Blowing in the Wind

ICISE
International Center for Interdisciplinary Science and Education

August 07-14, 2016

Synopsis

Blowing in the wind has as an objective to bridge the gab between researchers working on the inside and on the outside of stars. To build this bridge, we need to consider many different fields all revolving around stellar winds: stellar structure evolution and abundances, winds launching mechanisms in luminous stars (such as OB, WR or AGB stars), pulsations and dust formation, meteoritic stardust, mass transfer in binaries, winds impact on circumstellar environments, bow shocks and planetary nebulae, mass loss and its feedback onto host galaxies and stellar clusters. Summer 2016 is timely to examine what clues ALMA's fantastic resolution provides on stellar neighbourhoods, and how the big radiotelescope FAST might be put to a good use for the next advances. Most Vietnamese astronomers work on stellar environments with the tools of radioastronomy and ICISE in Quy Nhon (Vietnam) is a perfect meeting point for Asian and Western countries. Given the diversity of the participants, emphasis will be given to introductory and review talks, and room will be kept for discussions between participants coming from different horizons.

The answer, my friend, is blowing in the wind !

ICISE Secretaries

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General information

Registration

The registration for all participants will take place from 14:30 on Sunday August 7th at Seagull Hotel. Please register as soon as you arrive at the hotel, fill in an ARRIVAL FORM and hand it to the conference secretaries.

All payments must be completed by Tuesday evening. The accommodation will be paid to the conference secretariat and not directly to the hotel. Our conference secretariat office is located at ICISE, opened from 8:15 to 12:30 and from 13:30 to 17:30.

Welcome Cocktail

All participants, their families and guests are invited to have a welcome drink on Sunday, 3rd August at Seagull Hotel followed by a buffet dinner at 19:30.

Khách Sạn Hải Âu - Seagull Hotel
489 An Dương Vương
Quy Nhơn, Bình Định
Phone: +84 56 3846 377

Meals

- Alcoholic or soft drinks will be charged to your hotel account. If you are sharing a room, please find an arrangment with your room mate for both your telephone and beverage bills.
- *Breakfast* will be served at the Seagull hotel: **you will need the daily coupon** provided by your hotel room.
- *Lunch* for participants will be served at 11:30 (12:00 on monday) at ICISE, except Wednesday when it will be served at the hotel (at 12:15). For accompanying persons, lunch will be served at 12:30 at the hotel. If you wish to have lunch at ICISE, please inform us **one day before**.
- *Dinner*: all participants and their families take the dinner in the Phong Lan restaurant of the Hotel at 19:00, with a few exceptions to be announced.
- *Conference Dinner*: it will be held at 19:00 on Thursday 11th August 2016 at ICISE. Transport from hotel to ICISE for accompanying persons will be arranged at around 18:15.
- Please let us know your preference (vegetarian, vegan ...) so that we can inform the hotel.
- In any case, **please bring along with you your meal coupons**, provided to you at registration time.

The conference center

The conference center is located at ICISE
(International Center for Interdisciplinary Science and Education) :

Trung tâm Quốc tế Khoa hoc và Giáo dục liên ngành (ICISE)
Address : Quốc lộ 1D, Khu vực 2,
Phường Ghềnh Ráng, Thành phố Quy Nhon
Tỉnh Bình Định, Việt nam
Phone number: (+84)056.3540099

Bus departures from the hotel to ICISE: from 7:45 to 8:10, EXCEPT on monday where it will be half an hour before: from 7:15 to 7:40.

Bus back to hotel: 17:30 and 18:30.

You can also go by yourself via the main road by taxi (10-15 min, and about 100 000 - 150 000 VND depending on the taxi's waiting time and rate). Or you can go by yourself via the trail along the coast either by walking (45 min) or by bike (a day's bike rental is around 150 000 VND).

Conference talks hours are:

8:30 - ∼11:30
and
13:00 - ∼15:30.

Tea and coffee will be served during the breaks (around 10:00 and 14:30) at the cafeteria of ICISE.

The time between the talks and dinner is devoted to posters, discussions, collaborative work and to the beautiful beach by the conference center.

Useful information

- *Internet.* WIFI is available at the ICISE. Password is ICISE20130812 for guests. Wifi is available almost anywhere in Vietnam: for example, you can get wifi access in any local cafes if you ask waiters for the password.
- *Beach time.* There are showers and changing rooms by the beach of the ICISE center and your laptops can be stored at the secretaries office. Bring along your towel, bathing suit and sun screen if you want to swim.
- *Prepaid Mobile phone and 3G internet SIM card*

  Prepaid sim card for phone and internet data is relative cheap in Vietnam. Vinaphone, Mobifone and Viettel are three phone and internet providers who propose a Tourist SIM which costs around 200000 VND or 10 USD. These tourist SIM offer you around 50 minutes international call, 100 minutes domestical call, free text messages, 3G internet connection (depending on the provider). These SIM cards can be bought at the airport, electronic or phone shops. Please check the details here if you're interested:

  `http://www.mobifone.com.vn/wps/portal/public/goi-cuoc/theo-doi-tuong/happy-tourist`

  `http://www.vietteltelecom.vn/mobile.php/chi-tiet-dich-vu/tourist-goi-cuoc-danh-cho-khach-du-lich`

  `http://www.3gvinaphone.pro.vn/2016/07/tourist-sim-vinaphone.html`
- *Telephone.* If you share a room, please keep track of your calls because there is only one telephone per room and the billing is done for each room. Telephone bills should be settled before you leave.
- *Banking facilities.* Exchange currency service is available at the hotel reception, local bank branches or any jewellery shops. ATM machines can be found on the opposite side of the hotel.
- *Pick-up from the airport on Sunday August 7th.* For the arrival in Quy Nhon on Sunday August 7th, there will be a transfer by bus from the airport to the Seagull hotel for the participants and their families. There will be a welcome team at the airport at the arrival of all flights from HCM and Hanoi. A desk with ICISE staff members is planned in the luggage arrival room. The luggage arrival room is very small so you will not miss it (the table with an ICISE name tag).

  To access to the conference bus, participants MUST inform the conference secretariat of their flight number and the scheduled arrival time before August 6th in order to secure a seat in the conference bus. For the other dates : please contact the conference secretaries for a pick-up by taxi.

  For the departure from hotels to the airport on Saturday August 13th, there will be a transfer by bus :

  For the flights VN 1393 (HCM city) and VN 1620 (1620)

  At 7:10 from the Seagull hotel (Breakfast served at 6:15).

For the flight VN 1397 (HCM city)

At 15:00 from the Seagull hotel. Lunch served at Seagull hotel at 12:00.

For the other flights

Please contact the conference secretaries to arrange a taxi transfer. The transfer cost will be at your charge.

DON'T FORGET TO GET BACK YOUR PASSPORT AT THE HOTEL RECEPTION DESK BEFORE YOU LEAVE!

- *Special announcements*

  A paperboard will be at the Secretaries office in ICISE. For accompanying persons, a paper board will be at the hotel reception hall. Please check it regularly.

Emergency contact

You can call us any time if you have any emergency request including visa at the airport, pick up, medical help...

Betty Binh : + 84 9 473 175 27

Programme

Sunday

Welcome cocktail in the Seagull hotel lobby

19:00

Dinner at hotel

Monday

8:00 - 8:10 *Tran Thanh Van*
Welcome

8:10 - 8:20 *Vice-President of the province*
Welcome

8:20 - 8:35 *Pierre Lesaffre*
Conference introductory words

8:35 - 9:10
Conference photograph

Winds mechanisms, physical processes

9:10-9:40 *Jorick Vink* (Invited)
Theoretical wind models p.13

9:40-10:00 *Andreas Sander* (Oral)
Unified stellar atmospheres: Connecting wind and static regime p.13

Coffee break

10:30-11:00 *Sofia Ramstedt* (Invited)
Observations of winds from AGB stars p.14

11:00-11:20 *Gioia Rau* (Oral)
Atmospheres of C-rich AGB - observations and models p.14

11:20-11:40 *Steve Goldman* (Oral)
The wind speeds, dust content, and mass-loss rates of evolved stars at varying metallicity. p.15

11:40-12:00 *Dries Nicolaes* (Oral)
The dusty winds of AGB stars as seen by Herschel PACS and SPIRE spectroscopy p.15

Lunch at ICISE

From the stellar cores to the winds roots

13:30-14:00 *Tim Bedding* (Invited)
A Golden Age of Asteroseismology with Kepler p.15

14:00-14:30 *Sylvie Cabrit* (Invited)
Discs, winds and outflows p.16

Coffee break

15:00-15:20 *Willem-Jan De Wit* (Oral)
Outflows at milli-arcsecond scales: the winds from young massive stars. p.16

15:20-15:40 *Stacey Bright* (Oral)
Disks inside pre-PNe: Modeling and analyzing disks observed with the VLTI p.16

15:40-16:00 *Ward Homan* (Oral)
A compact differentially rotating disk around the AGB star L2 Puppis p.17

