thermometer
17:55	END OF DAY	

Invited

Statistics of Binary / Multiple Stars

Maxwell Moe

I will overview the various observations of binary / multiple stars throughout the decades and attempts to correct for their respective selection biases, culminating in the review by Duchene & Kraus (2013) and our detailed meta-analysis in Moe & Di Stefano (2016). Interestingly but not surprisingly, the distributions of binary star properties, e.g., binary fraction / multiplicity frequency, primary mass, mass ratio, separation, eccentricity, age, environment, and metallicity, are all correlated with each other. I will discuss the trends in the intrinsic statistical distributions after accounting for selection effects and highlight the implications for binary star formation and evolution. Most important in the context of interacting binary stars, especially those with massive primaries $M_1 > 5$ Msun, the properties of very close binaries (periods $P < 20$ days; separations $a < 0.3$ AU) are quite different than companions at intermediate separations ($P = 20 - 10^4$ days; $a = 0.3 - 20$ AU).

The nearby M dwarfs and their dance partners

Jennifer Winters

We present the results of an all-sky volume-limited survey of 1121 M dwarfs, known via trigonometric parallaxes to lie within 25 pc of the Sun, for stellar companions at separations 2" to 300". In addition to a literature search for known companions, I-band images, primarily from the CTIO/SMARTS 0.9m and the Lowell 42in telescopes, were obtained in order to probe these systems for companions at separations of 2" to 180". A complementary reconnaissance of wider companions to 300" was done via the blinking of SuperCOSMOS BRI images.

We find a stellar multiplicity fraction of 27.4 (1.3)% for M dwarfs, with a peak in the log-projected separation distribution of the companions at 23 AU, i.e., distances on the scale of our Solar System. A hint that M dwarf multiplicity may be a function of age/composition was revealed, with faster moving (and generally older) systems being multiple slightly less often. We calculate that at least 16% of M dwarf mass is made up of the stellar companions in these systems and that at least 10% of all M dwarf mass is hidden in unresolved companions. This is the most comprehensive study ever done of the multiplicity of the most common stars in the Galaxy.

Invited

Multiplicity at birth and how this impacts star formation

Cathie Clarke

I will review the evidence that the fundamental unit of star formation is the small N cluster and that the dynamical interactions that occur within this environment (on timescales of order 0.1 Myr) are key to understanding stellar multiplicity. In this picture, all stars (whether ultimately destined to be single, binary or existing in a higher order multiple system) are the outcome of this evolutionary process. The talk will focus both on the simulations that support this hypothesis and the challenges involved in testing it observationally. It will also be emphasised that the prime importance of dynamical interactions on small scales (i.e. within few body, unstable clusters with size of order the Jeans length) means that the initial production of multiple stars should be relatively insensitive to the mean stellar density within the larger scale region. Nevertheless the initial production of multiples is likely to be further modified in high density clusters and I will also discuss how, on longer timescales, interactions beyond the natal grouping can lead to both the production and destruction of the initial multiple population.

Multiplicity among 3500 Young Stellar Objects in Orion A

Christine Ackerl

When studying the impact of binaries on stellar evolution, it is critical, to determine the multiplicity fraction in the very early stages of stellar evolution. Yet, whether and how pre-main-sequence stellar multiplicity depends on environmental conditions remains unclear.

In order to provide answers we present in this talk the largest known sample of young visual binaries towards one single star forming cloud, the rich and nearby star forming region Orion A. The sample is taken from the Vienna Survey in Orion (Meingast et al. 2016), which provides high-quality, sub-arcsecond seeing limited ESO-VISTA images and JHKs-photometry for more than 800,000 stars covering a vast range of different physical environments, from well known dense clusters to isolated (Taurus-like) environments towards the Southern end of Orion A. Our sample is sensitive to separations ≥ 300 AU and is about an order of magnitude larger when compared to previous studies (e.g. Kounkel et al. 2016).

Invited

The impact of binary systems on the determination of the stellar IMF

Pavel Kroupa

Theoretical considerations and observational data strongly indicate that virtually all stars form as binary systems in compact embedded clusters spawning from molecular cloud cores on a sub- to pc-scale. Within the first Myr the binary population evolves through system-internal processes (termed pre-main sequence eigenevolution) and dynamical encounters within the cluster. Eigenevolution changes the orbital elements and the mass-ratios of binaries with periods typically shorter than about 1000d, while dynamical processing affects systems with longer periods. The details depend on the density of the embedded cluster and on its mass and on issues such as mass segregation and the expulsion of residual gas. The dynamical processes lead to the disruption of binaries, to binary-star hardening and stellar mergers as well as to dynamical ejections from the embedded cluster. Deducing the stellar IMF thus becomes a difficult process involving corrections for all these physical processes and it emerges that the stellar IMF does not exist in reality, because there is never a time when the full stellar population is assembled. The IMF is only a mathematical tool allowing us to perform simplified numerical experiments such as setting up stellar populations in star clusters and in galaxies. It nevertheless constitutes one of the most important astrophysical tools and the estimation of its functional form remains an important research goal. When synthesising a stellar population one needs to take into account that the population in a galaxy stems from a dynamically processed population which emerges from an ensemble of embedded clusters, and this has major implications for the galaxy-wide IMF and on the population of exotic stars.

Invited

Low- and intermediate-mass star evolution: open problems

Maurizio Salaris

The main challenges to low- and intermediate-mass (single star) stellar evolution models involve the treatment of convection, plus chemical- and angular momentum transport in radiative regions. These uncertainties play an important role also when modeling interacting binary systems, because they affect the evolution of the binary chemical composition and the mechanisms of mass and angular momentum transfer.

This talk will review how the current generation of models for single stars treat chemical and angular momentum transport, and how the existing uncertainties impact the models' predicting power.

Oscillation double-lined binaries as test cases for understanding stellar evolution

Paul Beck

The growing number of binary stars with solar-like oscillating (SLO) components from observations of the NASA Kepler space telescope (e.g., Beck et al. 2014, Gaulme et al. 2014) provides a large and consistent sample of rewarding objects to study stellar physics on the main sequence and in the red-giant phases. Due to the exquisite precision of Kepler photometry, we can combine the classical photometric and spectroscopic binary analysis with the wealth of information derived through Asteroseismology.

In this talk, we present results of the joint photo-spectroscopic, seismic and tidal analysis of the ensemble of ~50 binaries, hosting SLO components. We further discuss the intriguing case of the double-lined spectroscopic binary KIC9163796, hosting two oscillating components. While the mass ratio proves that the masses are similar within 1%, spectroscopic analysis shows that both stars have significantly different fundamental parameters and Li abundances, placing the primary and secondary in the late and early phase of the first dredge-up event. Comparing the Li abundances with model predictions allows us to test the history of mixing and angular-momentum transport inside the stars.

Formation of low-mass helium white dwarf binaries and constraints to binary and stellar evolution

Xuefei Chen

Many extremely low-mass white dwarfs (ELM WDs) have been discovered by ELM and WASP surveys, and by Kepler observations. ELM WDs are generally in binaries and the companions are MS stars, WDs or MSPs. Some ELM WDs are still in proto-WD phase i.e. being in a rarely observed state evolving to higher effective temperature at nearly constant luminosity prior to becoming an ELM WD, such as those in EL CVn-type binaries. This immediately causes some problems in stellar evolution e.g. what the minimum mass of the He WDs is and how long the timescale of the proto-WD phase is. ELM WD binaries are produced by binary evolution, either from mass transfer (MT) or common envelope ejection (CEE). In this contribution, we will show that CEE cannot produce the observed EL CVn binaries but MT may well reproduce the properties of such objects. Both MT and CEE contribute to the formation of ELM WDs in DDs. By reproducing the observational properties of the two types of ELM WD binaries, we will show some constraints on binary evolution such as mass loss and angular momentum loss during MT and energy budget in CEE, and on stellar evolution in such as the minimum He WD mass and the lifetime of photo-WD.

