Physics of Evolved Stars 2015

8-12 Jun 2015
France

Sciencesconf.org

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Session 2: Winds, Mass loss, Jets

ALMA data suggest the presence of a spiral structure in the inner wind of CW Leo

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Evolved low-mass stars lose a significant fraction of their mass through stellar winds. While the overall morphology of the
stellar wind structure during the asymptotic giant branch (AGB) phase is thought to be roughly spherically symmetric, the morphology changes dramatically during the post-AGB and planetary nebula phase, during which bipolar and multi-polar structures are often observed. We have observed the close-by carbon-rich AGB star CW Leo using ALMA (Cycle 0) in band 9 around 650 GHz. The channel maps and position-velocity diagram of the 13CO J=6-5 line show a complex structure. Using detailed 3D radiative transfer models, we show that curved structure in the position-velocity map of the 13CO J=6-5 line can
be explained by a spiral structure in the inner wind of CW Leo, probably induced by a binary companion. From modelling the ALMA data, we deduce that the potential orbital axis for the binary system lies at a position angle of 10?20 to the north-east and that the spiral structure is seen almost edge-on. We infer an orbital period of 55 yr and a binary separation of 25 au (or 8.2 stellar radii). We tentatively estimate that the companion is an unevolved low-mass main-sequence star.

The role of jets: from common envelope to nebula

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I will review the different phases of late stellar evolution where jets seem to play crucial roles. The relevant processes where jets play a key role include common envelope evolution, grazing envelope evolution (GEE), shaping bipolar nebulae, and compressing equatorial rings.

The problematically short superwind of OH/IR stars

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OH/IR stars are believed to be the final stage on the asymptotic giant branch (AGB) of intermediate main-sequence mass (5-8 solar masses) stars before they evolve into the post-AGB and planetary-nebula stages. AGB stars lose most of their stellar envelope in the form of a gaseous and dusty stellar wind. This wind eventually grows to such high mass-loss rates that the central star becomes entirely enshrouded by a dense, dusty superwind. Before reaching such high mass-loss rates, these stars go through a phase of a lower mass-loss rate of at most a few times 10^-6 solar masses per year. Evolutionary models suggest that this phase does not last much longer than 10^5 years, implying that these stars are not likely to have lost more than one solar mass before entering the high mass-loss phase. To evolve into a post-AGB star, with a white dwarf cooling at the center, OH/IR stars must lose more than ~3 solar masses during the superwind. At a rate on the order of 10^-4 solar masses per year, this phase must last at least 10^4 years. This contrasts heavily with recent the findings that OH/IR superwinds seem to have started at most 10^3 years ago. This was shown by two entirely independent approaches: one based on low-excitation CO emission and one based on the 69-micron emission band caused by crystalline forsterite. Interestingly, a few post-AGB objects have been shown to be enshrouded by a circumstellar envelope that appears to be of extremely high density, much higher than what is currently believed to be the highest possible mass-loss rate on the AGB. Is then the OH/IR superwind not the final stage on the AGB? Do these stars evolve into objects with even higher mass-loss rates than is common for a superwind? Should we be looking for hyperwinds? An open-ended discussion.

Mass loss of red supergiants: a key ingredient for the final evolution of massive stars

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During the past decade, an increasing number of observations have shown that, at least at some points, the mass-loss rate of red supergiants (RSG) could be significantly higher than the standard one, usually used in stellar evolution code.
In this talk, I will show how an increased mass-loss rate during the RSG stage, in addition with rotation, affects the later evolution of the star. Particularly, I will discuss how it could solve the so-called "red supergiant problem", and impact the population of Wolf-Rayet stars. Accounting for an increased mass-loss rate has also large impacts on the end-points of stellar evolution, and allows to explain the unexpected position in the HRD of type IIn or IIb supernovae progenitors.

Probing mass loss at the end stages of massive star evolution

Groh Jose [1]

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Mass loss has a profound impact on the evolution and fate of massive stars. Recent observational evidence has shown that massive stars may lose significant amounts of mass at their late stages. In this talk, I will discuss observations and radiative transfer modeling of supernovae observed early enough that dense regions of the progenitor wind can still be detected. I will focus on the progenitors of SN 2013cu and 1998S, which we propose to arise from the explosion of unstable luminous blue variables, yellow hypergiants, or red supergiants undergoing extreme mass loss events. I will show how the mass loss, wind velocity, and chemistry of stars at their end stages can be directly constrained using the radiative transfer code CMFGEN to model early-supernova spectra, with similar accuracy as for hot stars.

The nature and origin of the central constant emission component of Eta Carinae

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The wind-wind colliding (WWC) binary system, Eta Carinae, experienced periastron passages in 2003.5, 2009 and 2014.5. We performed campaign observations of the star using all available X-ray observatories around these timings to observe the WWC X-ray variation. The WWC X-ray emission varied strongly in every cycle, while a non-variable X-ray component appeared when the WWC plasma was heavily obscured by the thick primary wind. This component, dubbed the central constant emission (CCE) component, is confined within ~500 AU (~0.2») in projected radius. The X-ray spectrum extends up to ~20 keV, suggesting hot plasma with the temperature of >~4-5 keV. The absorption column derived from the soft-band cut-off, ~3-5e22 cm-2 is as low as those to the WWC X-rays around apastron. These results suggest that the CCE plasma fills the foreground cavity carved by the secondary stellar wind ejected in prior orbital cycles. Interestingly, the plasma emission measure did not apparently change between the cycles, while the absorption column significantly decreased from 2003 to 2009. This decrease may be related to the change of the stellar mass loss that is claimed to explain the spectral variation seen around 2009. We will present the detailed X-ray emission line analysis and discuss the condition of the CCE plasma cavity.

Colliding Winds among Massive Stars

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Massive stars distinguish themselves by their high luminosities and thus capacity to drive strong winds that are also fast when the stars are hot. We also know now that binaries among massive stars are the norm rather than the exception. It is thus inevitable that the winds will collide in such systems, close and wide, producing energetic phenomena that can be studied across the electromagnetic spectrum. In some cases, e.g. when the primary star has reached the enhanced-wind WR phase as a carbon-rich WC star, copious quantities of carbon-based dust are produced and ejected into the ISM.

CO mass-loss rate of red-supergiants at low metallicity

Matsuura Mikako [1]

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It is yet well understood how mass-loss rates from evolved stars depend on metallicities. With a half of the solar metallicity and the distance of only 50 kpc, the evolved stars of the Large Magellanic Cloud (LMC) are an ideal target for studying mass loss at low metallicity. We have obtained spectra of red-supergiants in the LMC, using the Hershel Space Observatory, detecting CO thermal lines fro J=6-5 up to 15-14 lines. Modelling CO lines with non-LTE Radiative transfer code suggests that CO lines intensities can be well explained with high gas-to-dust ratio, with no obvious reduction in mass-loss rate at the LMC. We conclude that the luminosities of the stars are dominant factors on mass-loss rates, rather than the metallicity.

GK Per, morpho-kinematical observations and modelling

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GK Persei (1901, the ?Firework Nebula') is an old but bright nova remnant that offers the chance to probe the physics and dynamics of nova shells. To gain an extra insight into the dynamics of this shell remnant, which has fragmented into a distinctive system of knots and tails, we have carried out a spatio-kinematic analysis of the knots and their proper motion.
New and archival longslit optical echelle spectra were analysed kinematically using the SHAPE software. New imaging from the Aristarchos telescope continues to track the proper motion, extinction and structural evolution of the knots, which have been observed intermittently over several decades.
These observational constraints allow for the generation of models for individual knots, interactions within knot complexes, and the jet feature. Put together, and taking into account dwarf-nova accelerated winds emanating from the central source, these data and models give a deeper insight into the structure and dynamics of the GK Per nova remnant as a whole. GK Per is then compared to AT Cnc and Z Cam.

3D Models of Stellar Wind Interactions

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Symbiotic binaries consist of a cool, evolved mass-losing giant and an accreting compact companion. As symbiotic nebulae show similar morphologies to those in planetary nebulae (so much so that it is often difficult to distinguish between the two), they are ideal laboratories for understanding the role a binary companion plays in shaping the circumstellar envelopes in these evolved systems. We will present 3D Smoothed Particle Hydrodynamics (SPH) models of interacting binaries, e.g. R Aquarii and Mira, and discuss the formation of spiral outflows, arcs, shells and equatorial density enhancements.We will also discuss the implications of the former for planetary nebulae, e.g. the Egg Nebula and Cat's Eye, and the latter for the formation of bipolar geometries, e.g. M2-9. We also investigate accretion and angular momentum evolution in symbiotic binaries which may be important to understand the formation of jets and more episodic mass-loss features we see in circumstellar envelopes and the orbital characteristics of binary central stars of planetary nebulae.

The first water fountain in a planetary nebula with synchrotron emission

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We present the first planetary nebula were synchrotron emission has been detected. The spectral index of this radio continuum emission has changed in only two years due to processes related to the onset of photoionization. This puzzling object also shows high velocity water masers that are detected for the first time in a star at this evolutionary phase.

Hydrogen lines in Mira stars through interferometry and polarimetry

Fabas Nicolas [1]

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Balmer lines in emission are most prominent features in Mira stars spectra and have a strong potential as a proxy to study the lower atmosphere's dynamics. During my thesis, I accumulated spectropolarimetric observations of Balmer lines in emissions. As the shock is propagating outwards, linear polarization increases and evolves. Assuming that linear polarization arises from anisotropic scattering, it tells us something about the geometric structure of the shock as it propagates. Such a line of study is typically one to be undertook by interferometry. In 2012, Amber data on the Mira stars omicron Ceti and R Horologii have been collected, in which the Brackett ? is studied.
In general, the polarimetric and interferometric approaches are thought to be very complementary for this kind of studies. Spectropolarimetric observations are more convenient to perform but for the models we have to deal with complex radiative transfer theory. On the other hand, interferometry is not as easy to perform but we can resort to simple models to fit visibilities and phase closures. Olivier Chesneau was in the jury of my PhD thesis and he was seduced by the idea to study these shock waves with interferometry and use polarimetry as a complementary study.

Session 3: Binaries

New insights from close binary central stars of planetary nebulae

Miszalski Brent [1]

1 : SAAO/SALT

Planetary Nebulae (PNe) appear in an extremely wide variety of shapes, but exactly how they are shaped into such a diverse range of morphologies is still highly uncertain despite over thirty years of vigorous debate. Binaries have long been thought to offer a solution to this vexing problem. Now, thanks to recent surveys and improved observing strategies, it is clear that a binary channel, in particular common-envelope (CE) evolution, is responsible for a large fraction of planetary nebulae. I will review the main observational results achieved so far including morphological traits of post-CE nebulae, accretion and jet formation, and the significance of close binaries with Wolf-Rayet (WR) components. I will also report on the discovery of only the second WR close binary central star in a spectacular southern PN that will help drive the discovery of more of these rare binaries. This new discovery is the result of an ambitious project started in 2012 for which we were grateful to have had Olivier Chesneau's enthusiastic encouragement during his 2013 visit to Cape Town.