19:00
Dinner in Qui Nhon (venue TBA)

Tuesday

Winds and circumstellar envelopes

8:30-9:00 *Leen Decin* (Invited)
High spatial resolution studies of the winds of evolved stars p.17

9:00-9:20 *Pham Ngoc Diep* (Oral)
Space reconstruction of the morphology and kinematics of axisymmetric radio sources p.18

9:20-9:40 *Pham Nhung* (Oral)
Morphology and kinematics of the gas envelope of Mira Ceti p.19

9:40-10:00 *Sofie Liljegren* (Oral)
Variability and dust winds of AGB stars p.19

Coffee break

10:30-10:50 *Thibaut Le Bertre* (Oral)
HI emission from red giants with the VLA and FAST p.20

10:50-11:10 *Van Trung Dinh* (Oral)
Mass loss and structure of the envelopes around AGB and post-AGB stars p.20

11:10-11:30 *Hoang Phuong Thanh Nguyen* (Oral)
CO and N2 differential depletion in prestellar cores: experimental study of N2 desorption induced by the presence of CO on ices p.21

11:30-11:35 *Nick Cox* (Poster)
The Yellow Hypergiant Hen3-1379 p.21

Lunch at ICISE

Bow shocks

13:20-13:40 *Allard Jan Van Marle and Nick Cox* (Invited)
Bow shocks p.22

13:40-14:00 *Olga Katushkina* (Oral)
Interstellar dust distribution in the region of interaction of the stellar wind with the interstellar medium p.23

Coffee break

14:30-14:50 *Vladislav Izmodenov* (Oral)
Stellar and interstellar magnetic field effects on the global structure of astrospheres p.23

14:50-15:10 *Ngoc Tram Le* (Oral)
H2 emission from magnetised bow-shocks around stellar winds. p.24

15:10-15:15 *Willem-Jan De Wit* (Poster)
The origin of B-type runaway stars: Nitrogen abundances as a diagnostic. p.24

19:00

Dinner in Qui Nhon (venue TBA)

Wednesday

Planetary nebulae

8:30-9:00 *Yong Zhang* (Invited)
Molecules in planetary nebulae p.24

9:00-9:20 *Eva Villaver* (Oral)
Stellar Archeology using Wind Properties p.25

9:20-9:40 *Gabor Orosz* (Oral)
Maser jets around water fountain stars: insights into late stellar evolution from VLBI astrometry p.25

9:40-9:45 *Nick Cox* (Poster)
PAHs and H2 in the Ring Nebula p.26

Coffee break

Dust and winds: when, where, how much and what is it made of ?

10:15-10:45 *David Gobrecht* (Invited)
Dust formation in AGB stars p.26

10:45-11:05 *Iain Mcdonald* (Oral)
Sowing the seeds of dust: what does it take to make a giant star dusty? p.27

11:05-11:25 *Ambra Nanni* (Oral)
Constraining dust properties in Circumstellar Envelopes of C-stars in the Small Magellanic Cloud: optical constants and grain size of carbon dust p.27

12:00
Lunch at hotel

13:30
Excursion: departure from the hotel

19:00
Dinner at hotel

Thursday

Stellar evolution and winds

8:30-9:00 *Kyung-Won Suh* (Invited)
Stellar evolution and winds p.28

9:00-9:20 *Drisya Karinkuzhi* (Oral)
Binary evolution of CH and Barium stars p.28

9:20-9:40 *Norhasliza Yusof* (Oral)
Very Massive Stars in High Metallicity p.28

9:40-10:00 *Carolyn Doherty* (Oral)
Evolution & nucleosynthesis in low- and intermediate-mass stars of metallicities Z = 0 to 0.04 p.29

Coffee break

10:30-10:50 *Jan Cechura* (Oral)
Focused stellar wind in Cygnus X-1 p.29

10:50-11:10 *Dorottya Szécsi* (Oral)
The mass-loss of the hot massive stars in I Zwicky 18 p.30

11:10-11:30 *Aruna Goswami* (Oral)
Carbon-Enhanced Metal-Poor stars: binarity, evolution, nucleosynthesis, and, the impact on cosmochemistry p.30

Lunch at ICISE

Duplicity and winds

13:00-13:30 *Shazrene Mohamed* (Invited)
Modelling the interactions of evolved stars with (sub)stellar companions p.31

13:30-13:50 *Ka Tat Wong* (Oral)
Resolving the extended atmosphere and the inner wind of Mira (omicron Ceti) with long ALMA baselines p.31

13:50-14:10 *Natalia Shagatova* (Oral)
Light curve asymmetry of the symbiotic binary SY Mus as a result of absorption by the wind from its giant component p.32

14:10-14:30 *Rainer Hainich* (Oral)
Dichotomy of wind-fed HMXBs p.32

Coffee break

15:00-15:20 *Hans Olofsson* (Oral)
An ALMA view of the (post-common-envelope-evolution) post-AGB object HD101584 p.33

15:20-15:40 *Martha Irene Saladino Rosas* (Oral)
AMUSEing winds in binary stars p.33

15:40-16:00 *Tomer Shenar* (Oral)
Wolf-Rayet binaries in the Magellanic Clouds: winds versus Roche lobe overflow at low metallicity environments p.34

16:00-16:20 *Astrid Lamberts* (Oral)
Combining interferometric measurements with hydro simulations to understand the colliding wind binary Gamma Vel. p.34

19:00
Conference Dinner at ICISE

Friday

Winds feed back to the large scales

8:30-9:00 *Maurizio Salaris* (Invited)
Stellar winds and the complex evolution of globular clusters p.34

9:00-9:20 *Anne Klitsch* (Oral)
A comparison of galactic metallicity gradients: the Illustris simulation vs. recent IFU observations p.35

9:20-9:50 *Bram Ochsendorf* (Invited)
Wind-blown bubbles in the Galaxy p.35

Coffee break

10:20-10:40 *Jesus Toala* (Oral)
Diffuse X-ray emission as probe of Stellar Evolution p.35

10:40-11:00 *Gerhard Hensler* (Oral)
Blowing a galactic wind - The impact of stellar feedback at low star-formation rates in numerical simulations p.36

11:00-11:05 *Gerhard Hensler* (Poster)
Radiation-driven and wind-blown HII regions and their energy transfer efficiency p.36

Lunch at ICISE

Current and future instruments for winds

13:00-13:30 *Michael Lindqvist* (Invited)
Science highlights from the European VLBI Network and SKA p.36

13:30-13:50 *Hiroshi Imai* (Oral)
VLBI observations of circumstellar maser sources for exploration of stellar pulsation-driven shock waves p.37

Coffee break

14:20-14:40 *Xavier Haubois* (Oral)
A review of recent VLTI results on stellar winds and perspectives with second generation instruments. p.37

14:40-15:40 *Di Li and Philippe Stee*
Prospective discussion

Concluding remarks

19:00
Dinner at hotel

Abstracts

Theoretical wind models

Jorick Vink
(Armagh Observatory)

I will discuss various theoretical wind models, starting from the basic Parker thermal wind that has extensively been applied to the Sun. I then move on to radiation-driven wind models that are applicable to massive supergiants. These include both optically thin and optically thick wind models, which are needed to understand the final phases of stellar evolution. In addition to the wind physics, I will discuss practical mass-loss recipes that may be applied to stellar evolution models across the stellar Hertzsprung-Russell diagram.

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Unified stellar atmospheres: Connecting wind and static regime

Andreas Sander
(Potsdam University)

Stellar atmosphere models are a key tool in order to understand massive stars and their winds. Not only do they yield synthetic spectra which are then compared to the observations in order to deduce the stellar parameters, their stratification results are also used in a wide range of studies and simulations. Since winds are inherent to all massive stars, their proper accounting in atmosphere models is imperative. Unified model atmospheres that connect the quasi-hydrostatic and the supersonic wind regime in a consistent way are therefore a major breakthrough. However, this requires complex calculations, including the radiative transfer in an expanding atmosphere and the solution of the statistical equations in a non-LTE situation for large model atoms having hundreds of levels. On top of these two major problems there are several further challenges, so that only very few codes exist worldwide which can accurately simulate an expanding stellar atmosphere and provide synthetic spectra that sufficiently reproduce observations. One of them is the Potsdam Wolf-Rayet (PoWR) model atmosphere code. Originally developed to understand Wolf-Rayet (WR) stars, it has since been significantly extended and is nowadays applicable for any hot star. Using PoWR as an example, this talk will give a brief summary about the major tasks and the current status of modern unified atmosphere models and their challenges. An outlook is given on the next steps already under development, such as the self-consistent coupling of comoving-frame radiative transfer with hydrodynamics. This extension will open a new field of applications for stellar atmosphere codes and substantially extend our theoretical understanding of radiation-driven winds.

