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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 300$^{\text{th}}$ issue of the AGB Newsletter. Dating back to 1994 it has run nearly monthly apart from a two-year hiatus. It has since become associated with an IAU working group. While 300 is no more special than 299 or 301 in a purely sequential sense, it is always good to pause for a moment and reflect.

Last month's *Food for Thought* ("If there was one thing we should change in our research culture, what would it be?") provoked three responses:

"I think that a very-very simple thing to do is that each paper will be on the arXiv for 2–3 days before even the first submission. We must allow the community to have first reaction. It is hard to follow the literature, and readers can point out the authors' new results, missing references, and even mistakes. I myself post every new paper on the arXiv for 2 days before submission. And indeed, I get from time to time relevant and useful comments.
The other extreme is the unethical behavior of authors who announced new results in a press release, leaving no space for comments by the community. If the paper is beyond the 'Event Horizon', for example, we cannot make comments to the paper any more."

"Post-docs should be permitted to put down roots in a particular place. Expecting researchers to move around the planet every two years or so is detrimental to family life and means only certain types of people or very lucky people can stay in astrophysics, irrespective of their ability. A very healthy hermit with no social skills would be ideal.
Funding mechanisms should permit new ideas to be supported. The requirement for detailed time plans in fellowship proposals only works with certain types of science. If you are truly on the frontier of science you do not know what the answer is going to be and how long it is going to take to get it. When it all goes on the proposal and not on track record of innovation this is a problem."

"Fundamental and blue-skies science, astronomy included, do not benefit from competition more than they suffer from it. Some individual scientists may benefit in terms of their careers, but others suffer and the net effect is detrimental for our profession. It reduces diversity of ideas and approaches, creates and enhances inequality, and has a human toll that does not justify the means to an end. While its severity and pervasiveness is still the subject of studies, too many of us will know examples of lack of integrity and immoral behaviour. This ranges from citation bias, false claims and favouritism to systematic undermining and defamation, spreading misinformation and outright sabotage in evaluation processes. We need a research culture in which this is not tolerated, but also a culture in which it is not implicitly encouraged and rewarded. This requires structural changes to the way in which scientific validity is determined and scientific success is measured. Ethical behaviour must be recognised to have scientific value. It also requires individual responsibility for one's own attitudes and behaviour towards others, and a general willingness and open-mindedness to resolve conflict. The IAU needs to be the vanguard of this, in word and in action."

Regarding the newsletter itself, with the rapid changes in institutional IT policies and infrastructure, and the way we work in our profession, its future is uncertain – it will certainly need to change to adapt to this new landscape.

While you are contemplating the above, do not forget to check out the amazing work presented in this edition, the job opening and the meeting announcements. Three papers discuss the 'Great Dimming' of Betelgeuse, all making novel contributions to the debate.

The next issue is planned to be distributed around the 1st of August.

Editorially Yours,
Jacco van Loon, Ambra Nanni and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

How would you like to see this newsletter change?

Reactions to this statement or suggestions for next month's statement can be e-mailed to astro.agbnews@keele.ac.uk (please state whether you wish to remain anonymous)

Refereed Journal Papers

The Great Dimming of Betelgeuse seen by the Himawari-8 meteorological satellite

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Betelgeuse, one of the most studied red supergiant stars, dimmed in the optical by ~ 1.2 mag between late 2019 and early 2020, reaching an historical minimum called "the Great Dimming." Thanks to enormous observational effort to date, two hypotheses remain that can explain the Dimming: a decrease in the effective temperature and an enhancement of the extinction caused by newly produced circumstellar dust. However, the lack of multi-wavelength monitoring observations, especially in the mid infrared where emission from circumstellar dust can be detected, has prevented us from closely examining these hypotheses. Here we present 4.5-year, 16-band photometry of Betelgeuse between 2017–2021 in the 0.45–13.5-μm wavelength range making use of images taken by the Himawari-8 geostationary meteorological satellite. By examining the optical and near-infrared light curves, we show that both a decreased effective temperature and increased dust extinction may have contributed by almost the same amount to the Great Dimming. Moreover, using the mid-infrared light curves, we find that the enhanced circumstellar extinction actually contributed to the Dimming. Thus, the Dimming event of Betelgeuse provides us an opportunity to examine the mechanism responsible for the mass loss of red supergiants, which affects the fate of massive stars as supernovæ.