Using VLTI for measuring accurate nova distances

Ribeiro Valério A. R. M. [1]

1 : Radboud University

[ABRIDGED] Measuring accurate distance to a nova eruption is made difficult because we often have to wait months, if not years, to be able measure these. However, we really require to measure these distances accurately and early on. I will discuss some techniques being developed to apply to VLTI observations.

Planetary nebulae: What can they tell us about binary evolution?

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It is now clear that a binary pathway is responsible for a significant fraction of planetary nebulae, and this increased sample of known binaries means that we are now in a position to begin to constrain their influence on the formation and evolution of their host nebulae. I will review the properties of the currently known sample of binary central stars and of their host nebulae, focussing on some of the most important cases and what they tell us about binary evolution and the common envelope phase in particular, as well as trying to analyse the prospects using the growing sample to draw statistical conslusions.

Evolved stars as donors in symbiotic binaries

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Symbiotic stars are the widest interacting binaries, whose orbital periods run from hundreds of days to hundreds of years. They consist of an evolved cool giant as the donor star and a white dwarf accreting from the giant's wind. In my contribution I will briefly introduce: (i) The way to estimate the mas-loss rate from the giant using the nebular emission extracted from the model SED, (ii) the long-standing problem between the high luminosity of the burning white dwarf and its deficient fueling by the giant in the canonical Bondi-Hoyle accretion mechanism, and (iii) its possible solution by focusing the giant wind towards the orbital plane due to its slow rotation.

Symbiotic stars in the Local Group of Galaxies

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Highlights of the ongoing search for symbiotic binary stars in the Local Group of Galaxies will be presented and discussed.

6 years of high-resolution spectroscopic monitoring of evolved binaries with HERMES: lessons learned.

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With our high-resolution spectrograph HERMES mounted on the 1.2m Mercator telescope we initiated a monitoring programme with the aim to characterise and study binary evolutionary channels. We specifically focused on proven or suspected wide binaries with evolved components. The ultimate goal of this long program is to connect the zoo of different objects, into a sound evolutionary picture which accounts for the chemical peculiarities and the dynamical constraints set by the orbital distribution and binarity rates. In this contribution I summarise the main results and conclusions to be drawn after 6 years of monitoring and focus on post-AGB stars with discs, and expanding sheels, binary Planetary Nebulae, but also on sdB binaries and the evolutionary connection between these samples.

note for the SOC: from my institute and research group also young post-docs (Michel Hillen and Devika Kamath) submitted an abstract. Personally i would very much prefer they are allowed to give an oral contribution. If the programme becomes too dense, I will happely step back and change this request for an oral contribution into a request for a poster.

Newly discovered, dusty, evolved, low-luminosity post-RGB stars in the Magellanic Clouds.

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In our recent studies, we carried out an extensive search for post-asymptotic giant branch (post-AGB) candidates in the Magellanic Clouds. The known distances to the Magellanic clouds enabled luminosity estimations for all the objects which led to one of the most important results of this survey: the serendipitous discovery of a group of 139 and 41 «post-RGB» stars in the LMC and SMC. These are low-luminosity, evolved, dusty objects and have similar mid-IR excesses and stellar parameters as post-AGB stars (late-G to late-A spectral types, low log g values, and low metallicities with [Fe/H]~1.0). However, their luminosities are much lower (200 - 2200L) than that expected for post-AGB stars. It is likely that these objects are the result of a mass-loss that occurs via binary interaction on the RGB. In this talk, I will characterize these newly discovered objects. I will also present our findings on this unexplored phase in binary evolution via evolutionary connections between the possible precursors (Sequence-E variables) and successors (systems with white dwarf (WD) components like sub-dwarf B stars or He-WDs).

Observations of Novae in the Infrared in the SOFIA Era

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ABSTRACT
Classical novae may contribute to some of the isotopic anomalies that are present in the remnants of the primitive solar system. We describe the way infrared (IR) photometric and spectroscopic observations can quantify the physical parameters of nova explosions and their contributions to the Inter-Stellar Medium (ISM). Metal abundances in the ejecta can be deduced from both IR dust emission features and forbidden line emission. We show that some novae have produced ejecta extremely overabundant in CNO, Ne, Mg, Al, and Si. The properties of nova dust are compared to those of grains in pre-planetary nebulae and comet nuclei. We describe space observations of novae from theSpitzerSpace Telescope and anticipate the impact that the new NASA Stratospheric Observatory for Infrared Astronomy (SOFIA) will have on future infrared studies of novae.

Yet another spectro-interferometric study of the gas distribution in the enigmatic semi-detached binary beta Lyrae

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The mass transfer phase is an inevitable fate of the majority of close binaries. This process, which completely alters the shape, evolution of the binary components and reverses its mass ratio, is very fast and leaves the sky full of binaries, which slowly relax back to the detached state with a handful of binaries, which are undergoing the phase of the violent rapid and non-conservative mass transfer. Luckily the bright Be star beta Lyrae is in this rare evolutionary phase. The star has been a subject to many studies, which used various direct and/or indirect methods to investigate the gas distribution in the system and inferred that there is a mass stream, which emanates from the tip of the Roche-lobe filling donor star, and is attracted to the gainer until it hits the accretion disk, which fill the most of the Roche-lobe of the gainer. At the impact site the material may be heated and form a hotspot. The stream-disk interaction also lead to formation of jets, which expel material from the binary and form a circumbinary cloud. A definitive picture of the features of the circumstellar has not been established yet. Our ultimate goal is to obtain a picture of the gas distribution in the system, prove or disprove existence of structures listed in the previous sentence. To do so, series of long baseline spectro-interferometric observations were acquired with the CHARA/VEGA instrument. During nine observational nights all orbital phases were covered with observations in four different pass-bands in the visible. These observations are supported with a three-years long series of newly acquired spectroscopic and photometric observations. In this contribution we compare the spectro-interferometric observations with our early models and discuss their implications for further investigation of the system.

Mass Flows in Massive Binaries and their Evolutionary Implications

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Recent results from population studies indicate that most massive stars occur in binary systems; at least 75% will be aected by a companion during the course of their evolution. Given these statistics, we cannot afford to neglect binaries when discussing how massive stars give rise to supernovae and gamma-ray bursts. I will discuss how linear polarization in the emission lines of close binary systems allows us to probe the structures of these systems' winds and mass flows. Tracking line polarization over the course of a binary's cycle reveals the location and extent of line-scattering regions in the system. This makes it possible to map the complex morphologies of the winds, shocks, streams, and other mass loss and mass transfer structures that shape its subsequent evolution.
In Wolf-Rayet binaries in particular, observing line polarization variations with orbital phase also enables us to distinguish polarimetric signatures arising in the interaction zone between and near the stars from those produced far away from the orbital plane. The constant polarization in the far-scattering lines traces the degree of asphericity of the WR wind. Thus, these lines may form the basis for a "binary line-effect method" to detect rapidly rotating WR stars (and hence GRB progenitor candidates) in binary systems. I will demonstrate both these techniques using observations obtained with the University of Wisconsin's HPOL spectropolarimeter, now operating at the University of Toledo's Ritter Observatory.

FS CMa type binaries

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FS CMa type stars comprise a group of nearly 70 objects with the B[e] phenomenon formerly known as unclassified B[e] stars. They exhibit very strong emission-line spectra that are typically over an order of magnitude stronger than those of Be stars. This property in combination with their nearly main-sequence luminosity suggests a binary nature for them. They possess strong IR excesses due to radiation of circumstellar dust that implies a compact distribution probably in a circumbinary disk. Our long-term spectroscopic monitoring program revealed neutral metal lines in the spectra of a dozen of FS CMa objects indicating the presence of a cool star. This set of lines always includes the Li I 6708 A line whose origin in the spectra of evolved stars is still under debate. We present a summary of our results with a first overview of FS CMa type binaries, including determination of the first spectroscopic orbit, and review possible implications for the nature and evolutionary status of the entire group.

Session 4: Discs

The nearby AGB star L2 Pup: the birth of a bipolar planetary nebula ?

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We just discovered using NACO that the nearest AGB star, L2 Pup, is surrounded by a spatially resolved dust disk seen almost edge-on (Kervella et al. 2014, A&A, 564, A88). We also detected the thermal emission from an enigmatic dust "loop" extending to more than 10 AU from the star. As the light scattering is inefficient at IR wavelengths, we observe essentially the thermal emission from the central part. L2 Pup is currently a relatively "young" AGB star, so we may witness the beginning of the planetary nebula formation process. Our first hypothesis is that this dust disk is a key element in the future formation of a bipolar nebula. Other open questions are related to the origin of the disk, and its actual geometry (is it really a disk ?). The physical process that breaks the (probably) spherical symmetry of mass loss from the AGB star is currently uncertain. Although the presence of a companion star is a plausible explanation for the formation of the loop and disk, we did not detect it yet. We will present the current status of our ongoing research program on L2 Pup.

The surfaces of evolved stars and the importance of molecular layers

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Red supergiants are cool evolved massive stars before their transition toward Wolf-Rayet stars and core-collapse supernovae.They represent a similar phase in stellar evolution as asymptotic giant branch stars for low-mass stars. The role and importance of atmospheric molecular layers of both types of stars was only recently realized and is still not fully understood. This concerns the determination of fundamental parameters, the processes that levitate the gas, the mass-loss process, and the appearance of observed surface images. I will present latest VLTI results on the atmospheric molecular layers including recent image reconstructions obtained with the VLTI/PIONIER instrumnent. I will also provide a detailed outlook on the path of this research with the 2nd generation VLTI instruments and beyond.

Mass-loss and luminosities of AGB stars in the Magellanic Clouds

Groenewegen Martin [1]

1 : Koninklijke Sterrenwacht van Belgie (KSB)

An N-band interferometric survey of the disks around post-AGB binary stars.

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For Galactic post-AGB stars it is by now well established that their presence in a binary system (with Porb > 100 and

Modeling eccentric long period hot subdwarf binaries with circumbinary disks.

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Hot subdwarf-B (sdB) stars are core helium burning stars with a very thin hydrogen envelope (Menv Most currently known long period sdB binaries have eccentric orbits, even though binary evolution theory predicts them to be circularized before the onset of Roche-Lobe overflow (RLOF). We have tested several mechanisms to increase or re-introduce eccentricity in the orbit of long period binaries. The tidally enhanced wind mass loss scenario used to explain the eccentric orbit of IP Eri (Siess et al. 2014) does not work for sdB binaries. A combination of eccentricity pumping during RLOF due to phase dependent mass loss, and the interaction of the binary with a circumbinary disk formed during RLOF can explain the observed eccentricities of the long period sdB binaries.
We have extended the evolution code MESA with the missing processes for eccentric orbital evolution, and implemented the model of Lubow & Artymowicz (1996) for the interaction between the binary and a circumbinary disk. By tweaking the parameters of this model, the observed orbital parameters can be explained, even though the exact period-eccentricity distribution of long period sdB binaries cannot be recreated.