Observations of winds from AGB stars

Sofia Ramstedt
(Uppsala University)

Observational constraints for the wind properties of AGB stars were for many years provided by spatially unresolved observations of molecular gas and dust emission from their circumstellar envelopes (CSEs). These observations have provided valuable information regarding the physical and chemical characteristics of the CSE for large samples of stars. Dynamical models aimed at understanding the wind process in AGB stars are build on the theory of a pulsation-enhanced dust-driven wind and manage to reproduce the observed wind parameters rather well. In these models there is an intricate interplay between pulsations creating the right conditions for dust formation, and the available elements needed to create dust species that are capable of driving the wind. In recent years, 3D models aimed at studying both the stellar convection on the surface, and shaping processes further out in the wind (e.g., binary, or magnetic shaping) have also been developed. These models usually contain less detailed physics and simplified radiative transfer compared to the 1D models, and need to be constrained by spatially resolved observations. The development of new advanced instrumentation and facilities (e.g. VLT/SPHERE, ALMA) have allowed us to resolve intricate small-scale structures in the CSE down to the surface, and the detailed comparison between this new data and 3D models are currently in progress. In this talk I will discuss the current status of the comparison between wind observations and the dynamical wind models, both in 1D and 3D, and the implications it has for our understanding of AGB wind formation and evolution.

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Atmospheres of C-rich AGB - observations and models

Gioia Rau
(University of Vienna)

Dynamic models atmospheres (DMA, Eriksson et al. 2014) for the atmospheres of C-rich Asymptotic Giant Branch stars are quite advanced and have been overall successful in reproducing spectroscopic and photometric observations. Interferometry provides independent information and is thus a crucial technique to investigate the atmospheric stratification and to further constrain the dynamic models. We studied a sample of six C-rich AGBs with the mid infrared interferometer VLTI/MIDI. We combined interferometric observations with spectro-photometric data from the literature, and compared them with synthetic observables derived from DMA. The SEDs can be reasonably well modelled and the interferometry supports the extended and multi-component structure of the atmospheres, but some differences remain. We discuss the possible reasons for these differences and we derived stellar parameters, which we compared with stellar evolutionary models. Finally, we point out the high potential of MATISSE, the second generation VLTI instrument allowing interferometric imaging in the L, M, and N bands, for further progress in this field.

The wind speeds, dust content, and mass-loss rates of evolved stars at varying metallicity.

Steve Goldman
(Lennard-Jones Laboratories)

Metallicity and luminosity remain the largest uncertainties in current mass loss models. As a result, observations at lower metallicity like the Large Magellanic Cloud (LMC) at one half solar metallicity are critical for understanding this mass loss. From recent ATCA radio observations of AGB and red supergiant stars in the LMC we have discovered four new 1612 MHz circumstellar OH masers and increased the number of reliable winds speeds from five to twelve. Among these observations, we have observed a RSG with a spectacular polarised asymmetric variable maser emission similar to that of Vy CMa. Using our new wind speeds, as well as those from Galactic sources, we have derived an updated relation for the wind speed as a function of gas-to-dust ratio and luminosity. We have also developed a method of deriving gas-to-dust ratios for our sources by scaling the results of spectral energy distribution fitting to the results of our maser profiles. Using our new sample we have derive d a formula for mass loss rates as a function of gas-to-dust ratio and luminosity. We find that the gas-to-dust ratio has shown to have little effect on the mass loss of AGB and RSG stars within the Galactic neighborhood which suggests that mass loss is (nearly) independent of metallicity between a half and twice solar (Goldman et al. submitted).

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The dusty winds of AGB stars as seen by Herschel PACS and SPIRE spectroscopy

Dries Nicolaes
(Royal Observatory of Belgium)

During the asymptotic giant branch (AGB) phase, low- and intermediate mass stars (LIMS) expell a significant part of their initial mass. This mass loss is qualitatively explained as the result of a slow, dust driven wind. However, the time evolution of the mass loss rate and the precise physical and chemical processes involved, are still not fully understood. Between 2009 and 2013, the PACS and SPIRE instruments of the Herschel Space Observatory provided us with spectroscopic data for a few dozens of mass losing LIMS, spanning a large wavelength range in the infrared (PACS: 55-210 μm; SPIRE: 195-670 μm). We investigate the mass loss history and the far infrared dust opacities by performing a sample study of the dust continuum of the AGB-winds as observed by PACS and SPIRE.

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A Golden Age of Asteroseismology with Kepler

Tim Bedding
(University of Sydney)

Stellar astrophysics has entered a new golden age, thanks to wonderfully precise measurements being returned by NASA's Kepler mission. Kepler is a 0.9-metre space telescope that has been monitoring the brightness of more than 100,000 stars with extraordinary accuracy for more than four years. Its main goal is to discover extra-solar planets by detecting the small dips in light as they transit their parent stars. The mission has been spectacularly successful, with thousands of candidates reported. Meanwhile, Kepler's observations of oscillations in thousands of stars have led to a revolution in asteroseismology. Key results include detecting gravity modes in red giant stars and characterizing stars found to host exoplanets. Upcoming results from ESA's Gaia mission will add to the excitement, as will the launch next year of TESS, which is an all-sky follow-up mission to Kepler.

Jets, outflows and disc winds.

Sylvie Cabrit
(LERMA Observatoire de Paris)

Fast (∼ 100 km/s) highly collimated jets and slower (∼ 10 km/s) bipolar molecular outflows are unexpected and spectacular phenomena signaling the formation of a new star, a few 1000 yrs only after the onset of protostellar collapse. This ejection activity persists during a few Myrs, as long a the star accretes material through its circumstellar disk (classical T Tauri phase). I will review the observational characteristics of jets and outflows in these various stages of star formation, as revealed by the new powerful telescopes VLT, NOEMA, and ALMA, highlight their similarities and differences with age and their connection to accretion. I will then discuss the possible ejection and collimation mechanisms, in particular magneto-centrifugal disc winds, and how they compare with observations.

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Outflows at milli-arcsecond scales: the winds from young massive stars.

Willem-Jan De Wit
(European Southern Observatory)

Outflows are the signposts of embedded young stars in their formation stages. These winds are launched by the magnetically mediated accretion process onto the star itself and/or the manifestation of disk winds. We will demonstrate in this talk the advances attained in understanding this processes at milli-arcsecond scales, often achieved through interferometric techniques (ALMA, VLTI). We will highlight results of the effects on the circumstellar medium of the young massive star (e.g. Beltran & de Wit 2016; Boley et al. 2015; Caratti o Garatti et al. 2016) and discuss what this teaches us about mass-loss in the earliest phases of massive star evolution.

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Disks inside pre-PNe: Modeling and analyzing disks observed with the VLTI

Stacey Bright
(Space Telescope Science Institute)

Disks around evolved mass-losing stars are suspected to play an integral part in the mass-loss mechanism. AGB stars appear to lose mass spherically, but their progeny, PNe, have non-spherical shapes. Disks have been found inside bipolar PNe, but their exact role in the shaping mechanism remains largely unknown. Compact Keplerian disks have also been commonly found around post-AGB binaries, but these objects will likely never develop into PNe. Another subset of post-AGB stars are surrounded by pre-PNe, shining by reflected light or shock ionization. We used the VLTI to observe the inner-circumstellar regions of these post-AGB stars at high angular resolution, searching for disks. We have found at least 2 pre-PNe with disks in their cores and our preliminary analysis has given hints as to how they have formed and the role they play in collimating the nebulae. We are currently carrying out new modeling, using genetic algorithms which achieve more accurate results, to extrac t key parameters such as mass, size and geometry. We anticipate that these pre-PNe, with disks in their cores and their corresponding models, may be used as prototype targets in order to understand the role disks play in the mass-loss mechanism.

A compact differentially rotating disk around the AGB star L2 Puppis

Ward Homan
(KU Leuven)

The circumstellar environment of the AGB star L2 Puppis has been the focus of many recent observations by Kervella et al. Continnum observations have shown the AGB star to contain a compact circumstellar dust disk with a radius of some 10 AU. Subsequent high-resolution band 7 ALMA observations now show a compact, differentially rotating CO disk to be present around the star. The rotation characteristics are also unmistakably present in the additionally observed 13CO and 29SiO emission. These results make L2 Puppis the first AGB star with a confirmed rotating disk. We have modelled the CO disk with the 3D non-LTE radiative transfer code Lime. The disk is dense and optically thick, with a high inner disk temperature, and a very low outer temperature. This causes a strong absorption feature around systemic velocity. Besides the tangential velocity component, the disk has a possible inward velocity component, caused by a slower rotation of the outer regions. This could be explain ed by the strong friction the as would experience in such a dense environment. Finally, here are also indications that the dust and the gas may be stratified, resulting in a flat dust disk surrounded by a wider gas disk.