Constraining thermohaline mixing in Algol systems with the surface carbon-nitrogen abundance ratio

Ahmet Dervisoglu

Large-scale mass transfer in Algol-type binary systems not only lead to mass reversal and an exchange of the role between the components but also affects the photospheric chemical composition. Formerly deep layers can become exposed after a short-lived mass exchange. Therefore, tracing the photospheric elemental abundance pattern of the components might help to constrain their past, and in particular their initial evolutionary parameters. High-resolution spectra of several Algol-type systems, including Algol itself, were secured in the course of this project. Atmospheric diagnostics and detail abundance analysis are performed from disentangled components' spectra to avoid contamination of the gainer's spectra from their (usually) faint Roche-lobe filling companions. We, subsequently, build a grid of binary evolution tracks, based on CAMBRIDGE version of STARS code, to investigate the surface chemical evolution during mass transfer. The carbon-to-nitrogen (C/N) ratio is found to be a sensitive probe of the thermohaline mixing. Constraint on mixing processes allows us to estimate initial binary parameters on a more firm ground.

Invited

Mysteries in the formation of chemically polluted binaries

Onno Pols

Binary systems in which one star has been polluted by mass transfer from a former asymptotic red giant companion star, are excellent probes of some of the uncertainties both in binary evolution and in AGB nucleosynthesis. Examples include post-AGB binaries, barium stars and (at low metallicity) carbon-enhanced metal-poor stars. The orbital properties of these systems are at odds with the predictions of standard binary evolution theory.

Binary mass transfer occurs by Roche-lobe overflow in relatively close systems, and by wind accretion in systems that are too wide for either star to fill its Roche lobe. In the case of red giant primaries, RLOF is often (though not always) unstable and results in a highly non-conservative common envelope event that shrinks the orbit. On the other hand, wind mass loss tends to widen the orbit. This divergent orbital evolution is expected to produce a gap in the period distribution of mass-transfer remnant systems. However, the observed remnant systems are plentiful in this period range (roughly 100 days to a few years). In this intermediate regime the interaction processes are not well understood; wind interaction, Roche-lobe overflow and even common-envelope evolution are not easily distinguishable here. In this review talk I will explore some of the processes that may be at work here.

The binary fraction of dwarf carbon stars and their possible role as CEMP progenitors

Lewis Whitehouse

Contrary to expectations, the most abundant carbon stars in the Galaxy are long-lived, main-sequence stars. The origin of these dwarf carbon (dC) stars is an astrophysical curiosity that is 40 years(!) old, and the mechanisms for enhancing their observed C/O above unity are poorly constrained. Intriguingly, a significant fraction of the dC stars have clear halo kinematics, and are thus almost certainly related to the carbon-enhanced, metal-poor (CEMP) stars observed in the Galactic halo.

We will present a search for evolved binary companions via radial velocity measurements of these chemically peculiar dwarf stars, all of which are currently in the solar neighbourhood. Over several years, we observed a few dozen dC stars with the ISIS spectrograph on the WHT, and 22 stars with sufficient data are consistent with a 100% binary fraction. We hypothesise these main-sequence stars are essentially CEMP-r or CEMP-s stars of relatively low mass, and will discuss our ongoing and future investigations, including the binary-detection and kinematical prospects using GAIA.

When binaries keep track of a recent nucleosynthesis: The Zr–Nb pair as an s-process thermometer

Drisya Karinkuzhi

Barium stars are s-process enriched giants; they owe their chemical peculiarities to a past mass transfer, during which they were polluted by their binary companion, which was at the time an asymptotic giant branch (AGB) star, but now an extinct white dwarf. Hence barium stars are ideal targets to understand and constrain the s-process in low- to intermediate-mass AGB stars.

Actually, since the ^{93}Zr/Zr$ isotopic ratio is a sensitive function of the s-process operation temperature (independently of stellar evolution models), and since, in barium stars, ^{93}Zr has fully decayed into mono-isotopic ^{93}Nb, we can use the Nb/Zr abundance ratio to constrain the s-process operation temperature. Adopting the same methodology as in Neyskens et al. (Nature 517, 174–176, 2015), we analyze a sample of highly-enriched barium stars observed with the high-resolution HERMES spectrograph mounted on the MERCATOR telescope (La Palma). We determine the stellar parameters and abundance profile using MARCS model atmospheres. The derived Zr and Nb abundances provide more accurate constraints on the s-process operation temperature and therefore on the s-process neutron source.

To Ba or not to Ba: observational constraints to the formation and evolution of Barium stars

Ana Escorza

We focus on the poorly understood formation channels of chemically peculiar stars known as barium (Ba) stars. These main-sequence or giant stars show an excess of products of the slow-neutron-capture process of nucleosynthesis, which cannot be explained by single star evolution theory. Ba stars are known to be formed in binary systems where a former AGB companion (now a dim white dwarf) polluted the current Ba star with enriched products. A long-standing problem is, however, that their observed properties are not predicted by models, indicating that binary interaction processes are not well understood.

In this contribution, we will show the first HR diagram of Ba stars using GAIA parallaxes. New results of our long-term radial velocity monitoring will also be presented in the form of well determined orbital elements. By analysing their mass and period distributions, we want to investigate the evolutionary link between main-sequence and giant Ba stars. Comparing these observations with our state-of-the-art evolutionary models, our ultimate goal is to come to a prescription of the initial conditions and interaction processes required for a binary system to evolve into a Ba star.

TUESDAY 4 July 2017

09:00	**J. Sokoloski**	**Symbiotic stars**
09:35	M.I. Saladino	Wind mass transfer in binaries and its effect on orbital evolution
09:55	E. Griffin	Composite-Spectrum Binaries: the Rosetta Stone for studies of stellar evolution?
10:15	A.F. Pala	Testing the present models of binary evolution
10:35	S. Toonen	The evolution of triple-star systems
10:55	COFFEE	
11:25	**H. van Winckel**	**Binary post-AGB stars as tracers of stellar evolution**
12:00	D. Kamath	A Newly Discovered Binary Evolutionary Class: Dusty Post-RGB Stars
12:20	**D. Jones**	**The importance of binarity in the formation and evolution of planetary nebulae**
12:55	LUNCH	
14:20	P. Sowicka	Towards finding the missing intermediate period binaries in planetary nebulae
14:40	V. Schaffenroth	The EREBOS project: Studying the influence of low-mass companions on stellar evolution
15:00	T. Kaminski	Observing stellar mergers and their remnants
15:20	TEA	
15:50	**R. Mathieu**	**Binary Stars and Alternative Stellar Evolutionary Paths in Open Star Clusters**
16:25	K. Yakut	Close binary stars in the Galactic Open clusters
16:45	**F. Ferraro**	**The physics of Blue stragglers: defining a dynamical clock for star clusters**
17:20	C. Pallanca	Optical companions to binary MSPs in GCs
17:40	POSTER SESSION with Beer and Brezeln	

During the poster sessions, participants who have a poster should be available in front of their poster to answer queries.