Unraveling disks around AGB stars

Lykou Foteini [1*]

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It is commonly accepted that asymmetries found in the post-AGB stars and planetary nebulae should originate as early as during the AGB phase. I will present results of our high-angular resolution observing programs with the VLT of a sample of AGB stars that were known to present asymmetries at larger spatial scales (e.g. jets or torii). Disk-like structures within less than 20 stellar radii have been found in at least two of these stars with the use of aperture masking, while VLTI data indicate much more complex circumstellar environments. I will argue on the importance of these characteristics as indicators of binarity and explain how studying such objects, which are probably in transition to the post-AGB phase, can shed more light in ejecta shaping agents.

Session 5: Circumstellar environments

The circumstellar dust shells of Sakurai's Object and other "Born-Again" stars

Evans Nye [1], Gehrz Robert, Helton L., Woodward Chick

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We will describe the evolution of the carbon dust shells around Very Late Thermal Pulse (VLTP) objects, as seen at infrared wavelengths. This will include a 20-year overview of the evolution of the dust around Sakurai's object, to which Olivier made a seminal contribution. VLTPs may occur during the endpoint of as many as 25% of solar mass stars, and may therefore provide a glimpse of the likely fate of the Sun.

The convection of close red supergiants stars observed with near-infrared interferometry

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Massive evolved stars are important contributors to the chemical evolution of the Galaxy. During their red supergiant stage they experience heavy mass loss. Yet, the processes triggering this outflow and allowing the condensation of dust remain poorly understood. Our team has been leading an innovative observation program of the two closest red supergiant stars Betelgeuse (alpha Ori) and Antares (alpha Sco), ranging from the photosphere to the interface with the interstellar medium using high angular resolution facilities and various spectral windows.
I will review our recent results in the observation of these two stars with infrared interferometry. We have been monitoring the photosphere of Betelgeuse with the VLTI/PIONIER instrument for four epochs. Thanks to the extended configuration of the auxiliary telescopes of the VLTI, we got an unprecedented sampling of the visibility function Antares. These data allow us to get a new insight of the convective photosphere of massive evolved stars.

Eta Carinae and the pre-supernova circumstellar material around massive stars

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Eta Carinae is a unique object that has been influential in understanding the fates of very massive stars in general, dust formation in stellar ejecta, aspherical geometry in circumstellar material, and pre-supernova eruptive mass loss. Angular resolution has been critical in understanding this object. Given Olivier's interest in eta Carinae and emphasis on high angular resolution, we briefly review the history of increasing angular resolution at optical/IR wavelengths through the 70s and 80s, with HST, and with modern interferometry. We will discuss how the shape, structure, composition, and mass of the Homunculus nebula around eta Carinae have been transformational in understanding the late evolution of massive stars and in understanding some of the most luminous supernovae in the universe that occur when fast supernova ejecta collide with circumstellar material. There is also a great amount of synergy with the nebulae around lower-mass analogs, like the symbiotic bipolar planetary nebulae that Olivier studied. Finally, we will discuss how our views of eta Carinae's eruption and LBVs in general have undergone a revolution in understanding in recent years; this has been due in part to advances in angular resolution, but also to comparisons with extragalactic LBV eruptions and supernovae.

From nuclei to dust grains: How the AGB machinery works

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With their circumstellar envelopes AGB stars are marvelous laboratories to test our knowledge of microphysics (opacities, equation of state), macrophysics (convection, rotation, stellar pulsations, magnetic fields) and nucleosynthesis (nuclear burnings, slow neutron capture processes, molecules and dust formation). Unfortunately, due to the completely different environments those processes occur, the interplay between stellar interiors (dominated by mixing events like convection and dredge-up episodes) and stellar winds (characterized by dust formation and wind acceleration) is often ignored.
We intend to develop a new approach involving a transition region, taking into consideration hydrodynamic processes which may drive AGB mass-loss.
Our aim is to describe the process triggering the mass-loss in AGB stars with different masses, metallicities and chemical enrichments, possibly deriving a velocity field of the outflowing matter.
Moreover, we intend to construct an homogeneous theoretical database containing detailed abundances of atomic and molecular species produced by these objects. As a long term goal, we will derive dust production rates for silicates, alumina and silicon carbides, in order to explain laboratory measurements of isotopic ratios in AGB dust grains.

Session 6: Modeling, Evolution

Asteroseismology of B-type dwarfs and supergiants

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B-type main sequence and post main sequence stars exhibit a collection of pressure mode and gravity mode oscillations. Such modes are sensitive to the internal structure of the star, and are promissing means to probe the physics of stellar interior, through matching of the observed frequencies with theoretical predictions.
With such an approach, for B stars, we are able to independently infer stellar mass, metallicity, the width of the overshooting zone on top of the convective core, and the extra mixing in radiative layers. In this presentation, we demonstrate the success of asteroseismic modeling in constraining the above parameters for a Kepler target KIC 10526294 and the CoRoT target HD 50230. Both these stars are slow rotators, and allow ignoring the effects of rotation on the equilibrium structure and oscillation frequencies.
We also address the excitation mechanism(s) and physical processed - in play on the post main sequence phase - that can be inferred from asteroseismology of blue supergiant stars, such as Rigel (beta Ori).

The temperature and chronology of heavy-element nucleosynthesis in low-mass stars

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Asymptotic giant branch (AGB) stars are essential contributors to the heavy-element enrichment of the interstellar medium, because they are responsible for the production of roughly half of the elements heavier than iron and because they eject their envelope through strong stellar winds at the end of their lives.
Extrinsic AGB stars are binaries, they are not located on the AGB but bear the unaltered signature of an ancient AGB nucleosynthesis that once took place in their companion star. Detailed abundance determinations in both AGB and extrinsic AGB stars allow to put strong new constrains on the s-process nucleosynthesis taking place in evolved stars.
The s-process builds up heavier elements that are subsequently brought to the stellar surface by convection. Two neutron sources, activated at distinct temperatures, have been proposed: 13C and 22Ne. To explain the measured stellar abundances, stellar evolution models invoking the 13C neutron source (which operates at temperatures of about one hundred million kelvin) are favoured. Isotopic ratios in primitive meteorites, however, reflecting nucleosynthesis in the previous generations of stars that contributed material to the Solar System, point to higher temperatures (more than three hundred million kelvin), requiring at least a late activation of 22Ne. Here we report a determination of the s-process temperature directly in evolved low-mass giant stars, using zirconium and niobium abundances, independently of stellar evolution models. The derived temperature supports 13C as the s-process neutron source. The radioactive pair 93Zr?93Nb used to estimate the s-process temperature also provides, together with the pair 99Tc?99Ru, chronometric information on the time elapsed since the start of the s-process, which we determine to be one million to three million years (Nature 517,174?176,08 January 2015).

Synthesis of Complex Organics in the Late Stages of Stellar Evolution

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Observations of evolved stars have revealed a rapid and continuous synthesis of organic materials from the end of the asymptotic giant branch (AGB), to proto-planetary nebulae, to planetary nebulae. These synthesized products are ejected into the interstellar medium through stellar winds and as a result enriching the Galaxy with complex organics. Over 70 gas-phase molecules, including rings, radicals, and molecular ions, as well as fullerene (C60) have been identified by millimeter-wave and infrared spectroscopic observations through their rotational and vibrational transitions. Possible chemical pathways leading to the formation of complex organics will be discussed.
Analysis of the infrared spectra suggests that the chemical structure of the carrier is consistent with that of mixed aromatic and aliphatic nanoparticles (MAON). These structures are very similar to those of the insoluble organic matter found in meteorites, suggesting that the early solar system may have been enriched by stellar ejecta.

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The massive stars nursery R136

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As most stars are born in a clustered mode, young massive star clusters are the best places to find and study the formation and evolution of massive stars. R136 is one of the most massive nearby clusters in the LMC, which contains at least untill now 72 known O and Wolf-Rayet stars. These young objects are usually embedded in dust and gas so that correcting the local extinction plays an important role for estimating the mass of stars. The extinction is derived for 26 O-stars in different HST filters using TLUSTY[3] atmosphere model for O-stars. Then we derived the mass and hence the Mass Function (MF) by multi-colour photometry from HST data.
We also simulated series of R136-like clusters using the Nbody6 code to test the segregation scenario for R136. thus we checked if massive stars tend to be formed locally at the center of a cloud or homogeniously. By comparing the surface brightness profiles (SBP) of simulated clusters mimicking R136's SBP from HST data, we could determin which scenario is simulated the best R136.
the results of these studies bring a new homogenious insight to the understanding of R136 and similar clusters in the light of future VLT and E-ELT high dynamic imaging observations at the diffraction limit in visible and IR wavelengths.

Pathways for observing stellar surfaces using 3D hydrodynamical simulations of evolved stars

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Nowadays, the development of the observational instruments is so high that became very sensitive to the details of stellar surface. The interpretation of the stellar surfaces images, the fundamental parameters, the stellar variability needs realist simulations of stellar convection. Three--dimensional radiative hydrodynamics simulations of evolved stars are essential to a proper and quantitative analysis of these observations. I will present how these simulations have been (and will be) crucial to prepare and interpret the spectrophotometric, interferometric, astrometric, and imaging observations of these stars that strongly enrich the chemestry and the dust of Galaxies.

Double chemistry in Planetary Nebulae

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During the last decades, Polycyclic aromatic hydrocarbons (PAHs) and oxygen-rich material have been observed in the circumstellar environments of planetary nebulae (PNe). This combination of oxygen-rich and carbon-rich material is not expected to be seen around such objects. In the last three decades, two models have been proposed to explain this dual chemistry: one postulates that a recent dredge- up of carbon produced by nucleosynthesis inside the star during the Asymptotic Giant Branch changed the surface chemistry of the star. The other model postulates oxygen-rich material in a stable keplerian rotation around the central star. Occurrence of the latter model has already been observationally confirmed and we will present here the possible first observation of the dredge-up scenario. SOFIA observations of a double chemistry planetary nebula indicate that a thermal pulse occured ~1000 years ago, changing the composition of the nebula from oxygen-rich to carbon-rich. Both these scenarios work only if the star is currently carbon-rich. This is not the case for recently discovered dual chemistry PNe in the Bulge. We will show here that for those objects, the double chemistry is due to photodissociation of CO in a dense torus surrounding probable binary systems.

Posters P2: Winds, Mass loss, Jets

Numerical Simulations of Giant Eruptions from Massive Stars and their Recoveries

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We use a 3D hydro code to model the response of a massive star to a high mass loss episode. Starting with a modified version of the 1D stellar evolution code MESA, we obtain a model of an evolved massive star, with properties similar to those of Eta Carinae, known for its giant eruption in the 19th century. We simulate a giant eruption using two approaches:
1.Removing a layer from the star using energy from inner layers.
2.Extracting energy from inner layers to outer layers that spontaneously causes mass loss (« energy shift»). We map the 1D model to a 3D grid and follow the evolution of the star using the FLASH code. Our hydrodynamic simulation includes radiation transfer with OPAL opacities and convection. We find that the star develops a strong wind and mass loss, accompanied by radial pulsation in the inner parts of the star. We notice two phases: a strong eruptive mass loss phase that lasts for a few years, followed by centuries of continually weakening mass loss. The first approach simulation has a lower mass loss rate at the second phase in comparison to the second approach. Using the second approach, the amount of mass lost is consistent with the amount of energy that was extracted from inner layers to unbind that amount of mass ? almost all the energy flows outwards and does not return to the inner layers of the star.

