Scientific highlights IAUS366

A proper understanding of stellar evolution and of the chemical make-up of the building blocks in the Universe near and far cannot be achieved without a detailed understanding of the wind physics during the late stages of stellar evolution as a function of the cosmic environment and hence metallicity. The goal of this IAU Symposium 366 was to propel our understanding of stellar wind physics across stellar mass by bringing together the scientific communities which often focus on either the low-mass or the massive stars. This cross-disciplinary approach fuelled new scientific ideas and insights and facilitated for new collaborations to grow across communities. Key topics of the conference included (1) the theory of stellar outflows, (2) observing stellar outflows, (3) numerical models for stellar outflows, (4) binarity, (5) enrichment of the interstellar medium, (6) astrochemistry, and (7) current and new observing facilities.

The programme was centred around eight key questions that we wanted to address, in addition to presentations of the 'Hot topics' in the field. These questions included
- `Do we understand the wind-initiation mechanism for all stellar types? Which physical ingredients are important?'
- `How do density inhomogeneities impact stellar winds?'
- `What is the dependence of wind mass-loss rates on the cosmic environment, and hence on the metallicity?'
- `How do binary interactions impact the mass loss?'
- `How do binary interactions influence wind morphologies?'
- `What is the impact of mass loss on evolution and on the cluster environment (chemical, mechanical)?
- `Is the time integrated mass loss enough to understand the stellar end products? What about the initial-final mass relations? Which ingredients are most critical to be understood?'- 'Which roadmap for the use and further development of instrumentation and theoretical models?',

resulting in a scientific programme with 7 review talks, 6 invited talks and 45 contributed talks. In addition, 15 pitch talks and 31 posters were presented.

In addition, education and training were an integral part of our scientific mission, with sessions on the topics of the MAGRITTE radiative transfer code, the James Webb Space Telescope, the MESA stellar evolution code, the Virtual Observatory and Didactics in astronomy.

The proceedings of the IAUS366 will be published as International Astronomical Union Proceedings Series by Cambridge University Press. I invite you all to read the written reports of the invited reviews and of the invited and contributed talks. They do not only reflect our current knowledge and state of the art, but will serve as a legacy for years to come.

Best wishes,

Leen Decin - chair of the IAUS366 symposium

Executive summary IAUS366

The IAU Symposium 366 "The origin of outflows in evolved stars" has been organised between 1-5 November 2021. The original idea was to hold the symposium from 5 - 10 October 2020 in Leuven, Belgium. However, owing to the covid19 pandemic we had to decide to move the symposium from October 2020 to November 2021. However, even then we had to decide to change the format of the meeting from an in-person meeting to a virtual conference. This was the only way forward for inclusion at all levels to be guaranteed, since not all countries around the world had the same success in their vaccination strategy. Inclusion and diversity were key element of the IAUS366 symposium. We could welcome 328 participants from around the world (49 different countries); junior and senior scientists, female and male (201 male, 127 female) with a diverse ethnic background. The conference did run for ~five hours a day, at times that worked for people in different time zones.

The programme was centred around eight key questions that we wanted to address, in addition to presentations of the 'Hot topics' in the field. These questions included
- `Do we understand the wind-initiation mechanism for all stellar types? Which physical ingredients are important?'
- `How do density inhomogeneities impact stellar winds?'
- `What is the dependence of wind mass-loss rates on the cosmic environment, and hence on the metallicity?'
- `How do binary interactions impact the mass loss?'
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- `What is the impact of mass loss on evolution and on the cluster environment (chemical, mechanical)?
- `Is the time integrated mass loss enough to understand the stellar end products? What about the initial-final mass relations? Which ingredients are most critical to be understood?'- 'Which roadmap for the use and further development of instrumentation and theoretical models?'

Each topic/question was introduced by 1 review talk and 1 invited talk. The outcome was a well-balanced program with 7 review talks, 6 invited talks and 45 contributed talks. In addition, 15 pitch talks and 31 posters have been presented. All talks were recorded and made available to participants via YouTube. The posters and pitch talks were available throughout the conference via GatherTown. GatherTown was also used for the organisation of social events and a career advice speed-dating session.