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High spatial resolution studies of the winds of evolved stars

Leen Decin
(Institute of Astronomy Leuven University)

High spatial resolution observations have provided us with an amazing view on the winds of evolved cool giants and supergiants. The longstanding assumption of smooth spherically symmetric winds seems often not validated. Large scale structures in the form of spirals, circumstellar disks, bipolar outflows, bowshocks etc. are detected and smaller scale clumpiness seems omnipresent. These novel data challenge our understanding of the wind launching process. The observations serve as critical benchmark for 3D hydrodynamical models. Even more, these data push the theoretical models to include a higher form of complexity, in particular to incorporate a (more) consistent approach of chemistry, dynamics, and radiative transfer. In this talk, I will give a review of the recent observational results obtained with ALMA, SPHERE and Herschel. I will show how these data yield detailed information on the wind structure of evolved stars and elucidate which chemical and physical phenomena sho uld be captured in theoretical wind models. I will summarize ongoing efforts to improve these theoretical models, both in terms of numerical modeling and based on novel laboratory experiments. I will show how these theoretical models serve as a guideline to further improve the observing strategies.

Space reconstruction of the morphology and kinematics of axisymmetric radio sources

Pham Ngoc Diep
(Vietnam National Satellite Center)

The unprecedented quality of the observations available from the Atacama Large Millimetre/sub-millimetre Array (ALMA) calls for analysis methods making the best of them. Reconstructing in space the morphology and kinematics of radio sources is an underdetermined problem that requires imposing additional constraints for its solution. The hypothesis of rotational invariance about a well-defined star axis, which is a good approximation to the description of the gas envelopes of many evolved stars and protostars, is particularly efficient in this role. In a first part of the presentation, a systematic use of simulated observations allows for identifying the main problems and for constructing quantities aimed at solving them. In particular the evaluation of the orientation of the star axis in space and the differentiation between expansion along the star axis and rotation about it are given special attention. The use of polar rather than Cartesian sky coordinates is shown to better match the morphology and kinematics of actual stars. The radial dependence of the gas density and temperature and the possible presence of velocity gradients are briefly considered. In the second part, the results obtained in the first part are applied to a few stars taken as examples with the aim of evaluating their usefulness when applied to concrete cases.

Morphology and kinematics of the gas envelope of Mira Ceti

Pham Nhung
(Vietnam National Satellite Center - VAST)

Observations of the 12CO(3-2) emission of the circumbinary envelope of Mira Ceti, made by ALMA over a distance of 700 AU from the star and with excellent spatial resolution (beam FWHM of 0.32", meaning 32 AU) are analysed. The observed Doppler velocity distribution is made of three components: a blue-shifted south-eastern arc, which can be described as a ring in slow radial expansion, $\sim$1.7 km/s, making an angle of 50^o with the plane of the sky and born some 2000 years ago; a few arcs, probably born at the same epoch as the blue-shifted arc, distant from each other by several 100 AU, all sharing Doppler velocities red-shifted by approximately $3+/-2$ km/s with respect to the main star; the third, central region dominated by the circumbinary envelope, displaying two outflows in the north-eastern and south-western hemispheres. At short distances from the star, up to 1.5", they display very different morphologies. The south-western outflow covers a broad solid angle, expands radially at a rate between 5 and 10 km/s and is slightly red shifted. The north-eastern outflow consists of two arms, with a separation of 90^o on the plane of the sky, both blue-shifted, bracketing a broad dark region where emission is suppressed. At larger distances from the star, between 1.5" and 2.5" the dissymmetry between the two hemispheres is significantly smaller and both hemispheres display evidence for detached arcs, particularly spectacular in the north-eastern hemisphere. Close to the stars, we are observing a mass of gas surrounding Mira B, with a size of a few tens of AU, and having Doppler velocities with respect to Mira B reaching 1.5 km/s in each of the red and blue directions, which we interpret as gas flowing from Mira A toward Mira B, being eventually focused or even trapped by Mira B, with a possible small contribution of gas gravitationally bound to Mira B.

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Variability and dust winds of AGB stars

Sofie Liljegren
(Uppsala Universitet)

Asymptotic Giant Branch (AGB) stars are cool giants of low to intermediate mass that are violently bloated, pulsating and non-spherical, with very significant mass loss through a stellar wind. The wind driving in such stars is presumably a two-stage process; the large-amplitude pulsation of the stars induces shock waves levitating material to where dust can form. Radiative acceleration of this dust then induces a wind through collisional interaction between the dust and the gas. We explore the connection between the pulsations of AGB stars, which set the scene for a dust condensation, and the stellar atmosphere, where the wind driving occurs, to further investigate these processes. This is done by varying the pulsation properties at the inner boundary of dynamical model atmospheres (DARWIN), to replicate different possible pulsation scenarios, such as non-sinusoidal luminosity variations. It is found that assumptions made about pulsation properties can have large implications for the resulting mass loss rates and wind velocities.

HI emission from red giants with the VLA and FAST

Thibaut Le Bertre
(LERMA Observatoire de Paris)

Imaging studies with the VLA have revealed HI emission associated with red giants extended circumstellar shells. We analyse the spectral maps obtained on three AGB stars, Y CVn, RS Cnc and RX Lep. For Y CVn, the HI line profiles can be interpreted with a model of a detached shell resulting from the interaction of a stellar outflow with the local interstellar medium. We reproduce the spectral map by introducing a distortion along a direction corresponding to the star motion in space. We then use this fitting to simulate observations expected from the FAST radiotelescope. The HI maps of RS Cnc and RX Lep show a tail possibly resulting from stripping of the circumstellar shell by the ambiant medium. We discuss the potential of FAST for improving our description of the interaction between stellar winds and the ISM.

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Mass loss and structure of the envelopes around AGB and post-AGB stars

Van Trung Dinh
(Institute of Physics)

Evolved stars are usually surrounded by thick and expanding circusmtellar envelopes created by the mass loss process. These circumstellar envelopes are known to be strong sources of molecular emission. Observations of the molecular emission can provide detailed information on the structures and physical conditions within the envelopes, and thus can reveal the mass loss history of the central stars. In this presentation I will focus on the high angular resolution observations of the molecular emission from circumstellar envelopes around asymptotic giant branch (AGB), post-AGB stars. The high quality data together with detailed excitation modeling provide clear evidence of the clumpy and asymmetric structure of the circumstellar envelopes. The role of binary shaping of the circumstellar envelopes is also discussed.

CO and N2 differential depletion in prestellar cores: experimental study of N2 desorption induced by the presence of CO on ices

Hoang Phuong Thanh Nguyen
(LERMA LAMAP Cergy Pontoise University)

CO and N2 are two of the most abundant species in molecular clouds. CO molecules are heavily depleted from the gas phase toward the centre of prestellar cores, whereas N2 molecules still maintain a high gas phase abundance (i.e in L183, CO is depleted by a factor of 364 in the center by comparison with outer parts of the molecular cloud, whereas N2 is only depleted by a factor of 10 (Pagani 2012)). The reason of this difference is not understood because CO and N2 have identical masses, similar sticking, and relatively closed the binding energies (Fayolle 2015). Our aim is to analyse and interpret desorption energy of CO and N2 differences in the case of sub-layer regime when two molecules are mixed on the ice. All experiments are made using the experimental setup named VENUS (Vers de NoUvelles Synth'eses) set in the LERMA laboratory in the University of Cergy Pontoise. The CO and N2 are deposited on water ice surfaces (compact amorphous solid water, porous amorphous solid water, and crystalline). We have used the Thermally Programmed Desorption technique and the Reflection Absorption Infrared Spectroscopy to analyse the relevant binding energy distribution of CO and N2 molecules adsorbed in different proportions. The values of binding energy distribution range are calculated from 993 K to 1629 K for CO and from 890K to 1429 K for N2 in the pure cases. With the mixture case, the N2 binding energy is affected by the CO presence, whereas N2 desorb earlier in the presence of CO. Its effective binding energy is therefore lowered. We will show the results of our experiments and modelling following the method of Noble 2015, and will discuss the possible impact of the reduced values of the binding energy of N2 in the context of prestellar cores.

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The Yellow Hypergiant Hen3-1379

Nick Cox
(IRAP)

Hen3-1379 is a yellow hypergiant (YHG) with evidence for episodic non-quiescent mass-loss in the last 400-1000 years during the post-red supergiant (RSG) phase of its evolution. The observational evidence (mid-to far-infrared imaging) suggests that though similar to the low-luminosity LBV Wray15-751, it has not yet moved to the hotter phase and is thus pre-LBV. This confirms the scenario of significant mass-loss during the RSG phase.

Bow shocks

Allard Jan Van Marle
(Laboratoire APC)
Nick Cox
(IRAP)

As stars evolve, they deliver feedback to the surrounding medium in the form of stellar wind and radiation. These shape the surrounding matter, forming what is called an astrosphere, a sphere of influence in which the star dominates the morphology and composition of the surrounding medium. Astrospheres are fascinating objects. Because they are formed through the interaction between the stellar feedback and the interstellar gas, they can tell us a great deal about both. Furthermore, because they are shaped over time they provide us with a window into the past. This is of particular interest for the study of stellar evolution, because the astrosphere reflects changes in the properties of the stellar wind, which relate directly to the properties of the star. A special sub-class of astrospheres, the stellar bow shocks, occur when the progenitor star moves through the surrounding medium at supersonic speed. Because the properties of the bow shock relate directly to both the stellar wind and the interstellar medium, the shape and size of the bow shock can be used to determine these properties. Using state of the art numerical codes it is possible to simulate the interaction between the stellar wind and radiation and the interstellar medium. These results can then be compared to observations. They can also be used to predict the type of observations that are best suited to study these objects. In this fashion computational and observational astronomy can support each other in their efforts to gain a better understanding of stars and their environment.