Raman-scattered HeII 6545 A line in the symbiotic binary V1016 Cyg as a diagnostic tool of the wind from its mira-type donor

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V1016 Cyg is a dusty symbiotic binary comprising an evolved cool giant of a Mira-type variable and a white dwarf. The white dwarf increases its temperature and luminosity by accreting from the wind of the giant, and subsequently ionizes a part of the surrounding environment consisting mainly of the giant's wind. In our spectra from April 2006 and July 2007 we investigated a weak emission feature at 6545 A, which is a result of Raman scattering of the HeII 1025 A line photons, emitted in the ionized region around the white dwarf, on the neutral hydrogen atoms located around the giant. From the scattering efficiency, assuming a simplified ionization model of symbiotic stars, we determined the mass-loss rate from the evolved cool giant in V1016 Cyg to ~1.2E-6 and ~1.6E-6 solar masses per year.

NGC147 and NGC185: Star Formation History and Feedback from Dusty Stellar Wind

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Understanding evolution of galaxies gives an insight into the evolution of Universe. Galaxies evolution depends on the characteristics of interstellar medium (ISM), star formation rate and chemical enrichment of ISM which occurs at the end point of stellar evolution by dust production. Therefore to understand evolution of two low metallicity dwarf galaxies, NGC147 and NGC185, which are paired and satellites of Andromeda galaxy, we present the first reconstruction of the star formation history and dust production of these two galaxies using Asymptotic Giant Branch (AGB) stars especially the ones with long period variability.
We found that 57% of NGC147 total mass, 1.2 × 108 M? , formed in its peak of star forming epoch. NGC185 shows a peak of star formation with interchanging 45% of its total mass, 2.1 × 108 M? , to stars. The SFR dramatically decrease to a nearly constant amount after this epoch. Davidge (2005) reported the total mass of NGC185 around 2 × 108 M?.
We have also estimated the amount of mass shed into ISM. This amount is 2.9 × 10-4 M?yr-1 for NGC185 and 1.1 × 10-4 M?yr-1 for NGC147. Welch et. al.(1996) state that the mass of dust shed into ISM of NGC185 is 7.8 × 10-4 M?yr-1.

Prominent polarization in SiII lines during the pre-maximum phase of Nova Del 2013 (V339 Delphini)

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2 : Photocoding

We carried out spectral-polarimetries of Nova Del (V339 Del) in the early phase, using a high resolution spectro-polarimeter, VESPolA mounted on the 1.3 m Araki-telescope at the Koyama Astronomical Observatory, Japan. We detected the intrinsic polarizations with time variation both in the continuum and the SiII??6347, 6371 lines. This strange result can be interpreted as a patched or biasedly distribution of the SiII region on the asymmetric pseudo-photosphere in the pre-maximum phase. This should be deeply related to an asymmetric distribution of accrete matters and/or a localization of the TNR ignition in the WD atmosphere.

Short time variations of polarization line profiles in P Cygni

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We present high-resolution linear polarization spectra of P Cygni during about three months, using a high resolution spectro-polarimeter, VESPolA mounted on the 1.3 ?m Araki-telescope at the Koyama Astronomical Observatory, Japan. We detected temporal variations of polarization profiles in emission lines including H? and HeI?667.6 in a few days. It would originate from locally high density region such as a blob in the stellar wind, intermittently erupted from the photosphere. We discuss possible structures of the stellar wind of LBVs reproducing obtained polarization spectra.

Molecular Formation in Classical Novae: The Case of V2676 Oph

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Many classical novae are well known to be sources of dust grains in the Galaxy. Those dust grains are considered to form in the nova outflow followed by the molecular formation since the large molecules can act as nuclei at the dust formation. However, the molecular formation in the nova outflow is not well understood because of lack of observations.
The slow nova V2676 Oph was unique in that both C_2 and CN molecules were observed in optical wavelength region during its early phase around the visual brightness maximum (Nagashima et al. 2014, in ApJ Letters, 780, L26). Especially, C_2 has not been detected prior to the detection in V2676 Oph. The first detection of C_2 in novae was essentially important to understanding the formation of carbon-rich dust grains in novae. In the same nova, CO was also detected in the near-infrared wavelength region and the dust formation was confirmed in its later phase. Here we discuss about the molecular forming process in V2676 Oph based on our spectroscopic monitoring observations around its visual brightness maximum. We also report the mid-infrared spectroscopic observations of V2676 Oph after the dust formation of this nova.

Imaging and Spectroscopy of the Massive Binaries MWC 314 and HD 168625

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First results of an ESO imaging survey of LBVs and candidate LBVs (cLBV) reveal that the spectroscopic binary MWC 314 is possibly a triple hierarchical system. Near-IR NACO images in the K and Lp bands show a third star at 1.18" we calculate is bound in a wide orbit around the central massive binary (P=60.8 d, e=0.23). In HD 168625 we observe a companion star at 1.15" with small proper motion and low projected velocity indicating it is also bound in a wide orbit. MWC 314 is the second LBV binary known in the Galaxy and the third known after Eta Car and HD 5890. It shows a large bipolar Halpha nebula. We observe Discrete Absorption Components (DACs) in P Cyg-type He I lines during an orbital eclipse phase of 6 May 2014 due to warm structured wind variability at outflow velocities of 100 km/s to 600 km/s. The DACs are however absent around the quadrature phase (25 Oct 2014). We present a theoretical model of the prominently double-peaked Fe II ?6432 permitted emission line formed in the circumbinary disc around MWC 314. We find best fits to the high-resolution Fe II emission profile using a Keplerian disc model observed at an inclination angle of i > 60 deg, with a maximum emission line formation radius in the disc of 26 AU from the binary center of gravity.

HD 168625 is an important cLBV showing complex ring-like inner and outer nebular structures of which the formation remains unclear. High-resolution spectra we observed since 1997 show no indications of a central spectroscopic binary. The Vrad-values of selected absorption lines are invariable within 1-2 km/s. VLT-UVES slit spectra of the prominent [N II] ?6584 emission line observed off the cLBV star however reveal a centroid shift in Vrad of ~15 km/s signaling considerable differences of kinematic expansion velocity ~6" N-S across its inner loop-like nebular structure.

Mass loss rate of AGB stars

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The mass loss rates of AGB stars derived by the infrared colors and empirical formula are compared for each object.
The infrared observations for AGB stars from both ground based and space borne observatories are selected in the DB
The empirical formula of the mass loss rate are presented as a function of stellar luminosity and effective temperature.
The scatters in the relations between mass loss rate and other parameter are supposed to be the variability of AGB stars such as long term period in the Mira variable.
The periodically changing mass loss rate is may be due to the oscillation between the states of stars during their AGB evolution.

Study on dust formation in V1280Sco based on multi-epoch Infrared Observations

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We present the results of the late time infrared multi-epoch observations of dust forming nova V1280Sco with Cooled Mid-Infrared Camera and Spectrometer (COMICS) on the Subaru telescope, Thermal-Region Camera Spectrograph (T-ReCS) on the Gemini South telescope and the Infrared Camera (IRC) onboard the AKARI satellite, etc. The results of our analyses have shown that the infrared SED evolution of V1280Sco among 1272, 1616, and 1947 days from the outburst is well reproduced by both emissions from the amorphous carbon dust and the silicate dust that travel away from the white dwarf without any significant mass evolution. Although the values might be dependent on the geometry that is assumed, our SED analyses have shown that the amorphous carbon dust has a typical size of 0.1um rather than 0.01um and the mass of 4--6x10^{-8} solar mass while that the silicate dust has a typical size of >0.1um and the mass of 4.0x10^{-7} solar mass. The dust formation scenario around V1280Sco suggested from our analyses is that the amorphous carbon dust is formed in the nova ejecta followed by the silicate dust formation. The origin of both C-rich and O-rich dust is discussed in this presentation.

Unravelling the dust formation process in oxygen-rich AGB stars

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It is generally accepted that the mass-loss mechanism in AGB stars is based on pulsations and radiation pressure on newly formed dust grains. However, oxygen-rich AGB stars suffer from the so called 'acceleration deficit' dilemma: only oxides and pure Fe-free silicates do not sublimate close to the wind, i.e. species for which the radiation pressure is negligible. In addition, we still do not know which gas-phase species will be the first to nucleate and if the dust growth occurs in a homogeneous or heterogeneous way.
We aim to unravel the coupling between micro-scale chemical processes and macro-scale dynamical processes in oxygen-rich AGB stars by combiningobservations(including ALMA and Herschel data) withradiative transfermodels to retrieve the gas and dust topology, and novelforward chemistrymodels to simulate the interactions in the wind. With this poster, we present the preliminary results obtained for R Dor, a low mass-loss oxygen-rich AGB star.

A CRIRES-POP atlas of the K giant 10 Leo

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The CRIRES-POP project will provide a public database of high resolution, high signal-to-noise near infrared spectra of stars spanning the HR diagram. A relevant part of this library for the evolved star community will be the high quality reference spectra of several cool evolved giants. These atlases will be valuable references for future research, and will include comprehensive line identifications, abundance measurements, and isotope ratios, alongside stellar parameters derived through the inclusion of other data sources. All CRIRES observations have been completed, and reduction and analysis of the spectra, including improved telluric subtraction and wavelength calibration, is ongoing. We present a project update and preliminary results of the first atlas to be produced, that of K1 III giant 10 Leo.

Simplified models of stellar wind anatomy to interpret high-resolution data: Analytical approach to embedded spiral geometries.

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Recent high-resolution observations have shown stellar winds to harbour complexities which strongly deviate from the classical spherical outflow, generally used as standard wind model. One such morphology is the archimedean spiral, generally believed to be formed by binary interactions, which by now has been directly observed multiple times. By means of an extended parameter study, we model rotational CO emission from the stellar wind. To this end, we develop a simplified analytical parametrised description of the 3D spiral structure (embedded in a spherical outflow), which is fed into the 3D radiative transfer code LIME. Generally, the rotational transitions of CO are very efficient at concealing the dual nature of the wind. However, if spatial information on the source is also available, the use of wide-slit PV diagrams systematically expose the embedded spiral.

High resolution spectra of a classical nova V2659 Cyg

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In high resolution spectra of classical novae during the early decline phase, not only P-Cygni profiles but also multiple blue-shifted absorption components with different velocities are often detected. These complex features are expected to be clues for understanding the structure of nova ejecta involving clumpy gas, shells or nova wind. However, the origin of these absorption lines is still unclear. We detected multiple blue-shifted absorption components in HDS/Subaru spectra of a jitter type nova V2659 Cyg (=Nova Cyg 2014) at 43 days after the discovery. At the Balmer, Fe II and Ca II lines, absorption lines are detected at -620 km and -1100 -- -1500 km/s. Components at -1100 km/s seem to be accompanied by P-Cygni profiles. Furthermore, we found absorption lines of heavy elements (Fe I, Ti II, Cr II, etc...) only at the components of -620 km/s. Observational characteristics of these absorption features are similar to THEA reported in Williams and Mason (2010). Here we report on the results of identifications of absorption lines of V2659 Cyg, and discuss the structure of nova ejecta of V2659 Cyg.