Invited

Symbiotic stars: Beyond the Tip of the Iceberg

Jennifer Sokoloski

In a symbiotic binary star, a compact object that is typically a white dwarf accretes from a red giant. With binary separations of AU to tens of AU, symbiotic stars have the potential to show when, how, and at what rate mass transfer occurs in common, wide, low-mass binaries. Due to selection effects in traditional optical spectroscopic searches, however, a major part of this population has very likely been missed. I will review the basic properties of symbiotic stars, as well as recent progress on using observations at radio through X-ray wavelengths to find and characterize populations of symbiotic stars in nearby galaxies and the Milky Way.

Wind mass transfer in binaries and its effect on orbital evolution

Martha Irene Saladino

Wind mass transfer is a common phenomenon in low-mass binaries containing asymptotic giant branch (AGB) stars, as a result of their slow (5-30 km/s) and dense stellar winds. Binary evolution models treat these winds as isotropic, predicting a gap in the orbital period distribution of post-AGB binaries between 1-10 yr. However, most post-AGB binaries have periods in this range, indicating that strong interaction between the wind and the orbit must have occurred. We perform hydrodynamical simulations to model wind mass transfer in binary systems containing an AGB star. We study the amount of material accreted by the companion and the specific angular momentum lost from the system as a function of the terminal velocity of the wind. We use this to predict its orbital evolution. We show that the interaction with the companion is strongest at low terminal velocities. For terminal velocities larger than the orbital velocity of the system we find a Bondi-Hoyle-Lyttleton flow and we reproduce the isotropic wind mode, leading to a widening orbit. However, for low wind velocities an accretion disk forms and the angular momentum transferred to the outflow implies that the orbit will shrink.

Composite-Spectrum Binaries: the Rosetta Stone for studies of stellar evolution?

R. Elizabeth M. Griffin

Of the many different types of observable binary systems, the ones with a particularly great potential for informing models of stellar evolution are those which show composite spectra. The (detached) components are a cool, evolved giant and a relatively hot, unevolved star, the differences in type resulting from different initial masses. Their SEDs cross over in the blue or near-UV, where both spectra can be seen; they can thus be separated and measured independently of one another. A precise SB2 orbit thereby derived yields the mass ratio; if eclipses occur, the masses are given absolutely. Assuming the components are coeval, their present HR-Diagram positions offer a direct - and sometimes conflicting - challenge to where theoretical models would have them be. I will describe a comprehensive study of 45 systems; most now have masses for both stars. The sample it reveals interesting heterogeneity, but also some fascinating surprises which neither observer nor theoretician can explain satisfactorily.

The title of this Workshop is interestingly ambiguous: which has the impact on which? The statistics deriving from the above study have something to say on that point.

Testing the present models of binary evolution

Anna Francesca Pala

Cataclysmic Variables (CVs) are close interacting binaries containing a white dwarf accreting from a low-mass main sequence star. CVs are one of the best classes to test our understanding of the evolution of compact, interacting binaries, as they are numerous, relatively bright, and both stellar components are structurally simple. Nonetheless, there are a number of discrepancies between current population models and observations as our results from a large HST program (Pala et al. 2017) have highlighted. Only once these discrepancies are resolved we can trust the theoretical models to be sensibly applied to more complex systems, such as black hole binaries, X-ray transients, milli-second pulsars or SN Ia progenitors. In particular, one of the most striking disagreement is the lack of period bouncers, i.e. old CVs in which the companions have been eroded down to brown dwarf masses. These systems are predicted to make up for ~70% of the observed CV population, yet very few have been identified so far. For this reason we have started a high cadence photometric survey using the OAJ/T80Cam aimed to find these elusive systems and we present here the preliminary result from this program.

Invited

Binary post-AGB stars as tracers of stellar evolution

Hans Van Winckel

When the first post-Asymptotic Giant Branch stars in binaries were discovered serendipitously, it was noticed that their Spectral Energy Distributions (SEDs) showed very characteristic properties: the few systems all showed a near-infrared excess, indicative of the presence of warm dust. This allowed an efficient search for similar systems and in this contribution, I will summarise what we have learned of the properties of post-AGB binaries. It is now well established that the near-infrared excess is produced by the inner rim of a stable circumbinary dusty disk. These disks are secondary and likely created when the current post-AGB star was at giant dimensions. The review will start with a detailed description of some illustrative individual objects. This will allow the identification of common properties of the whole sample. The orbital properties illustrate that the research is still mainly observational driven, as the theoretical predictions of evolution of an AGB star in a binary system are in stark contrast to what we observe. We review the properties of these post-AGB binaries and put the objects in evolutionary perspective by comparing them to possible progeny.

A Newly Discovered Binary Evolutionary Class: Dusty Post-RGB Stars

Device Kamath

The dusty post-Red Giant Branch (post-RGB) stars are a newly discovered class of low-luminosity, low-metallicity objects that have dust excesses and stellar parameters similar to post-Asymptotic Giant Branch (post-AGB) stars. However, they have luminosities lower than the tip of the Red Giant Branch (RGB). We suspect that they have evolved off the Red Giant Branch (RGB) instead of the AGB due to binary interaction. Our recent studies on dusty post-RGB objects in the LMC and SMC (based on spectra from VLT and SALT) include the first radial velocity monitoring of these objects and also investigations of their photospheric chemistry, both of which are excellent tracers for binarity. In this talk, I will present our efforts and new results on revealing their true evolutionary nature, formation channels and connection to other evolved binaries. I will also discuss the implications of this new class of objects on the widely accepted theories of stellar (binary) evolution in low- to intermediate-mass stars.

Invited

The importance of binarity in the formation and evolution of planetary nebulae

David Jones

Planetary nebulae are some of the most strikingly beautiful astrophysical phenomena known, gracing many a glossy-paged, coffee-table book and earning them the nickname "cosmic butterflies". It has long been believed that binarity may play and important role in the formation of aspherical planetary nebulae, but it is only now becoming clear how significant binarity may be with observational evidence of a significant fraction of surviving binaries inside planetary nebulae. Indeed, some surveys place the binary fraction at close to 100%, with some theories even going as far as to claim that binarity may be a prerequisite for all but the most massive stars to form a planetary nebula.

In this invited review, I will begin by outlining the fundamental pathways for binary evolution and how they each may relate to the formation of planetary nebulae. I will then go on to discuss some of the more interesting developments in the field, with emphasis on post-common-envelope central stars and what they can tell us about the common envelope phase itself. Finally, I will discuss the growing connections between planetary nebulae and other binary phenomena including novae and supernovae type Ia.

Towards finding the missing intermediate period binaries in planetary nebulae

Paulina Sowicka

It is now clear that a significant fraction of planetary nebulae are formed via a common-envelope evolution. Models of the common-envelope phase predict a significant number of post-common-envelope binaries with intermediate periods (~10s of days), however only one planetary nebula central star system with a period greater than ten days is known. Here, I will present the first results of an exploratory programme to search for these missing intermediate-period post-common-envelope binary central stars which has led to the discovery of a binary central star in IC 4776. The nebula displays a remarkable hourglass morphology with an extended precessing jet, consistent with a binary evolution which prompted its inclusion in our radial velocity survey. The best fitting periods to the sparse data indicate that the binary is one of, if not, the longest period post-common-envelope central stars known. The system would not be detectable by the photometric monitoring techniques, supporting the hypothesis that there is a significant population of intermediate period, post-common-envelope binary central stars yet to be discovered.