Training and education were an integral part of this IAUS366 symposium. Skill training sessions on the topics of the MAGRITTE radiative transfer code, the James Webb Space Telescope, the MESA stellar evolution code, the Virtual Observatory and Didactics in astronomy were offered live/recorded. Unluckily, specific in-person trainings and art collaborations could not be offered owing to the covid19 situation.

The only event that took place live in Leuven was the public lecture by Robbert Dijkgraaf, Director and Leon Levy Professor of the Institute for Advanced Study in Princeton. The lecture was held in the largest auditorium in Leuven, aula Pieter de Somer. All seats were registered in advance, all covid measures were taken into account. Similar to all scientific contributions mentioned above (see also 'Scientific highlights), the lecture was recorded and can now be watched at https://www.youtube.com/watch?v=uB2NR66Zdpo.

This conference was organised in the context of the ERC Consolidator Grant AEROSOL "Astrochemistry of old stars: direct probing of unique chemical laboratories" (P.I. Leen Decin, grant number 646758) and KU Leuven C1 Excellence Research Grant: "MAESTRO: Massive Stars Outflows" (P.I. Leen Decin, grant number C16/17/007). The conference was supported by the IAU, in particular did Division G Stars and Stellar Physics act as the coordinating division, with supporting divisions being Division B Facilities, Technologies and Data Science, Division C Education, Outreach and Heritage, Division H Interstellar Matter and Local Universe.

The SOC members
- Leen Decin (KU Leuven, Belgium) – chairperson
- Alex de Koter (UvA Amsterdam, the Netherlands)
- Francisca Kemper (Academia Sinica, Taiwan & ESO Garching, Germany)
- Tom Millar (Belfast, Ireland)
- Shazrene Mohamed (Cape Town, South-Africa)
- Albert Zijlstra (Manchester, UK)
- Orsola de Marco (Sydney, Australia)
- Hans Van Winckel (KU Leuven, Belgium)
- Hyosun Kim (Korea)
- Jeremy Yates (UCL London, UK)
- Martha Boyer (STScI, USA)
- John Plane (Leeds, UK)
- Aki Takigawa (Kyoto, Japan)
- Noam Soker (Israel)
- Katrien Kolenberg (University Antwerp, Belgium)

The LOC members were
- Clio Gielen (KU Leuven, Belgium) – LOC chair
- Leen Decin (KU Leuven, Belgium)
- Monique Van Meerbeek (KU Leuven, Belgium)
- Maarten Dirickx (KU Leuven, Belgium)
- Taïssa Danilovich (KU Leuven, Belgium)
- Jan Bolte (KU Leuven, Belgium)
- Jolien Malfait (KU Leuven, Belgium)
- Silke Maes (KU Leuven, Belgium)
- Frederik De Ceuster (KU Leuven, Belgium)
- David Gobrecht (KU Leuven, Belgium)

The editors for the IAUS366 proceedings will be
- Leen Decin (KU Leuven, Belgium)
- Clio Gielen (KU Leuven, Belgium)
- Albert Zijlstra (Manchester, UK)

I thank all of you who contributed to the success of this IAUS366 symposium.
Leen Decin - chair IAUS366 symposium