Properties of massive stars in five clusters of the VVV survey

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The evolution of massive stars is only partly understood. Observational constraints can be obtained from the study of massive
stars located in young massive clusters. The ESO Public Survey «VISTA Variables in the Via Lactea (VVV)» discovered several new clusters hosting massive stars.
We present an analysis of massive stars in five of these new clusters. Our aim is to provide constraints on stellar evolution and
to define evolutionary sequences from observational results.
Methods. We use the radiative transfer code CMFGEN to analysis K-band spectra of fifteen stars with spectral types ranging from O and B to WN and WC.
We derive the stellar parameters of all targets as well as surface abundances for a subset of them. We build the Hertzsprung-
Russell diagram and compare our results with theoretical predictions. For the cluster with the largest number of objects, we establish firmly that the WN and WC stars were initially more massive than the O stars still present in the cluster. We show quantitatively that the Wolf-Rayet stars are more chemically evolved. We establish a plausible sequence of evolution in this cluster:

Dusty Mass Loss from Low- to Intermediate Mass Stars seen by AKARI

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Low- to intermediate-mass stars lose a significant fraction of their mass while they are on the asymptotic giant branch (AGB). The material ejected from the stellar photosphere forms a circumstellar envelope in its surroundings and this mass loss is considered to determine the final stages of their evolution. By studying the layers of the circumstellar envelope we are actually studying the footprint of the mass-loss history.
AKARI - the first Japanese satellite dedicated to infrared astronomy - was launched in 2006, and continue its science operation until 2011. The main objective of AKARI was to perform an all-sky survey with better spatial resolution and wider wavelength coverage than IRAS, mapping the entire sky in six infrared bands from two focal plane instruments. Interspersed within this all-sky survey operation were slow-scan pointed observations for specific target sources.
The MLHES (excavating Mass Loss History in Extended dust shells of Evolved Stars) program was aimed at collecting the largest far-IR imaging data set for the analysis of circumstellar dust shells around evolved low- to intermediate-mass stars using one of the two focal plane instruments, the Far-Infrared Surveyor (FIS), which has four bands at 65, 90, 140, and 160 ?m. Far-IR radiation from the circumstellar dust shell is generally optically thin, and thus, the surface brightness distribution of the target circumstellar dust shells allows us to see the whole nebula volume along the line of sight. With the MLHES data, we can address some of the still open questions concerning the circumstellar dust shells of evolved stars, such as, what is the geometry of mass loss?, what is the time evolution of the mass-loss rate?, and how do the characteristics of the progenitor star affect mass loss?
The work presented here focuses on the characterization of the geometric properties of the circumstellar dust shells. This is achieved by subtracting an aligned, scaled template PSF image from the image of the circumstellar dust shell (which included emission from the central star). By subtracting the PSF, we are able to uncover the circumstellar dust distribution free from the presence of the still bright central star, which will allow better characterization of the mass-loss history. By assessing the mass-loss history for individual sources, we aim to establish general trends in the mass-loss history for AGB stars.

Luminous Blue Variables, Cool Hypergiants, and Supernova Impostors: The Role of Episodic Mass Loss

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The role of mass loss, especially episodic mass loss, in evolved massive stars is one of the outstanding questions in stellar evolution theory. IFU observations provide information on the recent mass-loss history and the evolutionary stages of the targets. We have observed with VLT MUSE a representative sample of massive stars from different evolved stellar classes that underwent episodic mass loss, which gave rise to extended nebulae. The simultaneous observation of all lines at each position in the nebulae provides very accurate line ratios for physical diagnostics and the structural inhomogeneities and associated velocity differences in the nebulae are tracers of the mass-loss history.

Posters P3: Binaries

WDs in binary systems that can lead to SNIa

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Focusing on nova binary systems, we explore the parameter space of white dwarf (WD) masses and rates of accretion, to determine the parameter combinations that result in retaining of a fraction of the accreted mass at the end of each cycle. Thus, the WD may secularly grow towards the Chandrasekhar limit and inevitably explode as a Type Ia Supernova. We discuss the various limits imposed on such a system, considering the secondary mass and evolution time scales. We also discuss observable features of the system, which can assist in identifying potential progenitors of Type Ia Supernovae.

The fraction of type Ia supernovae exploding inside planetary nebulae

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Using three independent directions we estimate that the fraction of type Ia supernovae (SNe Ia) exploding inside planetary nebulae (PNe), termed SNIPs,is at least ~20%. Our three directions are as follows. (i) Taking the variable sodium absorption lines in some SN Ia to originate in a massive circumstellar matter (CSM), as has been claimed recently, we use the results of Sternberg et al. (2014) to imply that > ~20% of SN Ia occur inside a PN (or a PN descendant), hence classify them as SNIPs. (ii) We next use results that show that whenever there are hydrogen lines in SN Ia the hydrogen mass in the CSM is large (> 1 M_Sun), hence the explosion is a SNIP. We make the simplest assumption that the probability for explosion is constant in time for up to about 10^5 yrs after the merger of the core with the white dwarf (WD) in the frame of the core-degenerate scenario. This results with at least few x10 of SNe Ia that may have a SNIP origin. (iii) We examine the X-ray morphologies of 13 well-resolved close-by SN remnants (SNRs) Ia and derive a crude upper limit, according to which 10-30% of all SNRs Ia possess opposite ear-like features, which we take as evidence of SNIP origin. Our results, together with several other recent results, lead us to conclude that the two scenarios most contributing to SNe Ia are the core degenerate and the double degenerate scenarios. Together these two account for >95% of all SNe Ia.

Indication of the high mass-transfer ratio in S-type symbiotic binaries

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Mass loss from the red giant in the form of a wind, and its transfer onto the white dwarf companion in symbiotic binaries represent the principal interaction between the binary components. However, the wind mass transfer in these systems is connected with the long-standing problem of the large energetic output from the hot component and its deficient fueling by the giant in the canonical Bondi-Hoyle accretion mechanism.
In our contribution, we determine the velocity profile of the wind from the giant at the near-orbital-plane region of eclipsing S-type symbiotic binaries EG~And and SY~Mus, and derive the corresponding mass-loss rates. Our analysis revealed the mass-loss from the giant at rates that are 1-2 orders of magnitude higher than values obtained by methods independent on the direction of the line of sight. This result suggests a high density of the wind material around the orbital plane, which thus reflects an efficient wind mass transfer mode in these systems. Our findings support the recent suggestion that the wind from giants in S-type symbiotic binaries can be compressed towards the orbital plane due to their slow rotation.

Chemical abundances of symbiotic giants

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The elemental abundances of symbiotic giants are essential to address the role of chemical composition in the evolution of symbiotic binaries, to map their parent population, and to trace their mass transfer history. Until recently, the number of symbiotic giants with fairly well determined photospheric composition was insufficient to apply them in statistical considerations. In the recent studies we have increased this number by several times making it possible to perform a first attempt of statistical analysis. Our chemical composition measurements were performed with use of high-resolution (R ? 50 000), high signal-to-noise (S/N), near-IR spectra. Spectrum synthesis analysis employing standard local thermal equilibrium (LTE) and atmosphere models was used to obtain photospheric abundances of CNO and elements around the iron peak (Sc, Ti, Fe, and Ni) for several dozens of symbiotic giants. Our analysis revealed metallicities distributed in a wide range: from significantly sub-solar to slightly super-solar in several cases.The enrichment in 14N isotope found in all these objects, indicates that the giants have experienced the first dredge-up, what is also confirmed by the low 12C/13C isotopic ratios for about half of our sample. We found that the relative abundance [Ti/Fe] is large in both, the red and the yellow symbiotic systems, what suggest it can be characteristic of all symbiotic giants.

The Gamma2 Velorum binary system

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We will present AMBER observations of the Wolf-Rayet + O-star system Gamma2 Velorum. Since the first work done on this system with the AMBER instrument, new spectro-interferometric observations were obtained. We interpret the data as a binary star with varying flux ratio and look at the residuals in order to evaluate the contribution from circumstellar material.
We use 1D radiative transfer models and 3D hydrodynamic simulations to model the system and evaluate the contributions from different sources to the observed residuals, namely the resolved wind from the WR star, and/or the shocked regions between the WR and O-winds. We will compare these simulations of the system with the AMBER data.
This work is one of the many works that Olivier Chesneau initiated and largely contributed to.

Testing the s-process pollution paradigm in binary systems with WDs

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We first present the system IP Eri, a system consisting in a He WD and a K0 IV primary that HERMES@MERCATOR found to be a long-period eccentric system (~1000 d). The non-zero eccentricity is a challenge to be accounted for by binary-evolution models, which end up with circular orbits for post-Roche Lobe OverFlow (RLOF) systems. A solution is proposed that involves the periastron mass transfer which operates to pump up the eccentricity. An abundance analysis confirms that the primary in IP Eri has not been polluted with s-process elements, as it should for the companion of a post-RGB star (the He WD). We report on a similar abundance analysis of the primary components for various systems with WD components of increasing masses, crossing through the mass threshold between He and CO WDs.

Radial Velocity and Light Curve Study of Pulsation and Binarity in Proto-Planetary Nebulae

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We have been carrying out a long-term light curve (since 1994) and radial velocity curve (1991-1995, 2007-present) study of 7 bright proto-planetary nebulae (PPNe). They are all variable, and periods (or quasi-periods) have been found for them in the range of 35-135 days. Contemporaneous light, color, and velocity curves are used to document the variability in an effort to better understand the pulsations. In a few cases the radial velocities suggest long-term variations, but these are affected by complexities in the spectra of these post-AGB objects. The results to date will be discussed.

Binary Cepheids at high angular resolution

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Classical Cepheid stars are important standard candles thanks to their Period-Luminosity relation, but not only, they are also powerful astrophysical laboratories, providing fundamental clues for studying the pulsation and evolution of intermediate-mass stars. One of the most fundamental parameters is the Cepheid mass, which is a long-standing problem since decades because there is a 10-20% difference between masses predicted from stellar evolution and pulsation models. Cepheids in binary system are the only tool to constrain models and progress on the mass discrepancy problem. However, most of the companions are located too close to the Cepheid (

Analysis of the optical variability of cataclysmic variable UU Aqr

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Photometrical monitoring of an eclipsing novalike variable UU Aqr has been carried out for last 13 years. The orbital period of the system has been refined according with the new data. There were showed the significant changes of the eclipse form even from cycle to cycle. The character of the optical variability and rapid brightness fluctuations was described. Some physical characteristics of the system's components based on the numerical modeling of the light curves UU Aqr were calculated .

Multicolor photometry of WZ Sge-type variable CSS130418: J174033+414756 - the 2013 and 2014 outbursts, similarities and differences.

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The multicolor photometry of helium cataclysmic variable - the short periodic close binary system J174033+414756 (Porb ~ 65 min) during outburst of 2014 was provided. The compare of the light curves, changes of color-indices, tracks on the two-color diagrams, superhump periods of previous (2013 yr) and present (2014 yr) outbursts is considered. Spectra obtained during two outbursts are compared and described. The interpretation of the results is considered.