The evolution of triple-star systems

Silvia Toonen

Adding a third star on a (wider) orbit to a binary, can significantly alter the evolution of that inner binary. And so, over the last few years, triple evolution has been provoked regularly to explain the formation of binaries that cannot be explained easily with our standard theory of binary evolution. However, a clear picture is lacking of how and which triples evolve differently from binaries. Here, I will show results from our new code TRES (Toonen et al. 2016) for simulating the evolution of triples consistently, taking into account both the three-body dynamics, as well as the stellar evolution and interactions.

In this talk, I will give an overview of the common evolutionary pathways that triple systems evolve through and how it differs from binary evolution, as calculated with TRES. I will also show that triple evolution can lead effectively to mergers and collisions of compact objects, and show the consequences for gravitational wave sources and supernova type Ia progenitors.

The EREBOS project: Studying the influence of low-mass companions on stellar evolution

Veronika Schaffenroth

Common envelope ejection triggered by a close companion is regarded as most probable formation channel for hot subdwarf stars (sdO/Bs), which are stripped cores of red giant stars, as the fraction of close binaries with periods of 1.5 h to about 1 day is with 50% much higher than in standard stellar evolution. Of special interest are hereby eclipsing post-common envelope systems with hot subdwarf stars and cool low-mass companions (HW Vir systems), as they are perfect systems to study the influence of cool, low-mass companions on stellar evolution. They are easily discovered by their characteristic lightcurves with the eclipses and the prominent reflection effect. By systematically investigating the lightcurves provided by the OGLE survey we discovered 90 new HW Vir systems additionally to the only 17 systems that were published before. We were awarded with a ESO Large Program for a spectroscopic follow-up of 23 of this systems. The main goal is to find the mass distribution of the companions to better understand which kind of companions are able to survive a common envelope phase and eject the envelope. Here we will give the current status of the project and the first results.

Observing stellar mergers and their remnants

Tomasz Kaminski

Stellar mergers take place before our eyes. One manifestation of this phenomenon are red novae, also known as intermediate-luminosity transients, with V1309 Sco being the most spectacular member of this group of eruptive stars. V1309 Sco was an eclipsing binary with a shortening orbital period prior to its eruption in 2008 as a red nova. I am going to present observations of this and similar objects that were taken during and after their eruptions. I am going to discuss the importance of these observations for our understanding of the physics of stellar mergers, the common envelope phase, and angular momentum balance in the merger remnants.

Invited

Binary Stars and Alternative Stellar Evolutionary Paths in Open Star Clusters

Robert D. Mathieu

Open star clusters have well-identified binary populations among solar-type stars that are very similar to the field binary population in frequency and period distribution less than 10,000 days. Thus it is inevitable that the evolution of the stars in many of these binaries will be affected by the presence of their companions, and follow alternative stellar evolutionary paths. In fact, roughly 25% of the evolved stars in older open clusters do not fall on single star isochrones. I will review the status of observations for blue stragglers, yellow giants, sub-subgiants and other stars of interest in open clusters with ages greater than 1 Gyr, including recent results from the K2 campaign on M67. As time permits I will show the results of recent modeling of select systems.

Close Binary Stars in the Galactic Open Clusters

Kadri Yakut

Studies on the detached close binaries (DCBs), near-contact binaries (NCBs), and low-temperature contact binaries (LTCBs) in the Galactic open clusters may help us to test single/binary stellar evolution models. In this study, using the Kepler data and ground-based observations the physical parameters of some selected systems are obtained. We collected the physical parameters of these three classes of interacting binary stars that are members of the Galactic open clusters to study the role of mass loss and angular momentum loss in these systems and the possible evolutionary connections between these three classes are studied.

Invited

The physics of Blue stragglers: defining a dynamical clock for star clusters

Francesco Ferraro

I present an overview of the main observational results obtained to date about Blue Straggler Stars (BSSs) in Galactic Globular Clusters (GCs). The observational properties of BSS are discussed in the framework of using this stellar population as probe of GC internal dynamics. In particular, the shape of the BSS radial distribution and their level of central segregation have been found to be powerful tracers of the level of the dynamical evolution of the hosting stellar systems, thus allowing the definition of an empirical “clock”.

Optical companions to binary milli-second pulsars in GCs

Cristina Pallanca

According to the "canonical recycling scenario", milli-second pulsars (MSPs) form in binary systems containing a neutron star that is spun up through mass accretion from the evolving companion. Therefore, the final stage consists of a binary system made of a MSP and the core of the deeply peeled star. However, an increasing number of systems deviating from these expectations has been discovered, thus strongly indicating that our understanding of MSPs is far to be complete. In the last years we identified 8 new companions to MSPs in Galactic globular clusters (GCs), more than doubling the number of previously known objects, and also reporting the first and unique detections of both a transitional-MSP companion and 2 Black-Widow companions in GCs.

In this talk I review the main techniques used to identify MSP companions and highlight the observational properties of the main different classes (Canonicals, Redbacks and Black-Widows), collocating them in the rising scenario.

WEDNESDAY 5 July 2017

09:00	**M. Mapelli**	**The Maxwell's demon of star clusters, aka the impact of binaries on N-body system evolution**
09:35	M.C. Ramirez-Tannus	A lack of massive short period binaries in M17
09:55	**N. Langer**	**Testing massive binary evolution models: a necessary challenge**
10:30	G. Rauw	Evidence for past Roche-lobe overflow in two O-type binaries
10:50	COFFEE	
11:20	S. Ohlmann	Recombination energy in common envelope phases
11:40	**H. Sana**	**Binarity at high mass, many (futile) attempts to find genuine single stars**
12:15	E. Alecian	Magnetic fields in massive close binaries
12:35	Y. Goetberg	Stars stripped in binaries: their characteristic spectral features and how to observe them
12:55	K. Garofali	Using High-Mass X-ray Binaries to Probe Massive Star Evolution
13:15	FREE AFTERNOON	

Invited

The Maxwell's demon of star clusters, aka the impact of binaries on N-body system evolution

Michela Mapelli

I review the multiple roles of binary systems in a star cluster. Most star clusters (open clusters, young star clusters, and globular clusters) are collisional systems, implying that their dynamical evolution is extremely fast. Mass segregation, gravothermal instability, runaway collisions, Spitzer's instability, and three body encounters are the main drivers of the evolution of collisional systems. Binaries act like a "Maxwell's demon" in all these processes, participating in three-body encounters and providing the energy source to reverse gravothermal instability. Moreover, binaries are expected to trigger the formation of stellar exotica, such as intermediate-mass black holes, blue straggler stars, and massive black hole binaries.

I review these processes and the main simulation tools that have been used to study them in the last decades. I conclude discussing the future challenges of the study of binaries in N-body systems.

A lack of massive short period binaries in M17

María Claudia Ramirez-Tannum

The radial velocity dispersion measured for 12 massive young stellar objects in the 0 - 1 Myr old cluster M17 is strikingly low. This can be explained by a very low binary fraction (f_{bin} = 0.12) or a lack of short period binaries (P_{cutoff} > 9 months), or by a combination of both scenarios. These findings are at odds with observations of 2 - 3 Myr old clusters. We hypothesize that massive stars are born at large separations and harden their orbits at a later stage, but within a few Myrs. If that is true, this would place important constraints on the formation mechanism of close massive binaries.

