

REPORT ON THE RADIONET3 NETWORKING ACTIVITY

TITLE: STELLAR END PRODUCTS: THE LOW MASS-HIGH MASS CONNECTION

DATE: *6-10 JULY 2015* **TIME:** **4 DAYS**

LOCATION: *GARCHING/DE*

MEETING *<https://www.eso.org/sci/meetings/2015/STEPS2015.html>*
WEBPAGE

HOST *ESO*
INSTITUTE:

PARTICIPANTS: *112*

MAIN LEADER: *ESO*

REPORT:

1. Programme of the meeting

Attached

2. Scientific Summary

The mass loss from cool asymptotic giant branch (AGB) and red supergiant (RSG) stars leads to the formation of planetary nebulae and supernovae, respectively, and puts a large amount of material into the interstellar medium (ISM). Collectively it is therefore an important process for understanding the ecology of a galaxy and the lifecycles of stars of both low and high mass. There have been significant recent advances in observations and theory of the late stages of stellar evolution motivating a workshop to consider the synergies of AGB and RSG evolution. High resolution facilities, such as the Very Large Telescope Interferometer (VLTI) in the near-infrared and the Atacama Large Millimeter/submillimeter Array (ALMA) in sub-millimetre and millimetre wavebands, and other telescopes such as Hubble Space Telescope, start to resolve scales down to the size of the stars themselves. These new data provide an opportunity to revisit the outstanding questions of late stellar evolution which formed the core topics of the workshop.

The workshop extended from Monday afternoon to Friday, providing an intense 24 invited talks, 24 contributed talks and five lively discussion sessions. There were 46 posters and a special session with Beer and Bretzen on Wednesday afternoon was provided so the posters could be appreciated and discussed. The 112 participants enjoyed extensive snacks and a conference dinner in Garching. Many of the talks are provided on the Workshop web page where copies of many of the posters are also available. Participants came from institutions all around the globe, including Iran, South Africa, Israel, Mexico and Taiwan. 10 of the invited talks were given by women and 35% of the participants were female. The meeting was well-attended by students and post-doctoral researchers.

Opening Reviews

The first afternoon was devoted to overviews of the exploration of AGB and RSG stellar products from the observational side. The first scientific talk was a grand overview by Albert Zijlstra where the important role of mass loss in evolved stars of all masses for the enrichment of the ISM was laid out. The topic of asymmetry of the mass loss at all stages was introduced and was a recurrent theme throughout the meeting. Eric Lagadec presented a summary of the closely related recent meeting to commemorate Oliver Chesneau, entitled “The Physics of Evolved Stars”, which was held in Nice in June. The topics of the meeting had many similarities with the Workshop, covering Chesneau's work on low and high mass stars with particular emphasis on the use of high resolution and interferometry for studying the shapes and surfaces of stars and their immediate environments. Roberta Humphreys reviewed the evidence for mass loss in RSGs from optical and near-infrared observations. The near- and mid-infrared imaging and spectroscopy are now providing increasing detail on the mass loss, revealing it to be episodic and driven by pulsation and convection. The introductory sessions closed with presentations on the capabilities of ALMA and optical near-infrared (NIR) interferometry.

Mass loss mechanisms and dust

Susanne Hoefner provided a theoretical view on the dynamical atmospheres of AGB stars. The stellar pulsations and convection drive shock waves and dust can form in the atmosphere in the wake of the shocks. Radiation pressure on the condensed dust then drives mass loss. The type of the AGB star, M or C type, then sets the dust formation as either O or C for that fraction of the matter not locked in CO. The infrared opacity of C grains is featureless but silicate grains have many features; in O rich stars the candidates species for mass loss driving is Mg_2SiO_4 .