Interstellar dust distribution in the region of interaction of the stellar wind with the interstellar medium

Olga Katushkina
(Space Research Institute RAS)

The interstellar dust is one of the components of the interstellar medium. Modeling of the dust distribution is needed for investigation of many different astrophysical problems. In particular, interstellar dust plays an important role for studying of the astrospheres (i.e. interaction regions between the stellar wind and the interstellar matter), because emission from the dust can be measured remotely and indicate the structure of the astrosphere (e.g. distance to the astropause and/or the bow shock). Nowadays an interest of the "astrospheric" research is growing due to a lot of new good quality observations that provide us images of different astrospheres. Most of these observational data reflect the dust distribution in the astrosphere. To analyze and interpret these data one needs to apply a numerical model of the dust motion in astrosphere. In this work we present a kinetic model of the interstellar dust distribution in the astrospheres. The model takes into account several forces, which determine the trajectory of a dust grain: electromagnetic Lorentz force, gravitational attractive force to the star, radiative repulsive force and drag force due to dynamical interaction with plasma component. To calculate the plasma parameters and magnetic field in the astrosphere we use three-dimensional MHD model developed by our group. It is shown that the dust distribution in the astrosphere can be quite complex and strongly depends on the charge-to-mass ratio of the considered dust grains. We present the results obtained for the heliosphere (astrosphere around the Sun) and several other stars.

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Stellar and interstellar magnetic field effects on the global structure of astrospheres

Vladislav Izmodenov
(Space Research Institute RAS)

We present results of 3D magneto-hydrodynamic modeling of the global structures of the astrospheres that is determined by the interaction of the stellar wind with the surrounding interstellar. We will explore 1) how the structure and size of an astrosphere depends on the magnitude and direction of the interstellar magnetic field, 2) how the magnetic field influence the shape of the bow shock, 3) effect of stellar magnetic field. We will show that even very week stellar field can dramatically change the astrospheric stucture. Also, we will discuss how the magnetic field effects are pronounced in the observed astrospheric images. Special case of astrosphere - the heliosphere - will be considered as well.

H2 emission from magnetised bow-shocks around stellar winds.

Ngoc Tram Le
(LERMA ENS)

When a fast moving star meets a diffuse interstellar cloud, the surrounding gas gets heated and illuminated: a bow-shock is born which delineates the wake of the star. In the process, new molecules are generated and excited and they become accessible to observations. When the star emits a wind, the wind material itself is shocked. Here, we revisit models of H2 emission in these bow-shocks. We approximate the bow-shock by a statistical distribution of planar shocks computed with a state-of-the-art magnetised shock model (the Paris-Durham shock code). We improve on previous studies by considering the effect of the age of non-steady C-shocks on the H2 excitation diagram and H2 emission line shapes. We examine how the line shapes depend on the shock velocity and the viewing angle. We demonstrate the observational biases which can occur when the number of H2 lines observed is too small. Finally, we present recent developments in the shock model which allow it to describe stellar winds. This enables a detailed description of the chemistry and the cooling and heating processes which take place in stellar winds.

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The origin of B-type runaway stars: Nitrogen abundances as a diagnostic.

Willem-Jan De Wit
(European Southern Observatory)

There are two accepted mechanisms to explain the origin of runaway OB-type stars, the Binary Supernova Scenario (BSS), and the Cluster Ejection Scenario (CES). In the BSS model, material processed by the CNO bi-cycle could be transferred from the primary to the secondary prior to the supernova explosion, leading to an enhanced nitrogen abundance. TLUSTY non-LTE model atmosphere calculations have been used to determine atmospheric parameters and nitrogen abundances for 40 B-type runaways. The N ii spectrum was employed to determine N abundances or upper limits, and the results analysed to investigate the relative importance of the BSS compared to CES. Most stars in the sample have normal N abundances, in accordance with single star evolutionary models, including rotational mixing. Only one object could show both the characteristics of having been ejected from the plane of the Galaxy by the BSS, i.e. high ve sin i and high N abundance.

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Molecules in planetary nebulae

Yong Zhang
(The University of Hong Kong)

Circumstellar envelopes (CEs) around evolved stars are an active site for the production of molecules. After evolving through the Asymptotic Giant Branch (AGB), proto-planetary nebula (PPN), to planetary nebula (PN) phases, CEs ultimately merge with the ISM. Thus the study of PNe is the key to understand he transition from stellar to interstellar materials. The gas-phase molecules synthesized in CEs are believed to be the precursors of complex organic compounds. Strong ultraviolet radiation from PN central star can heavily photoionize, photodissociate or process molecules, resulting in different molecular compositions during the AGB-PPN-PN evolution. The discoveries of C60 and C60+ in circumstellar and interstellar environments suggest that large molecules can survive in PNe and enrich the ISM. In this presentation I shall briefly review some recent radio and infrared observations of molecules in PNe. Circumstellar chemistry and its link with interstellar matters will be disc ussed.

Stellar Archeology using Wind Properties

Eva Villaver
(Universidad Autonoma de Madrid)

The details of the Planetary Nebulae (PNs) shaping remain one of the unresolved problems in stellar evolution. Classical nebular models assume that PN morphology is due to an asymmetric density structure developed as the star ascend the Asymptotic Giant Branch (AGB), caused either to a combination of stellar rotation and magnetic field, or to the presence of a stellar or sub-stellar companion. Observations show that circumstellar envelopes around AGB stars are spherical symmetric, while highly asymmetric outflows are observed in a good fraction of proto-PNs, similarly to PNs. We have build models that try to account for the observed evolutionary sequence by exploring the rotation of the star. We have developed models of the formation of shells due to the long-term evolution of AGB winds and we have explored how the circumstellar envelopes of AGB stars interact with the interstellar medium (ISM) due to their differential velocities. The goal is to determine what information and how can be extracted from models to account for the observed relations between the metal content of the gas, the progenitor mass, the PN morphology and the binary nature of the star.

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Maser jets around water fountain stars: insights into late stellar evolution from VLBI astrometry

Gabor Orosz
(Kagoshima University)

One of the pivotal questions in stellar evolution is how to explain the formation of planetary nebulae, whose morphology depart significantly from spherical symmetry. Understanding this evolutionary step requires us to investigate the short-lived change in the mass-loss mode from spherical to bipolar, or even multipolar. There is a lot of observational evidence that the asymmetric shaping of the circumstellar envelopes (CSE) of evolved stars is already well under way prior to photoionization, mainly in the asymptotic giant branch (AGB) and post-AGB phases.

The so called water fountain stars are probably key sources which may provide hints about the processes carried out during the changes in the regimes of stellar winds. They are evolved stars that host high-velocity water masers in their CSEs, which trace the shocked regions of recently formed bipolar outflows. These water jets allow us to use very long baseline interferometry (VLBI) to map and precisely measure the evolution of these compact masers on a milliarcsecond scale, which is the only method of measuring the astrometry of the outflows themselves. With maser VLBI we can directly observe the shape and kinematics of the shocks, which tell us about the nature of the host and the outflow mechanism. We can also infer the density of the medium by the propagation of the jets and see how these outflows evolve and interact with their environments.

Here we present the most recent results of our VLBI maser projects of two water fountain sources, IRAS 18043-2116 and IRAS 18113-2503. Both of them are post-AGB stars that host young and powerful jets pumeling into a surrounding CSE, and are just undergoing their final mass-loss phase. Based on the results, we illustrate the water fountain phenomenom, describe the shocked regions immersed within the outflows, the information obtained about the host star and the CSE, and the implications on stellar evolution.

PAHs and H2 in the Ring Nebula

Nick Cox
(IRAP)

We present a new analysis of Spitzer spectroscopic imaging of the Ring Nebula (NGC6720) which reveals for the first time the presence of polycyclic aromatic hydrocarbons in the main dust ring of this high-excitation oxygen-rich (C/O 0.6) Planetary Nebula. The spatial distribution of H2 and PAH emission are closely related and appear to be associated with dense knots (previously imaged at high resolution in the near-infrared H2 line) that are located inside the ionised region surrounding the hot (T 120.000 K) central star. The knots are exposed to a mild radiation field of G0   200. The infrared H2 emission corresponds to warm (T 620 K) molecular gas with similar conditions as found previously for the Helix Nebulae. We find an unusual low value for the I(7.7)/I(11.3) ratio which can be understood if all emitting PAHs are neutral. We discuss a scenario in which photo-dissociation of CO produces large quantities of free carbon which is necessary to start a rich carbon-chemistry (converting from an initially oxygen-rich gas) that provides a scheme for the bottom-up formation of large carbonaceous molecules. We address the implications these new results have for our understanding of the chemical enrichment of the interstellar medium by evolved stars.