Invited

Testing massive binary evolution models: a necessary challenge

Norbert Langer

Binarity dominates the evolution of massive stars. I will outline what this means and implies. I will discuss the key physics parameters which affect the evolution of massive binaries – including those which affect single stars, and what we know about them (or not). Finally, I will explore strategies of testing massive binary evolution models, and summarise which conclusions we can currently draw.

Evidence for past Roche-lobe overflow in two O-type binaries

Gregor Rauw

Using a series of high-resolution spectra of the two massive binary systems HD149404 and LSS3074, we have performed spectral disentangling. The reconstructed spectra of the binary components were then analyzed with the model atmosphere code CMFGEN to infer their properties with a special emphasis on the abundances of CNO and the rotational velocities of the stars. Theses studies reveal the signatures of past Roche lobe overflow episodes. Using photometric data of LSS3074, we have also analyzed the light-curve of this system. The results indicate that this system has apparently lower masses than one might from the spectral type of the O4If primary stars. We find that LSS3074 could be in an overcontact configuration. We compare these results with other observations of post-RLOF O-type binaries.

Recombination energy in common envelope phases

Sebastian Ohlmann

The common envelope (CE) phase is important for the evolution of close binary systems with compact stars. In the past, most 3D hydrodynamic simulations of the CE phase have failed to explain how the envelope is ejected. For a long time, it has been discussed if energy from recombination of H and He may help ejecting the envelope. Here, I present 3D hydrodynamic simulations of the CE phase of a two solar mass red giant with different companions including the release of recombination energy. I will show that releasing recombination energy helps ejecting the envelope: after the rapid spiral-in releases orbital energy and lifts large parts of the envelope to larger radii, recombination energy is released during expansion, largely unbinding the envelope during the simulated time. Moreover, I will show that convergence can be achieved in this type of simulations by increasing the resolution around the red giant core and the companion. I will also present first light curves computed from the simulations and compare the luminosities and colors to observations of luminous red novae and to analytical models.

Invited

Binarity at high mass, many (futile) attempts to find genuine single stars

Hugues Sana

Magnetic fields in massive close binaries

Evelyne Alecian

All along the formation and evolution of massive stars, magnetic fields are believed to play important roles on their internal structure and on the interaction with their environment. In short-period (P_{orb} < 20 d) binaries interaction between the stellar magnetic fields and the magnetospheres can also play an important role one the formation and evolution of the system. Binarity, by the presence of a massive companion in the close vicinity of a star, may also influence the origin and evolution of the magnetic fields. All these questions are being addressed within the Binarity and Magnetic Interaction in various classes of Stars (BinaMIcS) project. The BinaMIcS project has been awarded more than 800 h of telescope time at the CFHT (Hawaii) and at the TBL (France) to get ESPaDOnS and Narval spectropolarimetric observations of more than 200 short-period binaries and to characterize the magnetic properties of massive close binaries.

I propose to review the results of our investigation and the consequences they have on our understanding on massive binaries formation and evolution

Stars stripped in binaries: their characteristic spectral features and how to observe them

Ylva Goetberg

A potentially more common stellar evolutionary path than red supergiant is an exposed helium core, stripped of the hydrogen-rich envelope through mass transfer to a binary companion. These hot, stripped stars are sources of ionizing radiation, with significant impact both nearby and during the epoch of reionization. It is the first long-lasting post-interaction phase, indicating that stripped stars are relatively easy binary products to observe.

We model for the first time extensive grids of stripped star spectra, ranging from subdwarf up to Wolf-Rayet like objects. The atmospheres are modelled with the nLTE radiative transfer code CMFGEN, using stellar properties of models created with the binary stellar evolution code MESA.

Our models show characteristic spectral features possible to connect to recently observed stars in the LMC, so far classified as WN3/O3V type. Observed stripped stars would provide a valuable opportunity to better understand e.g. binary interaction and wind of hot stars. We present promising detection techniques, detections that would be of importance to better understand later evolutions including X-ray binaries, SNe IIb/Ib and gravitational wave sources.

Using High-Mass X-ray Binaries to Probe Massive Star Evolution

Kristen Garofali

High-mass X-ray binaries (HMXBs) provide an exciting window into the impact of mass transfer on massive star evolution. They are also likely progenitors of gamma-ray bursts and gravitational wave events. We present initial identification and age measurements of HMXBs in the nearby, star-forming spiral galaxy M33 using a combination of deep Chandra X-ray imaging, XMM-Newton observations, and archival Hubble Space Telescope (HST) data. We are able to measure HMXB ages to ~5 Myr precision from fits to the color-magnitude diagrams of the surrounding stars, which yield the star formation histories (SFHs) of the surrounding region. Furthermore, we can use a combination of the X-ray and optical characteristics of the HMXBs to constrain physical parameters for some of the HMXBs, including potential periods and companion masses in addition to ages. The distribution of these parameters for the population of HMXBs can be directly compared to models of HMXB production expected from the known SFH of M33. These comparisons put new constraints on prescriptions used by binary population synthesis models which attempt to map the characteristics of the parent population to the resulting HMXBs.

THURSDAY 6 July 2017

09:00	**N. Smith**	**The Luminous Blue Variable/WR connection and pre-SN evolution**
09:35	J. Sanchez Bermudez	GRAVITY/VLTI chromatic image reconstruction of the Eta Car wind-wind collision region
09:55	A. Kashi	Accretion Simulations of Eta Carinae and the Parameters of the Binary System
10:15	M. Pakull	A common-envelope LBV / ULX binary in a nearby galaxy
10:35	COFFEE	
11:00	**G. Nelemans**	**Binaries as Sources of Gravitational Waves**
11:35	J. Klencki	Rates of binary black hole mergers as probes of the massive star formation
11:55	C. Neijssel	Exploring binary evolution with gravitational-wave detections
12:15	POSTER SESSION	
13:00	LUNCH	
14:30	**F. Patat**	**Type Ia Supernovae: where are they coming from and where will they lead us?**
15:05	C. Pritchet	The Delay Time Distribution of Type Ia Supernovae
15:25	N. Hallakoun	The local double white dwarf population from SPY and implications for the SN Ia progenitor problem
15:45	**N. Tanvir**	**Binary Interactions and Gamma-ray bursts**
16:20	TEA	
16:50	A. Ruiter	Explaining Galactic antimatter with faint thermonuclear supernovae
17:10	S. Chaty	Formation and evolution of supergiant High Mass X-ray Binaries

SOCIAL DINNER

Invited

The Luminous Blue Variable/WR connection and pre-SN evolution

Nathan Smith

GRAVITY/VLTI chromatic image reconstruction of the Eta Car wind-wind collision region

Joel Sanchez Bermudez

Eta Car is one of the most massive, and intriguing, Luminous Blue Variables known. In its core resides a binary with a 5.54 years orbital period. Visible, infrared, and X-ray observations suggest that the primary star exhibits a very dense wind with a terminal velocity of about 450 km/s, while the secondary shows a much faster and less dense wind with a terminal velocity of 3000 km/s. The wind-wind collision zone at the core of Eta Car is thus a complex region that deserves a detailed study to understand the effect of the binary interaction in the evolution of the system. Here, we will present unique GRAVITY/VLTI observations of the core of Eta Car. The superb quality of our interferometric data, together with state-of-the-art image reconstruction techniques, allowed us to obtain, with milliarcsecond resolution, continuum and chromatic images cross the BrG and HeI lines in the Eta Car K-band spectrum (R~4000). These new data together with models of the primary wind of Eta Car has letting us to characterize the spatial distribution of the dust and gas in the inner 40 AU wind-wind collision zone of the target.