Programme

Time UTC	Speaker	Title	
Monday 01/11			
10:00-17:00	Skills training sessions	More information and registration	
17:00	Leen Decin	Welcome	
17:20	Stan Owocki (Review)	Getting started: How a supersonic wind is initiated from a hydrostatic stellar surface	Chair: Leen Decin
17:50	Nicolas Moens	The first 3D models of evolved hot star outflows	
18:05	Andreas Sander	The origin and impact of Wolf-Rayet-type mass loss	
18:20	Dominique Meyer	Magnetised gas nebulae of evolved massive stars.	
18:35	pause		
18:45	Arpita Roy - **cancelled (we will extend the pause)**	Importance of self-polluting massive stars in the chemical enrichment of early galaxies	
19:00	Nathan Smith (Review)	Mass loss and end products of massive stars	
19:30	Joel Kastner	Detached Shell Carbon Stars: Tracing Thermal Pulses on the Asymptotic Giant Branch	
19:45	Discussion	Chair: Leen Decin	
20:05	Break		
20:35	Peter Scicluna	The Nearby Evolved Stars Survey: The dust and gas return to the Galactic interstellar medium	Chair: Jeremy Yates
20:50	Roberto Ortiz	Long-term light curve variations of AGB stars: episodic mass-loss or binarity?	
21:05	Guillermo Garcia-Segura	Common Envelope Shaping of Planetary Nebulae. The Launching of Winds and Jets in Proto-Planetary Nebulae	
21:20	Raffaella Margutti (Invited)	The last hundred years: probing the mass-loss of massive stars outside the optical bands.	
21:45	pause		
21:55	Discussion	Chair: Jeremy Yates - "What experiments, both observation and numerical, can we design to understand how outflows are formed?"	
22:15	Poster session + social		
Tuesday 02/11			
9:30-10:30	Career-advice speed dating	More information and registration	
	& Social gathering	@GatherTown	
11:00	Benjamin Davies (Invited)	What does the Humphreys-Davidson Limit tell us about the mass lost by massive stars?	Chair: Alex de Koter
11:25	Marco Tailo	RGB mass loss: inferences from CMD-fitting and asteroseismology	
11:40	Iain McDonald	The onset of mass loss in evolved stars	
11:55	Susanne Höfner (Review)	Explaining the winds of AGB stars: Recent progress	
12:25	pause		
12:35	Theo Khouri	Unveiling the dust-formation and wind-acceleration region of the AGB star R Dor using ALMA and SPHERE	
12:50	Matthias Maercker	The properties of dust in wind-ISM interaction regions around AGB stars	
13:05	Julien Drevon	MATISSE first pictures of dust and molecules around R Scl	
13:20	Discussion	Chair: Alex de Koter	
13:40	Break		
14:10	Ambra Nanni	Dust and gas production from carbon-rich stars: the role of metallicity	Chair: Martha Boyer
14:25	Chiaki Kobayashi (Review)	The role of mass loss in chemodynamical evolution of galaxies	
14:55	Carmen Sanchez Contreras (presented by Javier Alcolea)	Dissecting the central regions of OH231.8 with ALMA: a salty rotating structure at the base of a young bipolar outflow	
15:10	Anita Richards	Detailing evolved star wind complexity with masers	
15:25	Sandra Etoka	Tracing the inner regions of circumstellar envelopes via high-excitation water transitions	
15:40	Discussion	Chair: Martha Boyer	
16:00	Poster session + social		
17:00-18:00	Career-advice speed dating	More information and registration	
	& Social gathering	@GatherTown	
Wednesday 03/11			
11:00	Sung-Chul Yoon (Invited)	Effects of wind mass-loss on the observational properties of Type Ib/Ic supernova progenitors	Chair: Andrea Dupree (replacement for Albert Zijlstra)
11:25	Paola Marigo	Shaping the initial-final mass relation of white dwarfs with AGB winds	
11:40	Jorick Vink	The link between hot and cool outflows from evolved massive stars	
11:55	Michaela Kraus	Environments of evolved massive stars - evidence for episodic mass ejections	
12:10	pause		
12:20	Alceste Bonanos	Introducing the ASSESS project: Episodic Mass Loss in Evolved Massive Stars: Key to Understanding the Explosive Early Universe	
12:35	Andrea Chiavassa (Review)	Atmospheric structure and dynamics of evolved massive stars	
13:05	Discussion	Chair: Andrea Dupree	
13:25	Break		
13:55	Miguel Montargès	The Great Dimming of Betelgeuse from the VLT/VLTI	Chair: Jacques Kluska (replacement for Hans Van Winckel)
14:10	Xavier Haubois	The inner dust shell of Betelgeuse seen with polarimetry	