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Dust formation in AGB stars

David Gobrecht
(INAF-Oacte)

Dust formation is intimately connected with stellar mass loss. In order to drive mass loss, the circumstellar matter must overcome the gravitational pull of the star. Such a situation occurs, if periodic stellar pulsations, which compress, heat and accelerate the ambient medium, and dust grains, which are subsequently driven outwards by radiation pressure, are present in the circumstellar envelope (Höfner 2008). Dust grains form from atmospheric gas phase molecules and elements that are abundant, refractory and nucleate efficiently. In oxygen-rich stars, clusters of metal oxides (SiO, AlO, FeO, TiO) and metals (Fe, Si, Al) fulfill these criteria. In Carbon-rich stars, clusters of PolyAromatic Hydrocarbons (PAHs), SiC and metal sulphides build up the dust grains. Clusters with sizes below   500 $\AA$ may differ significantly from their bulk analogues, owing to quantum effects and a large surface-to-volume ratio. In particular, geometric structure, atomic coordination, energetics and vibrational spectra are affected by small cluster sizes (Goumans & Bromley 2012). It is thus of great importance to characterise the various cluster forms and types, which ultimately link gas molecules with solid dust particles. I will review the complex state of an AGB star, involving the behavior of AGB internal layers (Cristallo et al. 2009, 2011) as well the physical and chemical structure of the dust formation zone. Moreover, I will present new results on structures, energetics, infrared spectra and nucleation pathways for dust clusters. In particular, I will focus on the formation of alumina, Mg-rich silicates (forsterite and enstatite) as well as SiC (Gobrecht et al. 2016).

Sowing the seeds of dust:
what does it take to make a giant star dusty?

Iain Mcdonald
(Jodrell Bank Centre for Astrophysics)

The familiar pulsation-enhanced dust-driven wind is the "standard model" of mass loss from AGB stars. Yet the detailed physics of this process are poorly understood, particular in stars unlike the well-studied solar-neighbourhood examples. Our knowledge of the gas-to-dust ratios, wind velocities and grain properties in these environments are very limited, making accurate comparisons difficult. One important parameter that is much less affected by these issues is the point at which AGB stars (and perhaps sometimes RGB stars) first perceptibly start to produce dust, and how that relates to the stellar pulsation properties. In this presentation, I will tour the populations of the Local Group, sampling stars of different masses and metallicities, and report on the luminosities, temperatures, and pulsation properties of the stars the are just beginning to produce dust. I will link these back to the physical principles underlying mass loss, uncovering some of the triggers that can dramatically increase the mass-loss rate. I will extend this tour to show what can be accomplished by marrying these observations to stellar evolution models, which can help determine the lifetimes of each phase, and provide a better absolute calibration to the mass-loss rate. I will finish by examining the near future, detailing our plans to derive an empirical relation describing the mass-loss rate from single stars as a function of mass, metallicity and evolutionary time.

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Constraining dust properties in Circumstellar Envelopes of C-stars in the Small Magellanic Cloud:
optical constants and grain size of carbon dust

Ambra Nanni
(Dipartimento di Fisica E Astronomia)

We present our recent investigation aimed at constraining the typical size and optical properties of carbon dust grains in Circumstellar envelopes (CSEs) of C-stars in the Small Magellanic Cloud. To achieve this goal, we apply our recent dust growth model, coupled with a radiative transfer code, to the CSEs of C-stars evolving along the TP-AGB, for which we compute spectra and colors. We then compare our modeled colors in the NIR and MIR bands with the observed ones, testing different assumptions in our dust model and employing several optical constants data sets for carbon dust available in the literature. Different assumptions adopted in our dust model change the typical size of the carbon grains produced. We finally constrain carbon dust properties by selecting the combination of typical grain size and optical constants which best reproduces several colors in the NIR and MIR at the same time. The approach is new and has never been adopted so far. We conclude that the complete set of selected NIR and MIR colors are best reproduced by small grains, with sizes between 0.06 and 0.1 microns, rather than by large grains of 0.2-0.4 microns. Remarkably, the inability of large grains to reproduce NIR and MIR colors seems independent of the adopted optical data set. We also find a possible trend of the typical grain size with the dust reddening in the CSEs of these stars. We finally emphasize that this work is preparatory to follow-up studies aimed at calibrating the TP-AGB phase through resolved stellar populations in star clusters and galaxies which include dusty, mass-losing evolved stars.

Stellar evolution and winds

Kyung-Won Suh
(Chungbuk National University)

Nearly all asymptotic giant branch (AGB) stars can be identified as long-period variables (LPVs) with large amplitude pulsation. The AGB phase of an LPV is characterized by dusty stellar winds with high mass-loss rates. The superwind and chemical transition from O to C, which are induced by a thermal pulse during the AGB phase, is known to make major effects on the dust stellar winds from AGB stars. As the star leaves the AGB phase, its mass-loss rate decreases significantly and the star may become hot enough to ionize its circumstellar material. When mass-loss reduces the mass of the remaining H-rich envelope below some critical mass, the stellar envelope begins to shrink and the effective temperature starts to increase until the central star is hot enough to ionize the circumstellar nebula and the object becomes a planetary nebula (PN). The intermediate phase between the end of the AGB phase and the PN phase is called the post-AGB phase. In this presentation, we review on how properties of the dusty stellar winds change as a star evolves from an AGB star to a PN.

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Binary evolution of CH and Barium stars

Drisya Karinkuzhi
(Indian Institute of Astrophysics)

CH stars and Barium stars are known to show enhanced abundances of heavy elements (neutron-capture elements). Most of these stars are binaries and the observed abundances are explained on the basis of a binary picture involving a now extinct white dwarf as a companion. In the recent years a number of binary scenarios are put forward to explain the observed abundances; however most of these scenarios that involve mass transfer through stellar winds and Roch-Lobe overflow still lack in several aspects to explain the observed abundances. We will examine some of these scenarios based on our observed abundance data and discuss some possible improvements that may necessary in reproducing these abundances.

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Very Massive Stars in High Metallicity

Norhasliza Yusof
(University of Malaya)

In this work, we are going to discuss the stellar evolution of Very Massive Stars (M>100 Mo) at Z=0.02 metallicity. This includes their general properties, the impact on the chemical abundances due to the rotation and the mass loss of very massive stars. Very massive stars have a very large convective core during the main sequence thus their evolution is not affected by rotational mixing but by the mass loss due to the stellar winds. In this work we are also going to discuss the the fate of VMS.

Evolution & nucleosynthesis in low- and intermediate-mass stars of metallicities Z = 0 to 0.04

Carolyn Doherty
(Konkoly Observatory, Budapest, Hungary)

We present evolution and nucleosynthesis computations for a large grid of low- and intermediate- mass stars. These detailed models are in the initial mass range from 0.8 Msun up to the limit for core collapse supernova of about 8-10 Msun and cover a broad range of metallicities from the first, primordial stars (Z=0) to those of super-solar metallicity (Z=0.04). Each model star is evolved from the zero-age main-sequence until the end of the thermally pulsing asymptotic giant branch (AGB) phase. In our nucleosynthesis calculations we follow all elements from H to Bi and use either a standard network of 475 nucleosynthetic species, or an extended network with over 700 species which includes more neutron rich isotopes further from beta stability. This larger network is appropriate for models, such as those at lower metallicity, which reach higher neutron densities. We describe a selection of the uncertainties that influence our evolution & nucleosynthetic calculations such as the efficiency of convection, the mass-loss rates, nuclear reaction rates, the third dredge-up efficiency and the Fe-peak opacity instability which may lead to expulsion of the entire remaining stellar envelope. We provide a broad overview of our study results as well as highlight interesting results such as heavy element production in low metallicity models and super-AGB stars.

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Focused stellar wind in Cygnus X-1

Jan Cechura
(Astronomical Institute of The CAS)

The isotropy of the stellar wind from the donor in the high-mass X-ray binaries (HMXBs) is significantly disrupted by the presence of the compact companion as well as by the mutual orbital motion of both components. The outflow is particularly enhanced in the direction to the companion, hence we talk about focused stellar wind. In HMXBs, the donor is a luminous massive OB supergiant. The process responsible for launching gas from the stellar atmosphere and, subsequently, pushing it outwards, is based on a modified version of the line-driven wind model where the material is accelerated by the line absorption of the star's radiation field. Such a mechanism is inherently sensitive to any changes of wind characteristics, e.g. ionization structure. Therefore, a self-consistent approach must be adopted in any realistic model of the wind in such systems. We developed a three-dimensional radiation-hydrodynamic model of the circumstellar matter and use it to simulate dynamics, aniso tropy and other characteristics of the stellar wind in HMXBs. In order to test the reliability of the numerical model as well as to set constrains on various physical parameters and processes, e.g. the accretion rate, we use Doppler tomography - an indirect imaging method - to probe the structure of radiation emitting material in Cygnus X-1. Here, we introduce a data interpretation method which uses synthetic Doppler tomograms calculated from the results of our simulations, and compares them directly with the observed Doppler tomograms based on phase-resolved optical spectroscopic data of Cygnus X-1.