Accretion Simulations of Eta Carinae and the Parameters of the Binary System

Amit Kashi

We present high resolution numerical simulations of the colliding wind system Eta Carinae, showing accretion onto the secondary star close to periastron passage. The smooth stellar winds collide and develop instabilities, mainly the non-linear thin shell instability, and form filaments and clumps. We find that a few days before periastron passage the dense filaments and clumps flow towards the secondary as a result of its gravitational attraction, and reach the zone where we inject the secondary wind. We run our simulations for the conventional stellar masses, M_1=120 Msun and M_2=30 Msun, and for a high mass model, M_1=170 Msun and M_2=80 Msun, that was proposed to better fit the history of giant eruptions in the nineteenth century. As expected, the simulations results show that the accretion processes is more pronounced for a more massive secondary star. We obtain orbital parameters of the binary system from the simulation results, and learn about the recovery of Eta Carinae from its giant eruptions.

A common-envelope LBV / ULX binary in a nearby galaxy

Manfred Pakull

Close to the well-studied ultraluminous X-ray source NGC~5408 X-1 we discovered an even more powerful ULX cousin. Apparently much more X-ray quiet (Lx~10^{37} erg/s), X-2 nevertheless photoionises a large He II region displaying HeII4686 and [NeV]3426 emission. This suggests a huge intrinsic X-ray power of several 10^{40} erg/s, in line with its luminous radio synchrotron emission. Even more outstanding is its unique Mv~–10 optical counterpart that recently underwent drastic spectral evolution displaying Halpha equivalent width changes from 20 nm some twenty years ago to presently 200 nm. The system appears to be in a very rapid stage of binary evolution with currently ongoing extreme mass loss and mass transfer to the compact binary component. We will discuss our finding in the framework of beginning common envelope evolution and point out its relevance to the evolutionary scenario of stellar BH-BH mergers.

Invited

Binaries as Sources of Gravitational Waves

Gijs Nelemans

Binary stars with compact objects are prime sources of gravitational waves and the first detected sources. They are detectable in both the high- and low-frequency GW bands. I will discuss the current detections and the prospects for the future, both for ground based detectors as for the LISA mission. Furthermore, I will discuss the astrophysical questions that can be answered with these detections and how complementary electro-magnetic will enhance the science.

Rates of binary black hole mergers as probes of the massive star formation

Jakub Klencki

The properties and the formation rate of massive binaries across the Universe are the key ingredients in deriving predictions for the compact binary mergers that will be detected by the advanced LIGO. Recently, Moe & Di Stefano (2016) combined the results from over twenty massive star surveys and for the first time fitted an inter-correlated distribution to the initial binary parameters. Moreover, the common assumption of the globally invariant initial mass function (IMF) is challenged by the observations of the Galactic globular clusters, which strongly suggest a top-heavy IMF in low metallicity environments (Marks et al. 2012). Such a trend is in agreement with the previously available indirect evidence (e.g. lack of observable Pop. III low mass stars, necessary UV photons for reionization).

We incorporate both these new results and study their significance for the merger rates of double black hole systems in the isolated binary evolution scenario, using the StarTrack population synthesis code. We also provide predictions for the metallicity distribution of the progenitor binaries.

Exploring binary evolution with gravitational-wave detections

Coen Neijssel

During its first 4 months of taking data, Advanced LIGO has detected gravitational waves from two binary black hole mergers, GW150914 and GW151226, along with the statistically less significant binary black hole merger candidate LVT151012. I will show how the rapid binary population synthesis code COMPAS is able to explain all three events by a single evolutionary channel—classical isolated binary evolution via mass transfer including a common envelope phase. I will discuss the promise of future gravitational-wave observations for improving our understanding of massive binary evolution.

Invited

Type Ia Supernovae: where are they coming from and where will they lead us?

Ferdinando Patat

I will review our current understanding of the binary channels that are considered as viable candidates for the Type Ia Supernovae progenitors. I will discuss the pros and cons of the favourite scenarios, and present the most recent observational evidences that support or contradict them. I will also attempt to place the Type Ia studies in a wider context, discussing why it is important to understand them, and what potential is still hiding behind them.

The Delay Time Distribution of Type Ia Supernovae

Chris Pritchet

The delay time distribution (DTD) of Type Ia Supernovae (SNe Ia) is a key to understanding SN Ia progenitors. In this talk we demonstrate a new method of empirically determining the DTD. This method is surprisingly insensitive to the stellar population mix from which the SN arises, and provides details on both the shape and slope of the DTD. First results on SDSS SNe indicate a DTD ~ $t^{-1.5}$, steeper than the t^{-1} commonly (although perhaps erroneously) associated with the double degenerate scenario. Binary population synthesis (BPS) models are not yet in a state to interpret this result, but heuristic arguments based on the DTD suggest that most of these SNe are not from the single degenerate scenario. Most important, future samples of SNe Ia (N > 1000) will provide excellent constraints on the shape of the DTD for comparison with the next generations of BPS models.

The local double white dwarf population from SPY and implications for the SN Ia progenitor problem

Na’ama Hallakoun

The nature of the progenitor systems of Type-Ia supernovae (SNe Ia) is unclear. Although a companion is likely required to trigger the explosion of a white dwarf (WD), the companion's identity is unknown. A model long considered is the double-degenerate scenario, in which a double WD (DWD) binary loses energy and angular momentum to gravitational waves, until merger and explosion as a SN Ia. One way to address the problem is to characterise the Milky Way's DWD population. From a sample of spectra of 439 WDs from the ESO-VLT Supernova-Ia Progenitor surveY (SPY), we measure the maximal changes in radial-velocity (DRVmax) between epochs, and model the observed DRVmax statistics via Monte-Carlo simulations, to constrain the population characteristics of DWDs. We find that 10% of WDs are in DWD systems in the separation range ~<4AU within which the data are sensitive to binarity. The implied Galactic DWD merger rate is 1-80 times the Milky Way's SN Ia rate. Therefore, in terms of rates, a possibly small fraction of all merging DWDs (e.g. those in which one of the WDs is above some mass limit) could suffice to produce most or all SNe Ia.

Invited

Binary Interactions and Gamma-ray bursts

Nial Tanvir

Both long- and short-duration gamma-ray bursts are likely outcomes of binary evolution of massive stars. In particular, there is increasing support for the long-standing notion that short-GRBs arise during the merger of two compact objects, with at least one neutron star component. Evidence comes from the association of short-GRBs with both young and old stellar populations, and the discovery of apparent kilonova/ macronova signals in a small number of cases. Interest in these systems is now heightened as they are electromagnetic-bright sources of strong of gravitational waves. In the case of long-GRBs, the progenitor is certainly a massive star lacking an extended envelope, but whether this might arise through a single star channel, or requires binary interaction (or both) remains an open question. This is a question that is important to resolve, both for our understanding of GRBs, and also for their use as probes of galaxy evolution.

Explaining Galactic antimatter with faint thermonuclear supernovae

Ashley Ruiter

Every second, ~10^{43} positrons are annihilated in our Galaxy, though the origin of these positrons is unknown. Different sources have been proposed: e.g. dark matter, core collapse supernovae, and 'normal' Type Ia supernovae. However, previously-proposed scenarios fail to explain why the positrons preferentially annihilate among old stellar populations. We propose that the main source of positrons in the Galaxy is thermonuclear explosions of a faint class of Type Ia supernova: 1991bg.