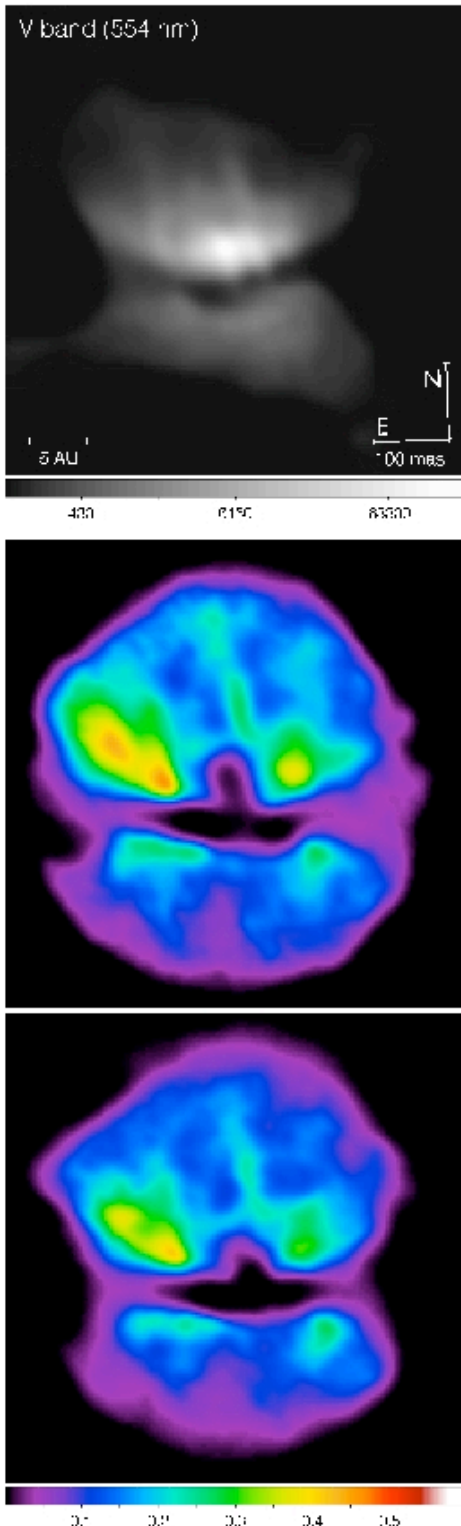


Figure 1: SPHERE ZIMPOL images of L2 Pup in V-band. Upper: the deconvolved intensity image (log scale); Middle: the linear polarization from the non-coronagraphic frames; Lower: linear polarization from the coronagraphic frames. The field of view is 0.60 by 0.60 arcseconds. From Kervella et al. 2015 (A&A, 578, 77)

Magnesium silicate grains with sizes in the range 0.1 to 1 μm appear to drive realistic winds in the models. More dust species are being investigated for their role in wind driving, especially for $\text{C/O} < 1$. Sara Bladh showed some of these time dependent wind models for M type stars and how the photometric variations through the pulsation cycle are well matched.

Anita Richards explored the properties of the clumps and asymmetries in the circumstellar environments of mostly O rich stars. The material is driven before it condenses to dust either by shocks in sub-photospheric layers or perhaps by the hottest dust condensing. Lynn Matthews described JVLA observations of some Galactic Cepheid stars to search for evidence of mass loss that could help to explain why the observed and model masses are not in good agreement. The discussion formed a comparison of the mass loss in high and low mass stars: it appears that AGB stars are more efficient at producing dust than the higher mass RSGs.

Binaries, shells & shaping

Michael Hillen showed the first milli-arcsecond (model-independent) image of the post-AGB binary star IRAS 08544-4431 taken with PIONIER. ALMA observations of binary AGB stars were presented by Sofia Ramstedt using CO as the main tracer of circumstellar gas and concentrating on sources with well-known binary separations. One of these is Mira where the combination of ALMA and APEX covers the compact and extended circumstellar structures: the fast wind from the evolved secondary has blown a hole in the slower primary star wind. A spiral structure, but viewed more end on than R Scl (or IRC+10216) was found for W Aql (also featured in the prize poster by Magdalena Brunner). Sphere ZIMPOL V- and R-band polarization images at a resolution of ~ 17 mas of the low mass 141 day period binary system L2 Pup were shown by Miguel Montargès (Figure 1). The structure was modelled by a dust disc using the RADMC-3D radiative transfer code; the binary with a separation of 3AU was resolved. L2 Pup is perhaps the progenitor of a bipolar PN.

Planetary nebulae & supernovae

Moving to the end products of evolution, planetary nebulae, from $M < \sim 8 M_{\text{sun}}$ stars, were the following topic. Joel Kastner gave a contemporary perspective on how wind shaping depends on successive episodes of asymmetry. A review of the last steps in the evolution of high mass stars – as progenitors of supernovae (SNe) – was given by Rubina Kotak. On account of the difficulty of detection and the sparsity of cases, detection of SN progenitors and postgenitors makes confirmation of the progenitor star(s) contentious in the majority of cases.