14:25	Jon Sundqvist	Analytic, Turbulent Pressure Driven Mass Loss from Red Supergiants	
14:40	Roberta Humphreys	Massive Gaseous Outflows and the Mass Loss Mechanism of Red Supergiants	
14:55	pause		
15:05	Rene Oudmaijer	Multiple mass loss events on timescales of hundreds of years of the post-Red Supergiant the Fried Egg	
15:20	Eric Blackman (Review)	Pre-Planetary Nebulae as a Context for Principles, Progress, and Persistent Questions as to how Binaries and Magnetic fields Produce Jets	
15:50	Discussion	Chair: Jacques Kluska	
16:10	Poster session + social		
18:00	Public Lecture: Robbert Dijkgraaf	Public Lecture (in Dutch) in Pieter De Somer aula, Leuven	
Thursday 04/11			
11:00	Alexander James	Treating gas-surface binding to bare dust in ABG outflows: effects on sulfur chemistry	Chair: John Plane
11:15	Marie Van de Sande	The impact of UV photons of a stellar companion on the chemistry of AGB outflows	
11:30	Maryam Saberi	Tracing the role of AGB stars in the Galactic Fluorine budget	
11:45	Shreeya Shetye	Tc-rich M stars: platypuses of low-mass star evolution	
12:00	Taissa Danilovich	The distribution of carbonaceous molecules and SiN around the S-type AGB star W Aql	
12:15	pause		
12:25	Discussion	Chair: John Plane - "What are the biggest discrepancies between observations and model simulations of molecular species in outflows, and which of these could be addressed by future laboratory kinetic experiments or theoretical calculations of reaction rates?"	
12:45	Hugues Sana (Review)	The interplay between binarity and outflows	Chair: Noam Soker
13:15	Ana Escorza	Learning about AGB stars by studying the stars polluted by their outflows	
13:30	Akke Corporaal	Circumbinary discs around post-AGB binaries as a result of binary interactions: an infrared interferometric view	
13:45	Levin Hennicker	BOSS-3D: A Binary Object Spectral Synthesis Code in 3D	
14:00	Break		
14:30	Amit Kashi (Invited)	Simulations of Colliding winds in Massive Binary Systems with Accretion	
14:55	Ondřej Pejcha	Mass loss from binary stars approaching merger	
15:10	Raghvendra Sahai	Accretion-powered outflows in AGB stars	
15:25	pause		
15:35	Discussion	Chair: Noam Soker - "Accretion and Jets"	
15:55	Poster session + social		
Friday 05/11			
06:00	Izumi Endo	Towards the identification of carriers of the unidentified infrared (UIR) bands in novae	Chair: Orsola De Marco
06:15	Atefeh Javadi	Mass-loss rates of cool evolved stars in M33 galaxy	
06:30	Ryan Lau	Revisiting and Resolving Carbon-rich Wolf-Rayet Dust Factories	
06:45	Geetanjali Sarkar	Outflows and disks in post-RGB Objects -- Products of Common Envelope Ejection?	
07:00	pause		
07:10	Miguel Santander-García	Lessons from the ionised and molecular mass of post-common-envelope planetary nebulae	
07:25	Mengfei Zhang (Invited)	How did the stellar winds of massive stars influence the surrounding environment in the Galactic center?	
07:50	Discussion	Chair: Orsola De Marco - "Galaxies' ISM is replenished of metals, molecules, organics and solids, ejected by stars or built in their circumstellar environments (e.g., PN, CVs, SN, LBVs, WR). What are the three most glaring knowledge gaps to completing the inventory of what compound is produced by what source and at what time in a given galaxy's history?"	
08:10	Poster session + social		
08:35	Break		
09:05	Jeremy Yates (Invited)	Emulation and Uncertainty Quantification in Radiative Transfer - Turning Simulation into Science	Chair: Shazrene Mohamed
09:30	Jolien Malfait	3D hydrodynamical survey of the impact of stellar and planetary companions on the morphology and dynamics of an AGB outflow	
09:45	Silke Maes	Route towards complete 3D hydro-chemical simulations of companion-perturbed AGB outflows	
10:00	Zhuo Chen	Mass transfer in AGB binaries - uncovering a new evolution channel by 3D radiation-hydrodynamic simulations	
10:15	Ileyk El Mellah	Morpho-kinematics around cool evolved stars: multiple companions and eccentric orbits	
10:30	pause		
10:40	Discussion	Chair: Shazrene Mohamed	
11:00	Leen Decin	Closing Words	
13:00-17:00	Skills training sessions	More information and registration	

	Male	Female	Total
Review talks	5	2	7
Invited talks	4	2	6
Contributed talks	25	20	45