It has been suggested that 1991bg supernovae originate from the merger of helium white dwarf and carbon-oxygen white dwarf pairs. Our binary evolution models predict a formation channel of these systems that merges within the correct age range (delay time) to explain the distribution, and amplitude, of the Galaxy's observed positron signal. We propose the positrons originate from the products of He-burning, namely the decay chain of Ti 44. We argue that other He-rich + CO WD merger channels do not lead to thermonuclear supernovae, but are more likely to lead to the formation of R Coronae Borealis variable stars.

Formation and evolution of supergiant High Mass X-ray Binaries

Sylvain Chaty

A previously unknown population of High-Mass X-ray Binaries (HMXB) hosting supergiant stars has been revealed during the last years, with multi-wavelength campaigns including high energy (INTEGRAL, Swift, XMM, Chandra) and optical/infrared (mainly ESO) observations, including interferometric VLT observations. This population is constituted of obscured supergiant HMXB, and some, called supergiant fast X-ray transients (SFXTs), exhibit short and intense X-ray flares.

I will discuss the formation and evolution of these HMXB, how these observations can constrain the accretion models (e.g. clumpy winds, transitory accretion disc, magneto-centrifugal barrier, etc), compare our observations to results from population synthesis models, and finally propose a scenario to explain the properties of these high-energy sources. Because these HMXB are the likely progenitors of Luminous Blue Variables (LBVs), and also related to compact object mergers and emission of gravitational waves, the knowledge of their formation and evolution is of prime importance.

FRIDAY 7 July 2017

09:00	**E. Starkenburg**	**Binaries and early Galactic chemical evolution**
09:35	K. Pavloski	Chemical composition of high-mass stars in binaries
09:55	**R. Izzard**	**Binary population synthesis**
10:30	COFFEE	
11:00	**S. Lucatello**	**Extremely low-metallicity binaries**
11:35	**J.J. Eldridge**	**Population and spectral synthesis: it doesn't work without binaries!**
12:10	C. Badenes	Stellar Multiplicity Meets Stellar Evolution: The APOGEE View
12:30	LUNCH	
14:00	**L. Eyer**	**Gaia and the LSST and their importance for stellar astrophysics and binary star research**
14:35	N. Mowlavi	Studying eclipsing binaries in large-scale multi-epoch surveys
14:55	**E. van den Heuvel**	**Summary of the conference**
15:30	END of Workshop	

Invited

Binaries and early Galactic chemical evolution

Else Starkenburg

The lowest metallicity stars that still exist today probably carry the imprint of very few supernovae in the early Universe. Additionally, they may carry the imprints of binary companions, or may be in binary systems. I will review our understanding of the origin for the peculiar abundance patterns in various chemical subclasses of these very pristine stars, taking into account new observational data from our radial velocity monitoring and abundance programs. I will subsequently discuss the implications of these results for our understanding of the formation and early evolution of both the Milky Way and its satellite dwarf galaxies.

Chemical composition of high-mass stars in binaries

Pavlovski Kresimir

The photospheric chemical composition of stars in close binary systems is important for a proper understanding of the stellar structure and evolutionary processes. In an on-going long-term observational project we aim to provide elemental abundances for a statistically significant sample of high-mass stars in detached eclipsing binaries.

We present new results for an additional dozen OB binaries from spectra secured with HARPS at ESO, and HERMES at the Mercator Telescope. Recent evolutionary models for rotating single stars predict changes in photospheric abundances even during the early phases of their main sequence lifetime. We compare our observational results with these predictions. Also, we address the long-term puzzle of the mass-discrepancy between dynamical and evolutionary masses which our high-precision observational results emphasised.

Invited

Binary population synthesis

Rob Izzard

The 21st century is all about big data and stellar evolution is no exception to this trend. Grand surveys such as Gaia and LSST will provide data on billions of stars, enough to be true samples of the stellar population in our Galaxy and beyond. The aim of population synthesis is to construct computer model versions of all the stars that we can see, be they single, binary or multiple. We can then compare the properties our models – number of stars of different types, number of explosions, chemical abundances, rate of stellar mergers etc. – to the observed data to improve our understanding. In many cases this is refinement of established theories and associated parameters, but big data will no doubt also lead to big surprises and, in some cases, prove revolutionary. I will outline the current state of binary population synthesis, where it works well and where it does not, and prospects for future improvement. Through analysing rare, outlier systems, often we gain the most astrophysical understanding. I will highlight some examples.

Invited

Extremely low-metallicity binaries

Sara Lucatello

The binary fraction of very metal-poor stars has bearing on our understanding of the origin of the large number of chemically peculiar objects found among them, providing important constraints on star formation in the early Galaxy. It has been shown that a majority of solar metallicity dwarf stars in the solar neighbourhood are in binaries, and while this result is often extended to other type of stars, very few studies exist, especially for what concerns extremely metal poor stars. Is there a metallicity floor below which binary systems do not form, or become rare or conversely very frequent?

I will summarise the status of the field and present and discuss the ongoing Lick Observatory program which employs both the Hamilton spectrograph and the Automated Planet Finder to monitor a sample of very low metallicity stars in order to determine their binary fraction.

Invited

Population and spectral synthesis: it doesn't work without binaries!

JJ. Eldridge

Individual stellar models can be combined to produce synthetic stellar populations for comparison to a broad range of observations. In this talk I will discuss the evidence that such comparisons show that a full understanding cannot be achieved unless interacting binary stars are accounted.

I will discuss the synthesis of obvious cases such as eclipsing binary stars and merging compact remnants. Then the non-so-obvious including core-collapse supernovae, spectra of high-redshift galaxies and the BPT diagram of HII regions.

Stellar Multiplicity Meets Stellar Evolution: The APOGEE View

Carles Badenes

The APOGEE survey has provided multi-epoch high resolution (R~20,000) spectra for ~100,000 stars in the Milky Way. We present a statistical analysis of this unique data set to infer the multiplicity statistics of field stars as a function of log(g) and metallicity. We can measure the rate at which stars lose short-period binary companions as they move away from the main sequence, up the red giant branch, and all the way to the red clump. This gives an observational constraint on the rate of common envelope events in the disk of the Milky Way.

Invited

Gaia and the LSST and their importance for stellar astrophysics and binary star research

Laurent Eyer

The observational parameters space that allows us to detect and describe binary stars is enormous. It comes from the fact the binary stars are very numerous, present themselves with a huge variety of physical properties and have signatures in all astronomical fundamental technics (astrometry, photometry, spectrometry). It is therefore not a surprise that any significant improvement in observational astronomical facilities have an important impact on our knowledge of binaries. The development of various large scale surveys has been impressive these two last decades.

Among them, Gaia and LSST are exceptional surveys, which have and probably will have a profound and longing impact on the astronomical landscape. We will review the status of these two projects, and see how they can improve the knowledge of binary stars.

Studying eclipsing binaries in large-scale multi-epoch surveys

Nami Mowlavi

Interacting binaries play a key role in a wide variety of astrophysical fields. Yet, their evolution is poorly understood. On the other hand, a wealth of data is being collected by multi-epoch large-scale surveys, from ground (e.g. OGLE, super-Wasp, NGTS, future LSST) and from space (e.g. Kepler, Gaia, future TESS and PLATO). Those surveys are gold mines for the field of binary stars. This is the more true for ESA's Gaia mission, expected to observe up to several millions of eclipsing binaries (EBs).