3. Attendance list (incl. participant names, affiliation and country) signed by the participants and confirmed by the organizer

Attached

4. Financial Report / RadioNet3 contribution

The RadioNet3 contribution of 4350€ was used

- to provide travel support to the invited speakers, SOC, LOC and select students by waiving the registration fee (25 x 150€=3750€).
- to support the travelling of three of the invited speakers (Rahul Shetty, Nia Imara, and Blakesley Burkhart) with 200€.

The list of people who received waived registration fees:

1. Betsey Adams, ASTRON (The Netherlands)
2. George Heald, ASTRON (The Netherlands)
3. Naomi McClure-Griffiths, RSAA-ANU (Australia)
4. Tom Oosterloo, ASTRON (The Netherlands)
5. Brad Frank, ASTRON (The Netherlands)
6. Eva Juette, Astronomisches Institut der Ruhr-Universitaet Boch (Germany)
7. Bob Benjamin, University of Wisconsin-Whitewater (USA)
8. Gurtina Besla, University of Arizona (USA)
9. Robert Braun, SKA (UK)
10. Blakesley Burkhart, Harvard-Smithsonian Center for Astrophysics (USA)
11. Erwin de Blok, ASTRON (The Netherlands)
12. Bruce Elmegreen, IBM (USA)
13. Edith Falgarone, ENS & Observatoire de Paris (France)
14. Filippo Fraternali, University of Bologna (Italy)
15. Mark Heyer, University of Massachusetts (USA)
16. Deidre Hunter, Lowell Observatory (USA)
17. Nia Imara, Harvard-Smithsonian Center for Astrophysics (USA)
18. Jill Rathborne, CSIRO (Australia)
19. Rahul Shetty, Heidelberg University (Germany)
20. Amiel Sternberg, Tel Aviv University (Israel)
21. Marc Verheijen, Kapteyn Astronomical Institute (The Netherlands)
22. Bahar Bidaran, Alzahra University (Iran)
23. Maryam Arabsalmani, ESO (Germany)
24. Anastasia Ponomareva, Kapteyn Astronomical Institute (The Netherlands)
25. Renzo Sancisi, Kapteyn Astronomical Institute (The Netherlands)

5. Conference Proceedings and Web page

There are no conference proceedings; instead presentations are available on the conference website at <http://www.astron.nl/localgas2015/programme.php>.

Day 1, Monday 6 July (afternoon)

13:00	Registration	
14:00	Tim De Zeeuw	Welcome and Opening
14:10	SOC/LOC	Announcements
Session 1: Overview (Chair:)		
14:20	Albert Zijlstra (invited)	Grand Overview
15:00	Eric Lagadec	Summary of the Recent Physics of Evolved Stars Meeting
15:20	Hans Olofsson (invited)	Radio/Mm/Submm Observations of AGB and RSG stars
15:50	Break	
16:20	Roberta Humphreys (invited)	RSGs and AGBs in the Optical and Infrared -- the Evidence for Mass Loss, Circumstellar Ejecta and Episodic Events
16:50	Leonardo Testi (invited)	Mm and Submm Interferometry, Current & Future Capabilities
17:20	Jean-Philippe Berger (invited)	Optical Interferometry: Current & Future Capabilities
17:50	Reception	

Day 2, Tuesday 7 July

Session 2: Stellar Evolution & Atmospheres (Chair:)		
09:00	Georges Meynet (invited)	Some Open Questions on the Physics of Stars
09:40	Paola Marigo	Linking the Evolution of AGB Stars with the Molecular Chemistry in their Circumstellar Envelopes
10:00	Alain Jorissen	Atmospheric Tomography of Supergiant Stars
10:20	Pierre Kervella (invited)	The Atmosphere of Red Supergiants at High Angular Resolution
10:50	Break	
11:20	Michael Gordon	Yellow Supergiants: Unlocking the Mysteries of Post-RSG Evolution
11:40	Ramiro De La Reza	Complex Organic and Inorganic Compounds in Shells of Lithium-Rich K Giant Stars
12:00	Benoit Mosser (invited)	Mixed Modes in Red Giants: a Window on Stellar Evolution
12:30	Discussion on Stellar Evolution & Atmospheres	