The mass-loss of the hot massive stars in I Zwicky 18

Dorottya Szécsi
(Astronomical Institute Czech Academy of Sciences)

Hot massive stars with weak winds have been recently predicted to exist at low-metallicity. We followed the post-main-sequence evolution of the hot massive star models of Szécsi et al. (2015), which were computed with the initial composition of the metal-poor dwarf galaxy I Zwicky 18. Our simulations of the post-main-sequence phase predict that both Wolf-Rayet stars, both Transparent Wind Ultraviolet Intense (TWUIN) stars are present in low-metallicity environments. Although these objects may help us interpret several observational results (e.g. the unusually high photoionization in metal-poor environments, or the metallicity-dependence of certain types of superluminous supernovae and gamma-ray bursts), their mass-loss rates are not well constrained. Here we investigate how a higher mass-loss rate changes the predictions of the models. We find that applying an alternative mass-loss rate (which is higher than the original) leads to 2/3 times less ionizing photons emitted by a theoretical stellar population in the He II continuum, and a lower number of WC type stars. We also find that the GRB to SN ratio becomes lower with a higher mass-loss, due to the higher angular-momentum loss of these models. Our results demonstrate the need for reliable mass-loss prescription for hot stars, especially at low-metallicity. We conclude that although stellar evolutionary computations could be used, for example, to predict the cosmic GRB rate, to do this, we need to have a good understanding of how the winds of hot massive stars at low-metallicity behave, as the quantitative outcome of the predictions depends very strongly on the mass-loss rates applied.

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Carbon-Enhanced Metal-Poor stars: binarity, evolution, nucleosynthesis, and, the impact on cosmochemistry

Aruna Goswami
(Indian Institute of Astrophysics)

Carbon-Enhanced Metal-Poor (CEMP) stars represent a significant fraction of the low end of the Galactic halo metallicity distribution. These stars exhibit four different heavy element abundance patterns. The most numerous class is characterized by enrichment of neutron-capture elements with an abundance pattern compatible with the operation of the s-process in asymptotic giant branch (AGB) stars. For these stars as well as for their more metal-rich counterparts, the CH stars, binarity is an essential requirement to explain their overabundances of carbon and neutron-capture elements. Another class of CEMP stars exhibits large overabundances of elements produced by both s-process and r-process. The CEMP stars that do not show enhancement of heavy elements form another class, and, there is yet another class of CEMP stars that are characterized by r-process enhancement, although this later class has very few confirmed examples till now. I will discuss how the chemical abundances observed in these stars are employed to unravel a variety of details and their impact on cosmochemistry.

Modelling the interactions of evolved stars with (sub)stellar companions

Shazrene Mohamed
(South African Astronomical Observatory)

Both hot and cool evolved stars, e.g., red (super)giants and Wolf-Rayet stars, lose copious amounts of mass and momentum through powerful, dense stellar winds. The interaction of these outflows with their surroundings results in highly structured and complex circumstellar environments, often featuring knots, arcs, shells and spirals. Recent improvements in computational power and techniques have led to the development of detailed, multi-dimensional simulations that have given new insight into the origin of these structures, and better understanding of the physical mechanisms driving their formation. In this talk, I review one of the main mechanisms that shapes the outflows of evolved stars: interaction with a companion. I will discuss both wind-wind interactions where the companion also ejects a stellar outflow, and mass-transfer interactions where the companion has a weak or insignicant outflow. I will also highlight the broader implications of these stellar wind interaction s for other phenomena, e.g., planetary nebulae, symbiotic and X-ray binaries, novae and supernovae.

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Resolving the extended atmosphere and the inner wind of Mira (omicron Ceti) with long ALMA baselines

Ka Tat Wong
(MPI for Radio Astronomy)

We present the recent ALMA data of Mira (omi Cet) which show its radio photosphere, extended atmosphere, and inner wind at an unprecedented detail. Mira was observed in the 2014 ALMA Long Baseline Campaign with baselines up to 15 km. The data produce images of SiO and H2O emission/absorption at an angular resolution of 30 mas at 220 GHz, which clearly resolve the wind of this prototypical Mira variable within the dust condensation radius. Very unique in the dataset is that molecular transition lines are seen in *absorption* towards the continuum source, even in lines which are dominated by maser emission, allowing detailed studies of physical conditions and chemistry along the line of sight. We have modelled the 28SiO J=5-4 v=0, 2 and H2O nu_2=1 J(Ka,Kc)=5(5,0)-6(4,3) emission and absorption with the aim to understand the spatial structures of Mira's extended atmosphere, dust condensation process, shock dissipation, and the kinematics. The results challenge previous hydrod ynamic and dust-formation models of Mira and Mira variables.

Light curve asymmetry of the symbiotic binary SY Mus as a result of absorption by the wind from its giant component

Natalia Shagatova
(Astronomical Institute Slovak Academy of Sciences)

Light curves of the symbiotic binaries, the widest interacting systems, often show an asymmetry of the descending and ascending branches of their minima. This effect can be caused by an asymmetrical distribution of the wind around the red giant with respect to the binary axis, which thus attenuates the light from the white dwarf accretor to different extent during the ingress and egress. In this contribution, we tested this hypothesis by modelling asymmetrical light curves of the eclipsing symbiotic binary SY Mus at 10 wavelengths, from 1280 to 3080A. We used the wind velocity profiles obtained by fitting measured neutral hydrogen column densities and included the ionization structure of the binary. As the relevant attenuation processes in the continuum, we considered: 1.) the Rayleigh scattering and the scattering on negative hydrogen (in neutral wind region) and 2.) the Thomson scattering and the scattering on neutral hydrogen (in predominantly ionized wind region). Our models support the idea that the observed asymmetry in the light curves of SY Mus is caused by the asymmetrical wind distribution in the circumbinary environment.

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Dichotomy of wind-fed HMXBs

Rainer Hainich
(University Of Potsdam)

High-mass X-ray binaries (HMXBs) encompass a massive star and a compact object that is orbiting deep inside the stellar wind of its companion. The degenerate object accretes matter either from the wind or a disk around the massive star, hereby emitting a strong X-ray continuum. These systems provide a variety of diagnostics, rendering them as unique physical laboratories for studying stellar winds and stellar evolution. In this talk, we present a detailed study of two types of wind-fed HMXBs: Supergiant X-ray Binaries (SGXBs) and Supergiant Fast X-ray Transients (SFXTs), which harbor similar donor stars but, at the same time, show very different behavior in the X-rays. Different theoretical explanations for this dichotomy are discussed in the literature. To distinguish between these theories comprehensive analyses of entire HMXB systems are indispensable. However, while HMXBs are often well studied in the X-rays, only a few donor stars are analyzed by means of sophisticated stellar atmosphere models. We have obtained optical and UV spectroscopy for the donor stars in six Galactic HMXBs, equally covering SGXBs and SFXTs. These observations are fitted with synthetic spectra, calculated with the Potsdam Wolf-Rayet model atmosphere code (PoWR), which accounts for the superionization of the stellar wind by the X-rays emitted from the compact object. The stellar and wind properties derived for the donor stars allow us to put constraints on the dichotomy observed for wind-fed HMXBs and to test the effect of the stellar wind on different accretion regimes.

An ALMA view of the (post-common-envelope-evolution) post-AGB object HD101584

Hans Olofsson
(Onsala Space Observatory)

HD101584 is among the most powerful proto-PN jet systems, and is unique in having a companion that was engulfed by an AGB star, during which process the stellar envelope was ejected - and survived. ALMA cycles 1 and 3 observations of CO isotopologues and 1.3 mm continuum are used in a study of the circumstellar environment of this binary system, a post-AGB star and a low-mass companion that is most likely a post-common-envelope-evolution system. These data are supplemented with new information from OH maser emission. It is inferred that the large-scale circumstellar medium has a bipolar hour-glass structure, seen almost pole-on, formed by an energetic, >150 km/s, jet. Significant amount of material still resides in the central region. It is proposed that the circumstellar morphology is related to an event which took place <500 yr ago, possibly a capture event where the companion spiralled in towards the AGB star. Several observed features remain to be explained, and may hint to a more complicated scenario. In addition to this, we have detections of line emission from SiO, CS, H2S, SO, SO2, OCS, H2CO, and some of their isotopologues.