SPH simulations of mass transfer in binary systems

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We present results of SPH simulations of mass transfer in binary systems involving an AGB star with a proper modelling of its wind and cooling in the wind.

Investigation of a rapid photometric variability of the symbiotic system CH Cyg during its current 2014-15 active phase.

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CH Cyg is one of the closest, brightest and enigmatic symbiotic system containing a particularly evolved giant of an M7III spectral type. The giant is semiregular, showing periods from ~100 to ~1400 days with changes of its optical brightness up to ~2 mag. Active phases (flares, bursts and sometimes a few years lasting brightening) are very heterogeneous. The activity of the accretor in the system can be recognized by an increase of the blue continuum. Photometrically we indicate a brightening in the U band so that U ~ V, and by the rapid variations on the time-scale of a few times 1-10 minutes.
In this contribution we present results of our photometric monitoring of CH Cyg during its current (2014-15) active phase on the time-scale of years and hours. The former revealed a brightening in U to 7-8 mag with U-V ~ 0, while the latter indicated rapid variations in U and B on the time-scale of 7-15 minutes and amplitude of 0.1 - 0.3 mag, superposed to a wave-like variability with a period around of 4 hours and the amplitude of ~0.5 mag. In addition, the rapid variations are followed with small changes in the B-V index up to ~0.1 mag. We also compare our recent results with our previous observations during the 2009 burst and during the 2011 - 2013 quiescent phase.

Outburst activity driven by evolved pulsating star in the symbiotic binary AG Draconis

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AG Draconis is one of the best studied symbiotic systems which regularly undergoes quiescent and active stages. The latter ones consist of the series of individual outbursts probably caused by increased thermonuclear burning on the white dwarf accreting matter from the wind of the evolved component. The photometric and spectroscopic behaviour of the symbiotic system AG Dra was studied. The period analysis confirmed the continued presence of the two periods. The longer one around 550 d is related to the orbital motion and the shorter one around 355 d could be due to pulsation of the evolved component of the AG Dra binary system. In addition, the active stages change distinctively, but the outbursts are repeated with periods from 359?375 d.

“Posters P4: Discs”

Study of enviroment and photosphere of 51 Oph

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understanding deeply the physical structure surrounding Young Stellar Objects (YSOs) is a crucial issue in their evolution process. In particular interest is the case of 51 Oph, a young fast-rotating star evolving from the Herbig Ae/Be class to the Vega-like one. We prob the photosphere of the fast rotating star 51 Oph and its circumstellar enviroment in the visible domain. We observed the 51 Oph star in the continuum to measure the angular diameter of the star and H$ \alpha $ line to study the kinematics within the circumstellar gaseous disk. We used visible SpEctroGraph-polArimeter (VEGA) installed on the CHARA optical array in medium spectral resolution (R=5000) with 3T and 2T of the array in the continuum and the H$ \alpha $ line respectively. For the first time, We were able to measure flattening for 51 Oph in the continuum and, as well as the disk extension in the H$ \alpha $ line using optical interferometry. We used a simple two-dimensional kinematic model of a rotating/or expanding equatorial disk and found some constrains for the gaseous disk. We showed that the disk kinematics is dominated by rotation with a Keplerian rotation law.

Forbidden Ca lines as disk tracers

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Forbidden emission lines are particularly valuable disk tracers, because they are optically thin, and therefore their profiles reflect the kinematics within their formation region. Gas diagnostics using forbidden [O I] lines is well known. Recently we have discovered also forbidden [Ca II] ?? 7291, 7324 lines in spectra of B[e] supergiants, which trace even hotter regions closer to the star than [O I] lines. We present results of spectroscopic survey of evolved massive stars surrounded by high-density disks. The observations were obtained using the Coudé spectrograph attached to the 2-m telescope at Ondrejov Observatory.

Exploring the circumstellar disk-like structure of the B[e] supergiant LHA 120-S 73

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The Large Magellanic Cloud hosts the peculiar B8-type star LHA 120-S 73. Belonging to the B [e] supergiant group, this star is surrounded by large amounts of material which forms a circumstellar disk-like structure, seen more or less pole-on. Within its dense and cool circumstellar disk, molecules form and dust condensates. Based on high-resolution optical and infrared spectroscopic data, we study the structure, kinematics and physical properties of the disk using different tracers, such as the emission lines of [O I] and [Ca II] for the innermost gaseous atomic region and the first-overtone bands of CO for the inner border of the molecular disk. Additionally, we analyse near- and mid-infrared spectroscopic observations to search for the presence of other molecules and to study the dust component of the disk, respectively. All the gathered information will allow us to give a clearer picture of the disk structure and kinematics of this enigmatic star.

Heuristic 3D radiative transfer modelling of discs in post-AGB stars

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We present heuristic approaches to the three dimensional radiative transfer modelling of interferometric post AGB sources. Such methods allow one to analyse the probability densities, through parameter space, of disk geometries, dust properties and stellar parameters of the source. The approach provides a more thorough search of parameter space, and through use of parallelism, does so more quickly. The method is not prone to local minima convergence, and provides an improvement in replicability over previous `by hand' methods. Overall the Bayesian-esque results allows one to provide a more insightful and meaningful analysis of the sources parameter space.

Posters P5: Circumstellar Environments

Observations of Evolved Stars from the ground and with the Stratospheric Observatory for Infrared Astronomy (SOFIA)

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TBD

Planetary Nebulae Dust as seen by Herschel

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The Herschel Space Observatory has allowed us to explore the far-IR wavelength range with an unprecedented sensitivity, spatial and spectral resolution. This wavelength range is ideal for investigating the mass-loss history of evolved stars. Harnessing Herchel's capabilities we conducted a spectroscopic and photometric survey of Planetary Nebulae (PNe): HerPlaNS. These data traces the colder dust and gas components of PNe giving us some insights into the older mass loss history and evolution of these objects.
I will present the results of the HerPlaNS photometry data at 70, 160, 250, 350 and 500um. These images reveal very extended haloes that correspond to the ionised haloes seen in narrow band optical data. I will show that the haloes in the far-IR are mainly due to thermal dust emission and that the temperature and the emissivity power index of the dust is very well constrained which helps us differentiate between the PNe environment and the Interstellar Medium (ISM). This hints toward a more complex ISM enrichment process than previously understood.

Panchromatic imaging and Spectroscopic Observations of the Mass Ejections of RY Scuti

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We describe recent panchromatic imaging and spectroscopic studies made with ground-based optical/infrared/radio telescopes, Hubble Space Telescope (HST), and the Stratospheric Observatory for Infrared Astronomy (SOFIA) of the massive over-contact, Algol-type binary star RY Scuti. Massive stellar systems like RY Scuti contribute substantial quantities of metals and heavy elements to the Inter-Stellar Medium (ISM) during their Post Main Sequence (PMS) evolution and when they die in supernova (SN) explosions. The fossil structures produced by the multiple winds that develop during their PMS mass-loss phase can profoundly affect the geometry of the SN remnant. Moreover, RY Scuti is a special system because it is a massive eclipsing binary caught in the brief phase of Roche lobe overflow, where one of the massive stars is being stripped of its H envelope to yield a Wolf-Rayet star and eventually a Type Ibc SN. The companion star is surrounded by an accretion disk. Material with excess angular momentum has expanded in the equatorial plane to yield a toroidal nebula that has been spatially resolved. The observations presented here delineate the current distribution of circumstellar matter produced by multiple ejections during the last few hundred years, and therefore offer important constraints on the fundamental parameters of binary mass transfer in SN progenitors. Special emphasis is given to describing the excitation structure, geometry, and ejection history of the fossil remnants.

Using Herschel-PACS to observe circumstellar emission

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PACS was a photometer and integral field spectrograph on-board the Herschel space telescope. It operated from 50-210 microns, producing images and spectral cubes. PACS was the first IFS operating at these wavelengths and from space.
In this poster I will present the technical issues concerning using PACS to observe circumstellar emission, be that from areas very close to the star (e.g. AGB stars), or areas further from the star (e.g. also AGB stars, PNe). I will discuss how to work with PAS cubes, what the considerations with the spatial sampling are, and comparing PACS spectral images created from the cubes, to images from other instruments.

The Molspheres of Mira Variables

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More than 30 years ago Hinkle and Barnes noted that extra absorption was present in low-excitation near-IR molecular lines in Miras. This absorption resulted from a 1000 K layer apparently of circumstellar origin. Tsuji investigated the line profiles of these same molecular lines in a variety of late-type giants and supergiants and dubbed the circumstellar region the molsphere. The relation of the molsphere to the stellar photosphere was never fully developed. We present results from a decade long time-series of Mira K and H band spectra. The velocities and strengths of CO and H2O lines show that the molsphere in Miras is time variable. The velocities are related to the cyclic Mira pulsation but vary aperiodically and on a longer time scale. We discuss the relation of the molsphere to stellar atmospheres and circumstellar regions in AGB stars.

Polarization Signatures of Stellar Bow Shocks

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Bow shocks around massive stars provide important information regarding the motion of the star, the stellar wind properties and the density of the surrounding ISM. Since bow shocks are asymmetric structres, they produce polarization signal which is a function of stellar wind and surrounding ISM. We use a Monte Carlo based radiative transfer code (SLIP)
to investigate the polarization created when photons from the source get scattered by electrons or dust in a surrounding bow shock. We vary parameters such as optical depth, temperature, and brightness of the bow shock and compare the simulated flux and polarization behavior with observational data. We discuss the behavior of the observed polarization with viewing angle and other parameters in both the resolved and unresolved cases. We also compare the bow shock results with those produced
by other circumstellar morphologies such as disks and shells.

Mapping the Central Region of the PPN CRL 618 at Subarcsecond Resolution at 350 GHz

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CRL 618 is a well-studied pre-planetary nebula. We have mapped its central region in continuum and molecular lines with the Submillimeter Array at 350 GHz at ~0."3-0."5 resolutions. Two components are seen in the 350 GHz continuum: (1) a compact emission at the center tracing the dense inner part of the H II region previously detected in a 23 GHz continuum and it may trace a fast ionized wind at the base; and (2) an extended thermal dust emission surrounding the H II region, tracing the dense core previously detected in HC3N at the center of the circumstellar envelope. The dense core is dusty and may contain millimeter-sized dust grains. It may have a density enhancement in the equatorial plane. It is also detected in carbon chain molecules HC3N and HCN and their isotopologues, with higher excitation lines tracing closer to the central star. It is also detected in CH2CHCN toward the innermost part. Most of the emission detected here arises within ~630 AU (0."7) of the central star. A simple radiative transfer model is used to derive the kinematics, physical conditions, and the chemical abundances in the dense core. The dense core is expanding and accelerating, with the velocity increasing roughly linearly from ~3 km s-1 in the innermost part to ~16 km s-1 at 630 AU. The mass-loss rate in the dense core is extremely high with a value of ~1.15 × 10-3 M &sun; yr-1. The dense core has a mass of ~0.47 M &sun; and a dynamical age of ~400 yr. It could result from a recent enhanced heavy mass-loss episode that ends the asymptotic giant branch phase. The isotopic ratios of 12C/13C and 14N/15N are 9 ± 4 and 150 ± 50, respectively, both lower than the solar values.