Published in Nature Astronomy

Available from https://arxiv.org/abs/2205.14165

and from https://www.nature.com/articles/s41550-022-01680-5

New semiregular variable star near the Wizard Nebula – Evolution of red giant "MaCoMP V1"

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The red giant MaCoMP V1 in Cepheus at coordinates RA (J2000) 22 : 49 : 05.49 DEC (J2000) +57 : 52 : 41.6 is a semiregular variable star classified as SRS, number 2225960 in the AAVSO VSX database. Using the Fourier transform, the period $P = (24.751 \pm 0.062)$ d was evaluated and, with the support of the ASAS-SN and ZTF surveys, a well-defined light curve was made. The analysis resulted in the fundamental physical parameters of MaCoMP V1, such as the mass $M = (4.97 \pm 0.38)$ $M_\odot$ and radius $R = (40.5 \pm 6.7)$ $R_\odot$, with consistent values suggesting the characteristics of a semiregular red giant. In addition, the effective temperature $T_{\rm eff} = (4500 \pm 135)$ K from the Gaia catalog and the stellar evolution based on the Schönberg–Chandraskehar limit was estimated.

Published in Open European Journal on Variable Stars (OEJV)

Period changes of Mira variables in the M 16–M 17 region

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We analyzed the light curves of 165 AGB variables, mostly Miras, in the sky area centered between M 16 and M 17 ($l = 16°$, $b = 0°$), using the OGLE GVS database in the I_C band. Comparison with the published light curves, derived about 50 years earlier by P. Maffei using Kodak I-N photographic plates, allowed us to check possible period variations: no significant period changes in any star was found. Remarkably, a few stars of the sample appear to have substantially changed their average luminosity, the most striking case being KZ Ser. We provide a better identification for three stars: IX Ser, NSV 10522, and NSV 10326, all of them being Miras. We classify the light curves of 6 stars, discovered but not classified by Maffei, (GL Ser, NSV 10271, NSV 10326, NSV 10522, NSV 10677, and NSV 10772) the first five being new Miras, and confirm the R CrB nature of V391 Sct. The magnitude scale used by Maffei is compared to the modern I_C one.

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Available from https://arxiv.org/abs/2206.00905

Excitation & excavation of the claws of the Southern Crab

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We show that the Southern Crab (a.k.a. Hen 2-104) presents an auspicious opportunity to study the form and speed of the invisible winds that excavate and shock the lobes of various types of bipolar nebulæ associated with close and highly evolved binary stars. A deep three-color image overlay of Hen 2-104 reveals that the ionization state of its lobe edges, or "claws", increases steadily from singly to doubly ionized values with increasing wall latitude. This "reverse" ionization pattern is unique among planetary nebulæ (and similar objects) and incompatible with UV photoionization from a central source. We show that the most self-consistent explanation for the ionization pattern is shock ionization by a fast ($\sim$ 600 km s^{-1}) "tapered" stellar wind in which the speed and momentum flux of the wind increase with equatorial latitude. We present a hydrodynamic simulation that places the latitude-dependent form, the knotty walls, and the reverse ionization of the outer lobes of Hen 2-104 into a unified context.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/2206.03346

Spatially resolved observations of Betelgeuse at λ7 mm and λ1.3 cm just prior to the Great Dimming

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We present spatially resolved observations of Betelgeuse (α Orionis) obtained with the Karl G. Jansky Very Large Array (VLA) at $\lambda \sim$ 7mm (44 GHz) and $\lambda \sim$1.3 cm (22 GHz) on 2019 August 2, just prior to the onset of the historical optical dimming that occurred between late 2019 and early 2020. Our measurements suggest recent changes in the temperature and density structure of the atmosphere between radii $r \sim$ 2–3 $R_\star$. At λ7 mm the star is $\sim$ 20% dimmer than in previously published observing epochs between 1996–2004. We measure a mean gas temperature of $T_{\rm B} = 2270 \pm 260$ K at $r \sim 2.1\ R_\star$, where $R_\star$ is the canonical photospheric radius. This is $\sim 2\sigma$ lower than previously reported temperatures at comparable radii and $>$ 1200 K lower than predicted by previous semi-empirical models of the atmosphere. The measured brightness temperature at $r \sim 2.6$ R$_\star$ ($T_{\rm B} = 2580 \pm 260$ K) is also cooler than expected based on trends in past measurements. The stellar brightness profile in our current measurements appears relatively smooth and symmetric, with no obvious signatures of giant convective cells or other surface features. However, the azimuthally averaged brightness profile is found to be more complex than a uniform elliptical disk. Our observations were obtained approximately six weeks before spectroscopic measurements in the ultraviolet revealed evidence of increases in the chromospheric electron density in the southern hemisphere of Betelgeuse, coupled with a large-scale outflow. We discuss possible scenarios linking these events with the observed radio properties of the star, including the passage of a strong shock wave.