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AMUSEing winds in binary stars

Martha Irene Saladino Rosas
(Radboud University Nijmegen)

Most stars are found in binary systems. During their evolution, especially during the AGB phase, stars lose material due to stellar winds; a fraction of this material can be gravitationally accreted by the companion, producing changes in the system. We investigate mass transfer in low-mass binaries to see how the mass accreted by the companion depends on the orbital parameters of the system and how it affects the evolution of the orbit. Using the AMUSE framework, we perform SPH simulations of the outflow from the primary star and by coupling it with a gravity code, we study the interaction of the matter with the secondary. We have studied the flow structure for a few simple cases: a constant wind velocity profile with isothermal and adiabatic equations of state, as well as more realistic simulations in which cooling of the gas has been included. Our preliminary results show a clear spiral structure in the outflow and evidence for an accretion disk forming around the secondary star.

Wolf-Rayet binaries in the Magellanic Clouds: winds versus Roche lobe overflow at low metallicity environments

Tomer Shenar
(University Of Potsdam, Germany)

Wolf-Rayet (WR) stars are evolved stars characterized by powerful, radiation-driven stellar winds, which immensely affect their surroundings. Massive stars reach the WR phase after having shed enough material to approach the Eddington limit, either via stellar winds or via mass-transfer in binary systems. About 40

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Combining interferometric measurements with hydro simulations to understand the colliding wind binary Gamma Vel.

Astrid Lamberts
(California Institute of Technology)

For decades, colliding stellar winds in massive binary systems have been studied through their radio and strong X-ray emission. Spectro-interferometric observations in the near infrared have recently become available for certain binaries and can provide unique information on the spatial structure of the wind collision region. However, identifying the different contributions to the emission remains a challenge. 3D hydrodynamic simulations reveal a complex double shocked structure and can guide the analysis of observational data. In this work, we analyse the wind collision region in the WR+O binary, γ^2 Velorum. We combine multi-epoch AMBER observations with mock emission maps and visibility curves obtained with hydrodynamic simulations with the RAMSES code to identify the colliding wind region.

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Stellar winds and the complex evolution of globular clusters

Maurizio Salaris
(Liverpool John Moores University)

The last decade has seen a 'revolution' in our understanding of the stellar content of globular clusters. Spectroscopic and photometric observations have conclusively disclosed the presence of several different stellar populations in individual globulars. Stellar winds from various types of stars (supernovae, AGB or massive rotating stars) and inflows/outflows are generally considered the main engine that drives the formation of these multiple populations.This review will discuss the role played by these winds, and the several open problems of these scenarios.

A comparison of galactic metallicity gradients: the Illustris simulation vs. recent IFU observations

Anne Klitsch
(Max Planck Institute For Astrophysics)

An important ingredient in our understanding of galaxy formation and evolution is the production and evolution of heavy elements ("metals") throughout cosmic time. As galaxies assemble, their gas phase metallicities evolve as a result of several distinct physical processes. Metals are produced in stars, released by supernovae and stellar winds and distributed throughout the nearby interstellar medium (ISM) by mixing and diffusion. While the former processes enrich the ISM, metals can be expelled entirely due to galactic winds driven by star formation, or through energetic feedback from super massive black holes. Furthermore, cosmological inflow of pristine or minimally enriched gas can dilute the local metallicity. A negative gradient, with high central metallicity decreasing outwards in radius, is the expected consequence of inside-out growth, while mergers can flatten these gradients, and inflow of gas can even cause positive gradients. I will present results from our study in which we analyze the metallicity distribution of galaxies using the Illustris simulation. By adopting an approach comparable to that used in observations we aim to compare these with recent results from IFU observations. We characterize in detail the physical metallicity profiles, considering both global behavior as well as sub-populations of different galaxy types at fixed stellar mass. By following the evolution of individual galaxies over time we will disentangle different physical contributions with a specific focus on the role of mergers and the influence of the assembly history on the metallicity gradients of galaxies. We investigate thereby how the observed metallicity gradient of any specific galaxy can provide insight into its past evolution.

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Wind-blown bubbles in the Galaxy

Bram Ochsendorf
(Johns Hopkins University)

The high-angular resolution and high sensitivity of Spitzer and Herschel revealed that the Galactic plane is dominated by filaments and shells on all spatial scales. Invoking the help of the general public, some 6000 'bubbles' have now been identified, demonstrating the major impact of massive stars and their dominance over the global structure of the Galactic ISM. In this talk I will review our current understanding of these Galactic bubbles spanning a wide range of morphologies and sizes that relate to their stellar content, evolutionary state, and physical structure of the ISM in which they expand. I will highlight different feedback mechanisms that may drive the evolution of Galactic bubbles, how we can use observations to distinguish between these mechanisms, and address in which regimes stellar winds dominate the expansion process. Finally, I will discuss the importance of Galactic bubbles to the energy budget of the ISM and (massive) star formation.

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Diffuse X-ray emission as probe of Stellar Evolution

Jesus Toala
(ASIAA)

Throughout their lives, massive stars shape and heat the Interstellar Medium with their powerful winds and ionising photon fluxes. They carve cavities of tens of parsecs filled with hot plasmas that can be studied with X-ray satellites. In this talk we review our current knowledge of the formation and X-ray emission of hot bubbles around massive stars in different evolutionary stages: O-type stars and Wolf-Rayet stars.

Blowing a galactic wind - The impact of stellar feedback at low star-formation rates in numerical simulations

Gerhard Hensler
(University of Vienna)

Over the recent years more dedicated observations uncovered star formation to occur with extremely low rates in dwarf galaxies and in the outskirts of galaxies like e.g. tidal tails and ram-pressure stripped gas clouds. For low-mass gas reservoirs the question must be addressed to what extent the empirical initial stellar mass function can be filled to the high-mass regime. While observations point towards steeper mass funtions with a lack of massive stars and upper-mass cut-offs of light stellar clusters, numerical simulations of galaxy evolution usually do not care for this fact. On the basis of numerical evolutionary models of dwarf galaxies with low star-formation rates we discuss to what extent varying initial stellar mass functions affect star-formation self-regulation, galactic winds, and chemical abundances.

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Radiation-driven and wind-blown HII regions and their energy transfer efficiency

Gerhard Hensler
(University of Vienna)

Due to their short lifetimes but their enormous energy release in all stages of their lives massive stars are the major drivers of the cosmic matter circuit. Since they affect not only their close environment during their lifes but also stir up the interstellar medium and lead to mass flows on galactic scales, for our understanding of galaxy evolution as well as of star-formation self-regulation it is of crucial importance to know the energy transfer efficiency by radiation-driven and wind-blown HII regions to the interstellar medium. Here we will compare analytical results with radiation-hydrodynamical models of single massive stars which allow us to directly derive energy-transfer efficiencies. As an additional issue of these models the element release in the Wolf-Rayet phases and the detectability of an element enrichment are investigated and compared with observations.

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Science highlights from the European VLBI Network and SKA

Michael Lindqvist
(Onsala Space Observatory)

The European VLBI Network (EVN) has improved considerably during recent years and as a result it is producing excellent science. This is of course of fundamental importance and the main motivation for further developments of the EVN. In order to meet the demands of the astronomers the EVN is making use of and driving technical progress. We will describe the present status of the array and outline some of the planned future technical directions. In addition, we will also show scientific highlights related to stellar winds that have been obtained using the EVN and illustrate possible science areas in the future.

VLBI observations of circumstellar maser sources for exploration of stellar pulsation-driven shock waves

Hiroshi Imai
(Kagoshima University)

Intensive, long-term VLBI monitoring observations of circumstellar masers (SiO, H2O, OH) are crucial for tracing in great detail the dynamics of circumstellar envelopes of long-period variable stars such as Mira variables, in which pulsation-driven shock waves may be generated and enhance intensive mass ejection flows from the stars with spatio-kinematical inhomogenity. Weekly-monthly monitoring campaigns for this exploration are necessary to trace both effects of stellar light curves and shock propagation in the field of up to the OH maser shells. Such observations require dedicated VLBI arrays, but their operation it is still challenging. We have developed new large projects on circumstellar H2O and SiO masers with the KaVA (KVN and VERA Array), a combined VLBI array with the Korean VLBI Network (KVN) and Japanese VLBI Exploration of Radio Astrometry (VERA). They aim to simultaneously and regularly monitor those masers associated with 10-20 stars throughout a few stellar pulsation cycles. On the other hand, we are studying scientific and technical feasibility of intensive OH maser observations with the Square Kilometer Array (SKA) in VLBI mode and with combination between the SKA precursors such as ASKAP and the existing telescopes.Note that those observations also aim high accuracy measurement of trigonometric parallax distances and secular proper motions of the maser sources. This presentation will provide the recent status of these project planning.

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A review of recent VLTI results on stellar winds and perspectives with second generation instruments.

Xavier Haubois
(ESO)

In this contribution, I will first start to introduce the characteristics of VLTI and its unique ability to provide high-resolution diagnostics on wind morphologies and dynamics.Recent results based on VLTI observations will then be reviewed, ranging from young stellar objects and rotating hot stars to evolved objects and planetary nebulae. I will highlight coordinated studies that involve VLTI and other complementary instruments that constrain winds at different spatial scales. Finally, I will present the second generation of VLTI instruments, MATISSE and the recently available GRAVITY.

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