Comparison between 30 micron sources in different galaxies

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The 30 micron feature is commonly found in C-rich AGB stars, C-rich post AGBs and PNe. However, the carrier of this spectral feature remains unclear. Magnesium sulfide (MgS) is now the most favored candidate to be the carrier of this feature.
Infrared Space Observatory (ISO) provided spectra of 63 objects with this feature (see Hony et al. 2002). Spitzer has provided spectra of ~140 more objects.
I will present the results of my research on objects from different galaxies, which I think have 30 micron features in their Spitzer spectra. I found a photometry from several infrared surveys for each object and I made SEDs diagrams, which were necessary to fit a reasonable continuum in their spectra. This was helpful to estimate the feature strength and peak wavelength of the feature for each object.

The circumstellar environment of the B[e] star GG Car

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The research of stars with the B[e] phenomenon is still in its infancy, with several unanswered questions. Physically realistic models that treat the formation and evolution of their complex circumstellar environments are rare. The code HDUST (developed by A.~C.~Carciofi and J.~Bjorkman) is one of the few existing codes that provides a self-consistent treatment of the radiative transfer in a gaseous and dusty circumstellar environment seen around B[e] supergiant stars. In this work we used the HDUST code to study the circumstellar medium of the binary system GG Car, where the primary component is probably an evolved B[e] supergiant. This system also presents a disk (probably circumbinary), which is responsible for the molecular and dusty signatures seen in GG Car spectra. We obtained VLTI/MIDI data on GG~Car at eight baselines, which allowed to spatially resolve the gaseous and dusty circumstellar environment. From the interferometric visibilities and SED modeling with HDUST, we confirm the presence of a compact ring, where the hot dust lies. We also show that large grains can reproduce the lack of structure in the SED and visibilities across the silicate band. We conclude the dust condensation site is much closer to the star than previously thought. This result provides stringent constraints on future theories of grain formation and growth around hot stars.

On the properties of dust and gas in the environs of V838 Monocerotis

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The exact nature of the outburst of V838 Monocerotis is yet unresolved. This study presents far-infrared observations of its central and extended circumstellar environment, which was previously revealed through a spectacular optical light echo as well as an mid-infrared thermal «echo».
PACS and SPIRE maps taken at different epochs were used to obtain photometry of the dust immediately around the V838 Mon, and of the dust in the surrounding infrared-bright region. The surface integrated infrared flux (signifying the thermal light echo), and derived dust properties (formation or processing of dust), do not vary significantly. The central object is associated with warm/hot dust and the extended region with 0.6 solar mass of cold dust.
PACS and SPIRE spectra, taken at a single epoch, were used to detect emission lines from the extended atmosphere of the central object and the measured flux densities are used as a probe of the physical conditions. A detailed an analysis of molecular gas in V838 Mon suggest also three CSE zones associated with hot, warm, and cold gas, respectively.

Circumstellar dust in symbiotic novae

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Physical properties of the circumstellar dust and associated physical mechanisms play an important role in understanding evolution of symbiotic binaries. We present a model of inner dust regions around the cool Mira component of the two symbiotic novae, RR Tel and HM Sge, based on the long-term near-IR photometry, infrared ISO spectra and mid-IR interferometry. The SED between 1 and 13 μm has been obtained from ISO spectra and photometry. Pulsation properties and long-term variabilities were found from the near-IR light curves by the use of PDM and DFT methods. The dust properties were determined using the DUSTY code which solves the radiative transfer. No changes in pulsational parameters were found, but a long-term variations with periods of 20-25 years have been detected which cannot be attributed to orbital motion.
Circumstellar silicate dust shell with inner dust shell temperatures between 900 K and 1300 K and of moderate optical depth can explain all the observations. RR Tel showed the presence of an optically thin CS dust envelope and an optically thick dust region outside the line of sight, which was further supported by the detailed modelling using the 2D LELUYA code. Obscuration events in RR Tel were explained by an increase in optical depth caused by the newly condensed dust leading to the formation of a compact dust shell. HM Sge showed permanent obscuration and a presence of a compact dust shell with a variable optical depth. Scattering of the near-IR colours can be understood by a change in sublimation temperature caused by the Mira variability. Presence of large dust grains (up to 4 μm) suggests an increased grain growth in conditions of increased mass loss. We have also estimated the distances of 2.7 kpc for RR Tel and 2.5 kpc for HM Sge based on the infrared bolometric fluxes. The mass loss rates of up to 17·10^-6 M_Sun/yr were significantly higher than in intermediate-period single Miras and in agreement with longer-period O-rich AGB stars.
Despite the nova outburst, HM Sge remained enshrouded in dust with no significant dust destruction. The existence of unperturbed dust shell suggests a small influence of the hot component and strong dust shielding from the UV flux. By the use of the CLOUDY code, we have showed that a high-density gas region can effectively stop most of the UV flux from the white dwarf and provide the observed dust shielding.

Planetary Nebulae extracted from the AKARI Far-IR All-Sky Survey Maps

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We extracted planatary nebulae from the AKARI Far-IR All-Sky Survey Maps using a PN list based on the Kohoutek and MASH I/II catalogues. We established a new method to correct for fluxes measured by means of contour photometry of compact extended sources, which are neither diffuse (for which the all-sky survey maps are calibrated against) not point-like (for which a flux correction method is presented for the shorter 3 bands). We determined far-IR flux values in 4 bands at 65, 90, 140, and 160 microns for at least 50% of the 2751 PNe. Comparison between these new flux values and the flux values listed in the AKARI point-source catalogue (PSC) suggest that the PSC flux entries often underestimate the flux values for compact extended sources such as PNe (and other objects like galaxies).

In Quest of the Circumstellar Dust Shell Structure in Proto-Planetary Nebulae

Ueta Toshiya [1]

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The circumstellar shell structure of proto-planetary nebulae keeps the fossil records of the mass loss history during the asymptotic giant branch stage of stellar evolution. For optically thin circumstellar shells, the brightly visible central star often presents challenges to capture the faint surface brightness distribution intrinsic to the shell, which is hidden under the prominent PSF structures. In this contribution I'd like to review a series of attempts to suppress the effect of the PSF and investigate the structure of the circumstellar shell in the past 15 years.

Very fast evolution of bi-lobed planetary nebulae

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To the axially symmetric pseudo-3D photoionization models of planetary nebulae we applied for the first time the recipe for estimating the kinematical age which method was developed and tested on spherical models. Six Galactic bulge planetary nebulae selected purely on their bi-lobed morphology appear to be at the same kinematical age despite of different sizes, expansion velocities and stellar temperatures. This age appears rather young - about 1000 yrs. The selected objects probably represent one of several possible pathways leading to planetary nebulae and are a good example of generalized interacting stellar winds theory where an isotropic stellar wind breaks through a flattened denser torus producing bipolar lobes.

On the inner circumstellar envelopes of R Coronae Borealis stars

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We present different analyses of Very Large Telescope Interferometer (VLTI) data to interpret the inner circumstellar envelope (CSE) morphology of R Coronae Borealis (RCB) stars. Three objects were considered: RY Sgr, V CrA, and V854 Cen. Chi-squared maps of different geometrical models allow to identify a reasonable description of these CSEs, which can be further studied in radiative transfer codes. Overall, the inner CSE morphology of these RCB stars are consistent with a central star surrounded by a dusty shell with at least a bright clump (or a dust cluster).

New planetary nebulae discovered by French Amateurs

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Since 2012, French amateurs in astrophotography have been equipped with CCD imagers with high sensitivity and ?1 arcsec resolution, allowing them to obtain images with high resolution and contrast, and with unprecedented depth, using narrow-band filters. On the other hand, they have been methodically scanning the digital sky survey (DSS), thereby visually identifying dozens of faint PN candidates in the Galactic plane. These two methods lead to the discovery of 68 possible/probable PN. The very large bipolar object Ou4 is one of the most interesting PN known.

“Posters P6: Modelling, evolution”

AGB modelling: current results and related uncertainties

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Asymptotic Giant Branch (AGB) stars are among the major polluters of the interstellar medium. These objects produce both light (C,N,O,F,Na) and heavy elements (via the slow neutron capture process, the s-process).
Our AGB models are available on-line at the web pages of the FRUITY database, in which we provide surface isotopic compositions and yields from hydrogen to lead at various metallicities (-2.15=[Fe/H]=+0.15). FRUITY is currently hosting chemical features of low-mass AGB stars (1.3=M/MSUN=3.0) and it will be very soon expanded to intermediate-mass AGB models (4.0, 5.0 and 6.0 Msun).
We test the robustness of our models by comparing our results to available spectroscopic observations and laboratory isotopic measurements of presolar SiC grains. Moreover, we discuss the uncertainties currently affecting AGB models and their effects on chemical yields. We first concentrate on surface composition changes induced by rotation; then, we highlight the chemical distribution variations found when using different RGB and AGB mass-loss rates. Finally, we stress the importance of the handling of the convective/radiative interface at the base of the cool envelopes on these stars.

Constraining stellar evolution models with observations

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Evolved stages of massive stars are the magnifying glass that reveals the problems encountered in stellar evolution modelling. Various of the physical ingredients that are actually included in stellar evolution codes exist in different flavours (mass loss recipes, implementations of rotation) and the choice of one implementation or the other is still quite subjective, while it has large implications for the modelling of stars, and particularly for the advanced stages. I will present the impact of the different prescriptions on the way stars cross the HRD, and behave in their evolved phases.
At a time when large surveys are arriving, we can start testing the various physics with observations performed where most of the stars lie: the main sequence. I will discuss the way to tackle this, and show some recent results obtained in the OB-type domain.

Linking 1D Stellar Evolution to 3D Hydrodynamical Simulations

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Stellar models are important for many areas of astrophysics, for example nucleosynthesis yields, supernova progenitor models and understanding physics under extreme conditions. One of the longest standing problems with stellar evolution models is the treatment of convection. To study convection and turbulent motions in stellar interiors, detailed 3D hydrodynamical simulations are needed, these simulations aim to improve existing prescriptions for convective boundary mixing (CBM) within stellar models.
In this contribution I will present initial results of a study on CBM in massive stars. Before undertaking costly 3D hydrodynamical simulations, it is important to study the general properties of convective boundaries, such as the composition jump, pressure gradient and the 'stiffness'. The 'stiffness' of a convective boundary can be quantified using the Bulk Richardson number, this is the ratio of the potential energy for restoration of the boundary to the kinetic energy of turbulent eddies. A 'stiff' boundary will suppress CBM, whereas in the opposite case a 'soft' boundary will be more susceptible to CBM. Typical values of Bulk Richardson numbers for 'stiff' and 'soft' boundaries are 10,000 and 10, respectively.
One of the key results obtained so far is that lower convective boundaries of nuclear burning shells are 'stiffer' than the corresponding upper boundaries, implying limited CBM at lower shell boundaries. This is in agreement with current 3D simulations (e.g. Meakin and Arnett 2007). This result also has implications for flame front propagation in S-AGB stars and the onset of novae.
I will also present an analysis of our latest multi-D hydrodynamical simulations of carbon-shell burning in massive stars.