In this contribution, we show the potential of the study of EBs in large-scale surveys. We describe a procedure to characterize and classify EBs based on the geometric morphology of their light curves, developed in the framework of Gaia, with two aims. First to study an ensemble of EBs on a statistical ground without the need to model the binary system. This allows to study the properties of binary systems on a statistical ground. The second goal is to identify EBs that display atypical light curves. This allows to study the physics of binary systems in specific configurations. We illustrate the potential on the OGLE sample of EBs in the Large Magellanic Cloud.

POSTERS

1	Michael Abdul-Masih	Is VFTS 352 a Gravitational Wave Progenitor?
2	Claudia Agliozzo	Luminous Blue Variables with collimated winds
3	Gustavo Aguayo	The nature of the binary star HV Lup
4	Fahri Alicavus	Comparison of Single and Binary Star Evolution Models for Selected Detached Binaries
5	Fahri Alicavus	Stellar Evolution of Binary Stars from Detached to Contact Phase
6	Metin Altan	Evidence of photometric and spectral variability for SDSSJ074625+423705
7	Roman Avramenko	Observability of characteristic binary-induced structures in circumbinary disks
8	Angie Barr	Eclipsing high-mass binaries
9	Liz Bartlett	CI Camelopardalis: The archetypal sgB[e]/X-ray binary almost 20 years on
10	Sopia Beradze	Old and New PhotometricObservations of P Cygni
11	Julia Bodensteiner	Interaction between Massive Stars and the Interstellar Medium
12	Henri Boffin	The mass-ratio distribution of spectroscopic binaries along the main-sequence
13	Michael Bremer	IRC+10216 in high-resolution molecular lines
14	David Brown	An Expansion of the Mass-Orbital Period Relation of sdBs from Stable Roche Lobe Overflow
15	Denise Castro	Carbon enrichment in APOGEE disk stars as evidence of mass transfer process
16	Drahomir Chochol	The Algol-type binaries RW CrA and DX Vel as multiple systems
17	Drahomir Chochol	GSC 3152-1202, a massive eccentric eclipsing binary with a fast apsidal motion
18	Martyna Chruslinska	How bad are we at predicting DNS merger rates?
19	Jesus Corral-Santana	On the orbital period of MAXI J1659-152: the shortest in a black hole candidate
20	Borbala Cseh	Constraints on AGB nucleosynthesis based on Barium star observations
21	Gergely Csepany	Multi-epoch observations with high spatial resolution of multiple T Tauri systems
22	Katarzyna Drozd	Comparison of the distribution of Symbiotic Stars in Milky Way and in M31
23	Steve Ertel	Heavy exo-cometary activity around the Helix central star?
24	Francis Fortin	Spectroscopic identification of INTEGRAL high-energy sources using VLT/ISAAC
25	Yan Gao	Tertiary Tides: A Novel Mechanism with Potential Implications for the Evolution of Some Binaries
26	Hongwei Ge	Rapid mass transfer in binaries and its application in common envelope evolution
27	Benjamin Giesers	Binary stars in Galactic globular Clusters observed with MUSE

28	Avishai Gilkis	The crucial role of binary interactions for energetic explosions of massive stars
29	Carlos Alberto Guerrero Pena	Binary stars as seeing by Speckle Interferometry
30	Zhao Guo	Post-mass Transfer Delta Scuti/Gamma Doradus Stars in Close Binaries
31	Catrina Hamilton-Drageri	The Photometric Evolution of V723 Cas (Nova Cas 1995) from 2006 - 2016
32	Zhanwen Han	Binary Evolution and Type Ia Supernovae
33	Berry Holl	Automatic determination of eclipsing binary period
34	Swetlana Hubrig	HD 96446: a long-period binary with a strongly magnetic He-rich component with beta Cep pulsations
35	Swetlana Hubrig	Upper main sequence binaries with magnetic components
36	Christian Hummel	The spotted active binary UX Arietis
37	Andrei Igoshev	Velocity of the MSP is an important probe of the binary evolution
38	Puji Irawati	An investigation of the peculiar photometric dips in the WDMS binary SDSS J1021+1744
39	Valentin Ivanov	New Binaries from infrared surveys
40	Chris Johnson	Exploring low and intermediate-mass binary properties in the young cluster Westerlund 2 using HST
41	Cole Johnston	Asteroseismology of close binary pulsators
42	Belinda Kalomeni	Evolution of Binaries Containing a White-Dwarf
43	Paulina Karczmarek	The occurrence of binary evolution pulsators in classical instability strip of RR Lyrae and Cepheid variables
44	Nino Kochiashvili	On the Binarity and the Possible Pulsations of P Cygni
45	Rainer Koehler	Dynamical Masses of young visual binaries as test for pre-main-sequence evolutionary models
46	Gloria Koenigsberger	Tidally excited oscillations in the context of stellar evolution
47	Yutaka Komiyama	Binary Fraction from Hyper Suprime-Cam Deep Imaging Survey for the Local Group Dwarf Galaxies
48	Michalis Kourniotis	Constraining the parameters of massive eclipsing binaries in the Local Group
49	Kateryna Kravchenko	Tomographic method and its application to the detection of binarity
50	Eva Laplace	Are long-term periodicities and giant outbursts in BeXRBs driven by Kozai-Lidov oscillations?
51	Georgi Latev	Rapid photometric variability of the unique binary system AE Aquarii during 2013-2016
52	Holger Lehmann	The Rossiter effect in Algol-type systems
53	Lifang Li	A Hottest White Dwarf SDSS J134430.11+032423.1 with a Planetary Debris Disk
54	Zhengwei Liu	The interaction of core-collapse supernova ejecta with a companion star
55	Christophe Martayan	Binarity: the clue to understand the LBVs behaviour and their surrounding environment?

56	Elena Mason	The Kepler Swift Survey (KSS): active stars as possible FK Com descendants
57	Andrea Mehner	The impact of binarity on the Luminous Blue Variable phenomenon
58	Ronald Mennickent	Interacting binaries of intermediate mass showing long-cycle photometric periods
59	Antoine Merand	The hunt of close-orbit companions of Galactic Cepheids
60	Tibor Mitnyan	Complex photodynamical analysis of the close hierarchical triple systems KIC 6525196 and KIC 8043961
61	Glenn-Michael Oomen	Exploring the orbital diversity of post-AGB binaries
62	Anna Pannicke	Runaway Stars in Supernova Remnants
63	Ingrid Pelisoli	Are sdAs He-core stars?
64	Bogumil Pilecki	Mass determination for SB1 systems with pulsating components and the RaveSpan software
65	Vincent Prat	Tides in binary, differentially rotating, cool stars
66	Chris Pritchet	The Spatial Distribution of Type Ia Supernovae in their Host Galaxies
67	Andrej Prsa	The distribution of orbital periods and eccentricities for close solar-type binary stars
68	Ying Qin	The spin of the second-born black hole in coalescing double black hole binaries
69	Oscar Hernan Ramirez Agudelo	The BBC survey: unbiased reporting of the 30 Doradus' B-star binaries
70	Noel Richardson	Possible Tidally Excited Pulsations in the eta Carinae binary Revealed from BRITE photometry
71	Noel Richardson	X-ray and Optical Variability of the colliding winds binary gamma2 Velorum
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