13:00	Lunch	
Session 3: Mass Loss Mechanisms & Dust (Chair:)		
14:30	Susanne Hoefner (invited)	Dynamical Atmospheres and Winds of AGB Stars: A Theorist's View
15:00	Sara Bladh	How M-type AGB Stars Bite the Dust
15:20	Theo Khouri	Investigating the Wind-Driving Mechanism in R Doradus
15:40	Ward Homan	Analytical Morphological Models and an Application to the CW Leo ALMA Data
16:00	Break	
16:30	Graham Harper (invited)	Testing Theoretical and Semi-Empirical Models of Red Supergiant Extended Atmospheres
17:00	Claudia Paladini (invited)	Surface Features with VLTI
17:30	Xavier Haubois	Probing the Inner Dust Shell of Betelgeuse with Polarimetric Interferometry
17:50	Peter Scicluna	Large Dust Grains in RSG Winds: High-Contrast Polarimetric Observations of VY Canis Majoris
Day 3, Wednesday 8 July		
09:00	Anita Richards (invited)	Radio/Sub-mm Clues to the Origins of Asymmetries and Clumps
09:30	Eamon O'Gorman	Spatially Resolved Radio/mm Continuum Studies of Red Supergiants
09:50	Dinesh Shenoy	Probing Hypergiant Mass Loss with Adaptive Optics Imaging and Polarimetry in the Infrared
10:10	Lynn Matthews	Searching for Evidence of Mass Loss on the Cepheid Instability Strip
10:30	Discussion on Mass Loss Mechanisms and Dust	
11:00	Break	
Session 4: Binaries, Shells & Shaping (Chair:)		
11:30	Orsola De Marco (invited)	Binary Stars Across the Mass Spectrum; From Observations to Theory and Back
12:10	Shazrene Mohamed	Shaping the Outflows of Evolved Stars
12:30	Michel Hillen	The First Milli-Arcsecond Image of a Post-AGB Binary: the Inner 10 AU of IRAS08544-4431
12:50	Lunch	
14:30	Sofia Ramstedt (invited)	Winds and Circumstellar Morphology of Binary AGB Stars with ALMA
15:00	Miguel Montarges	The Dusty Disk and Companion of L2 Puppis, the Nearest AGB Star, Observed with VLT/SPHERE
15:20	Foteini Lykou	Shaping Nebulae via Disks in AGB Stars
15:40	Break	
16:10	Henri Boffin (invited)	Binary Stars - an Interferometric View

16:40	Sebastian Ohlmann	Hydrodynamic Simulations of Common Envelope Phases
Session 5: Magnetic Fields (Chair:)		
17:00	Agnes Lebre (invited)	Surface Magnetism of Cool and Evolved Stars: the Harvest from the Spectropolarimetric Instruments
17:30	Posters	Poster viewing with beer and brez'n
Day 4, Thursday 9 July		
09:00	Wouter Vlemmings (invited)	Magnetic Fields in Evolved Stars: Theory & Radio/Submm Line Observations
09:30	Laurence Sabin (invited)	Detection of Magnetic Fields in Evolved Stars: From the Envelope to the Photosphere
10:00	Alizee Duthu	Magnetic Fields in C-Rich Evolved Objects
10:20	Binaries and B-Fields Discussion (Lead: Icke)	
11:00	Break	
Session 6: Evolved Stars and the Cycle of Matter (Chair:)		
11:30	Iain McDonald (invited)	How to Make and Break Dust Around Metal-Poor Stars
12:10	Jonathan Mackey	Cold Gas in Hot Star Clusters: the Fate of Winds from Red Supergiants
12:30	Discussion on Evolved Stars and the Cycle of Matter	
12:50	Group Photo	
13:00	Lunch	
Session 7: Evolutionary End Products, Planetary Nebulae (Chair:)		
14:30	Joel Kastner (invited)	Planetary Nebulae: a Contemporary (Multiwavelength) Perspective
15:10	Valentin Bujarrabal (invited)	Molecular Line Observations of Planetary and Protoplanetary Nebulae: Keplerian Disks
15:40	Daniel Tafoya	Sub-millimeter Maser Emission from Water Fountain Nebulae
16:00	Break	
16:30	Mark Hollands	Ancient Planetary Systems Around White Dwarfs

16:50	Discussion on Planetary Nebulae (20 min)	
19:00	Conference Dinner	
Day 5, Friday 10 July		
Session 8: Evolutionary End Products, Supernovae (Chair:)		
09:00	Rubina Kotak (invited)	Supernovae
09:40	Mikako Matsuura (invited)	Supernova 1987A
10:10	Noam Soker	Nebulae Powered by a Central Explosion
10:30	Break	
11:00	Santiago Gonzalez	The Rise-Time of Type II Supernovae
11:20	Discussion on Supernovae	
11:40	Franz Kerschbaum (invited)	Closing Remarks: Enriching STEPS in finding clues on complex giants
12:20	SOC/LOC	Announcements
12:30	End of Meeting	

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