SMC3 as a test to the binary evolution

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SMC 3 is one of the most interesting symbiotic stars. This binary contains a bright K-type giant transferring mass to a massive white dwarf comanion, which makes it is a very promising SN Ia candidate. We are going to present an analysis of spectroscopic observations of this system. We will also discuss the evolutionary status of the system using results of population synthesis code.

Getting ready for the changing sky

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In this presentation I will bring together planetary nebulae (PN) hydrodynamic simulations of binary interactions, intermediate luminosity optical transients and more in a review of the work past, present and future that's being carried out by our group. I will start the story with planetary nebulae and the realisation that many of these nebulae are not the product of peaceful single star evolution. They are instead likely to be the result of a binary interaction. Among the many possible binary interactions, we studied the common envelope interaction which, aside from being responsible for at least one in five PN, is also the gateway to a staggering amount of binary phenomena, including supernova type Ia. Simulations of common envelopes are not very advanced, and we have shown recently just how much we do not understand, along with ways to improve. Aside from simulations, there are other ways to understand these interactions, and I bring observations and analytical considerations to bear on common envelope jets, proposing them as one of the best way to understand common envelopes. It is also likely, that many binary interactions have a light signature and indeed there are outbursts that were ascribed to common envelopes interactions and mergers, such as V838 Mon or V1309 Sco. Such observations will multiply with new time-sensitive observing platforms, such as the LSST. Interestingly, today we think that some nebulae, including some PN, may be the aftermath of these outbursts, observed a few hundred years down the line. Our simulations of a variety of interactions (from those with stars in eccentric orbits, to those where the companion is only a planet), attempt to explore parameter space, an exploration that will be enhanced by our new light module to model and predict light curves from transients.

High-Resolution Near Infrared Observations of Red Horizontal Branch Stars in the Galactic Field

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We obtained, for the first time, complete H- and K-band spectra of some selected Galactic field red horizontal branch stars. High-resolution (R = 40,000) and high signal-to-noise (S/N > 200) data were gathered with the newly commissioned IGRINS- Immersion Grating Infrared Spectrograph on the 2.7m Smith telescope at McDonald Observatory. The wavelength coverage of H- and K-band ranges from 1.5 to 1.8 and 1.9 to 2.4 microns, respectively. Adopting the atmospheric parameters that we already determined from the high-resolution visible-wavelength spectra of the same targets, we were able to measure abundances of some important elements in the H- and K-band, including Na, Mg, Al, Si, Ca, and Fe. The existence of OH gave us to opportunity to confirm the oxygen abundances that had been previously measured from [O I] lines. We also detected the CO (3-0) bandhead in H-band and CO (2-0), CO (3-1) bandheads in K-band, and used these features to determine accurate values for 12C/13C ratios in the red horizontal branch stars.

Galactic Chemical Evolution: Insights from Field Red Horizontal Branch Stars

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We have conducted the first large-sample red horizontal branch field star survey in the Milky Way. High resolution and high signal-to-noise (S/N > 100) spectra of more than 300 candidates were obtained with 2d Coude Echelle Spectrograph of the 2.7 m Smith telescope and High Resolution Spectrograph of the 9.2 m Hobby-Eberly telescope at McDonald Observatory. Chemical abundances of the red horizontal branch stars with different kinematics allow us to gain more insight into the overall chemical evolution of the Galaxy through stellar nucleosynthesis. We carried out a detailed abundance analysis of mainly proton-capture elements (C, N, O, Li) and some selected alpha, Odd-Z, Fe-group and neutron-capture elements. We also derived 12C/13C isotopic ratios, an important indicator of stellar evolution, by using the CN features mainly located around the 8004 Å. The distribution of well-determined abundances and metallicities of, especially, thin and thick samples of field stars yield fresh perspectives on the structure of the Galaxy and brings more constraints to the theoretical studies

New orbits of CH and CEMP stars

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We present a new set of orbital elements for CH and CEMP stars, and discuss some implications thereof. Their orbital elements appear very similar to those of barium stars, despite the big difference in metallicities impacting the stellar radii. A clear distinction arises between circular orbits with P

Interferometric studies of Cepheids: the Gaia era

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Optical Interferometry has revolutionized the studies of the Cepheids pulsating stars by offering to directly measure distances using the parallax of pulsation method. In practice, most of the recent results arise from the "reverse" application of the parallax of pulsation: by assuming the distance to the Cepheid (measured by geometrical parallax), the physical hypothesis sustaining the parallax of pulsation method can be tested. We will review the results of the past recent years, in particular regarding the infamous p-factor. Gaia will offer unprecedented accuracy and sample size of Gallactic Cepheids, we will hint on what is coming and how we are preparing for the first results.

Formation and evolution of cosmic dust: the Nanocosmos project

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Evolved stars are the factories of cosmic dust. This dust is made of tiny grains that are injected into the interstellar medium and plays a key role in the evolution of astronomical objects from galaxies to the embryos of planets. However, the fundamental processes involved in dust formation and evolution are still a mystery.
The aim of the NANOCOSMOS project is to take advantage of the new generation telescopes and simulation experiments to progress in our understanding of the dust formation zone in evolved stars. The analysis of the astronomical observations will involve modelling, and top-level experiments to produce stardust analogues in the laboratory and identify the key species and steps that govern the formation of dust.
To achieve this goal, NANOCOSMOS gathers a multidisciplinary team composed of astronomers, vacuum and microwave engineers, molecular and plasma physicists, surface scientists, including both experimentalists and theoreticians. This contribution will describe the organization scheme of NANOCOSMOS and the current experimental and instrumental developments including the Stardust machine, the new astronomical receivers and the Molecular Analyzer.

Magnetic fields at different stages of stellar evolution

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Evolution of the magnetic fields during stellar evolution is considered. From observations follows that magnetic fields of stars increases during stellar evolution, reaching maximum values in neutron stars (10^13 -10^14 Gs). This is direct evidence that during the evolution of stars their magnetic flux through a surface is constant (B(R)^2 =Const). Due to this, the magnetic fields of the white dwarfs and neutron stars, which have significantly smaller radius than OB stars have the much stronger magnetic fields. The observations indicate on the dipole form of the magnetic fields in stars at different stages their evolution, both in the young OB stars, and in stars on the later stages their evolution (in white dwarfs and neutron stars).

Ba stars and circumbinary discs

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Barium (Ba) stars are Ba-enriched G- or K-type giants, formed by the accretion of material lost by an asymptotic giant branch (AGB) companion (which is now a white dwarf, see e.g. [1]) within a binary system. A puzzling feature of these objects is that they have significantly eccentric orbits, even among binaries with orbital periods typically around a few thousand days. Indeed, canonical binary evolution models predict that all orbits should be circular for orbital periods less than about 4000 days because of efficient tidal interaction [2]. However, circumbinary (CB) discs -- frequently observed around post-AGB binaries -- may be a promising mechanism to "pump" the eccentricity [3]. Using a simple model that describes its formation and structure, we explore the impact of a CB disc on the orbital evolution of Ba stars and their progenitors using our state-of-the-art binary evolution code BINSTAR [4]. This talk will summarise our results.

THROES: A caTalogue of HeRschel Observations of Evolved Stars.

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"THROES: A caTalogue of HeRschel Observations of Evolved Stars:
In this project we carry out a comprehensive and systematic study of the far infrared properties of low-and intermediate-mass (1-8 Msun) evolved stars using Herschel archival data with the ultimate goal of better understanding the important physical processes and dramatic chemical and morphological changes that take place in these stars at the end of their evolution.
As a first step, we concentrate our efforts on two main activities: 1) the reprocessing and data-reduction of more than 200 individual sources, observed by Herschel/PACS in the 55-210 micron range,available in the Herschel Science Archive (HSA) which were originally part of more than 40 different observing programmes. 2) The creation of a catalogue, accesible via web, with all the information relative to these observations and the classification of the sources. These objects, cover the whole range of possible evolutionary stages in this short-lived phase of stellar evolution, from AGB to PN, displaying a wide variety of chemical and physical properties."

GTC/OSIRIS observations of RWT152, a case study of a planetary nebula with an sdO central star

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Hot subdwarf O stars (sdOs) represent a small fraction of the central stars of planetary nebulae (PNe). We present OSIRIS/GTC red tunable filter imaging and intermediate-resolution, long-slit spectra of RWT 152, that allow us to describe for the first time the morphology and spectral properties of this PN, one of the few sdO+PN systems identified to date. The reconstructed Halpha image shows a bipolar shell surrounded by a circular halo. A bright region traces the equatorial plane of the shell while the two main bipolar lobes appear composed of multiple small lobes. A handfull of weak [NeIII], [OIII], [ArIII], [NII], HeI and H emission lines are identified in the spectra. Preliminary abundance analysis suggests some peculiarities in the chemical composition of the object.

Yellow Hypergiants: a comparative study of HR5171A, Rho Cas & HR8752

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We present a comparative study of the bright yellow hypergiants HR 5171A, Rho Cas, and HR 8752. Yellow hypergiants are massive stars very close to the cool upper luminosity limit with very large mass-loss rates evolving fast on blue loops in the HRD. They reveal massive outburst events on time-scales of about half a century. Over the last three decades Rho Cas and HR 8752 have been extensively monitored both spectroscopically and photometrically, while spectroscopic monitoring of HR 5171A in the Southern Hemisphere only recently started. We find that HR 5171A (Teff=5000 K, log g=0.0) is spectroscopically nearly identical to Rho Cas and HR 8752 with very broad absorption lines signaling extended dynamical stellar atmospheres. In HR 5171A atmospheric microturbulence velocity of 10 km/s is supersonic and comparable to 11 km/s in Rho Cas. We present a model of the circumstellar dust envelope of HR 5171 using detailed radiative transfer fits to the SED, while dust is nearly absent in Rho Cas and HR 8752. The prominent [N II] emission lines we observe in the three hypergiants signal extended gas nebulae. The changes in the blue H alpha line wing of HR 5171A indicate phases with variable mass-loss, possibly caused by atmospheric pulsations we also observe in Rho Cas and HR 8752.

Rotation of Red Giants

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A new rotation model for post-main sequence stars is proposed. Guided by recent Kepler observations, analytic scaling arguments, and numerical simulations, we consider strong differential rotation in a deep convective envelope, in combination with magnetically enforced solid rotation in the radiative core. This model quantitatively reproduces core and surface rotation rates of sub-giant stars, as well as the core rotation of helium-burning clump stars. This model has interesting implications for white dwarf spin and magnetism.

The very fast evolution of the VLTP object V4334 Sgr

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It is well known that intermediate mass stars experience thermal pulses at the tip of the AGB. It is theorized that about 20% of all objects will experience one additional (very) late thermal pulse (VLTP) after they have left the AGB and have become the central star of a planetary nebula. Despite this high percentage, this process is only very rarely observed. The discovery of Sakurai's star (V4334 Sgr) in 1996 provided the first opportunity in modern times to observe a very late thermal pulse. This object has baffled the scientific community with its very fast evolution. In an international collaboration we are monitoring this evolution using optical spectra (from the VLT) as well as radio observations (from the VLA and Merlin) to look for signs of ionization due to the reheating of the central star. We will give an overview of the recent results of this campaign.

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