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Available from https://arxiv.org/abs/2206.04144

Hydrodynamic modelling of pulsation period decrease in the Mira-type variable T UMi

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Pulsation period decrease during the initial stage of the thermal pulse in the helium-burning shell of the Mira-type variable T UMi is investigated with numerical methods of stellar evolution and radiation hydrodynamics. To this end, a grid of evolutionary tracks was calculated for stars with masses on the main sequence $1\ M_\odot \le M_{\rm ZAMS} \le 2.2\ M_\odot$ and metallicity $Z = 0.01$. Selected models of AGB evolutionary sequences were used for determination of the initial conditions and the time-dependent inner boundary conditions for the equations of hydrodynamics describing evolutionary changes in the radially pulsating star. The onset of period decrease during the initial stage of the thermal pulse is shown to nearly coincide with the peak helium-burning luminosity. The most rapid decrease of the period occurs during the first three decades. The pulsation period decreases due to both contraction of the star and mode switching from the fundamental mode to the first overtone. The time-scale of mode switching is of the order of a few dozen pulsation cycles. The present-day model of the Mira-type variable T UMi is the first-overtone pulsator with small-amplitude semi-regular oscillations. Theoretical estimates of the pulsation period at the onset of period decrease and the rate of period change three decades later are shown to agree with available observational data on T UMi for AGB stars with masses $1.04\ M_\odot \le M \le 1.48\ M_\odot$.

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Experimental study of the removal of excited state phosphorus atoms by H_2O and H_2: implications for the formation of PO in stellar winds

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The reactions of the low-lying metastable states of atomic phosphorus, $P(^2D)$ and $P(^2P)$, with H_2O and H_2 were studied by the pulsed laser photolysis at 248 nm of PCl_3, combined with laser induced fluorescence detection of $P(^2D)$, $P(^2P)$ and PO. Rate coefficients between 291 and 740 K were measured, along with a yield for the production of PO from $P(^2D$ or $^2P)$ + H_2O of $(35 \pm 15)\%$. H_2 reacts with both excited P states relatively efficiently; physical (i.e. collisional) quenching, rather than chemical reaction to produced PH + H, is shown to be the more likely pathway. A comprehensive phosphorus chemistry network is then developed using a combination of electronic structure theory calculations and a Master Equation treatment of reactions taking place over complex potential energy surfaces. The resulting model shows that at the high temperatures within two stellar radii of a Mira variable AGB star in oxygen-rich conditions, collisional excitation of ground-state $P(^4S)$ to $P(^2D)$, followed by reaction with H_2O, is a significant pathway for producing PO (in addition to the reaction between $P(^4S)$ and OH). The model also demonstrates that the PN fractional abundance in a steady (non-pulsating) outflow is under-predicted by about 2 orders of magnitude.

However, under shocked conditions where sufficient thermal dissociation of N_2 occurs at temperatures above 4000 K, the resulting N atoms convert a substantial fraction of PO to PN.

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FG Sge: new multicolor photometry and short-term dust shell clearing in 2019

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We present the results of a new stage of the long-term photometric study of FG Sge which is a quickly evolving central star of the planetary nebula Hen 1-5. Our new observations carried out on the SAI MSU telescopes in the optical (BVR_cI_c) and infrared (IR) (JHKLM) regions in 2008–2021 and 2013–2021, respectively, allowed us to trace the evolution of the star's brightness in recent years. The most significant observations were performed in 2019 when the star suffered a short clearing of the dust shell and became visible in BVR_c. Based on the spectral energy distribution of FG Sge in the 0.4–5-μm wavelength range we derived the dust shell parameters: the size of dust grains $a = 0.01$ μm, the inner radius temperature $T_{\rm dust} = 900$ K, optical depth $\tau(K) = 0.5$ ($\tau(V) = 4.5$), the total mass of dust $M_{\rm dust} = 7 \times 10^{-5}$ $M_\odot$. After the short-term clearing of the dust shell in 2019, another dust structure was ejected that resulted in the star fading in all the observed bands. Based on the IR brightness and color curves, we estimated the dust depth growth in 2019–2020.

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Evolution of Hen 3-1357, the Stingray Nebula

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The spectroscopic evolution of Hen 3-1357, the Stingray Nebula, is presented by analysing data from 1990 to 2021. High resolution data obtained in 2021 with the South African Large Telescope High Resolution Spectrograph and in 2009 with the European Southern Observatory-Very Large Telescope UVES spectrograph are used to determine physical conditions and chemical abundances in the nebula. From comparison of these data with data from different epochs it is found that the intensity of highly-ionized emission lines has been decreasing with time, while the emission of low-ionization lines has been increasing, confirming that the nebula is recombining, lowering its excitation class, as a consequence of the changes in the central star which in 2002 had an effective temperature of 60,000 K and from then it has been getting colder. The present effective temperature of the central star is about 40,000 K. It has been suggested that the central star has suffered a late thermal pulse and it is returning to the AGB phase. The nebular chemistry of Hen 3-1357 indicates that all the elements, except He and Ne, present subsolar abundances. The comparison of the nebular abundances with the values predicted by stellar nucleosynthesis models at the end of the AGB phase, shows that the central star had an initial mass lower than 1.5 $M_\odot$. We estimated the ADF(O^{2+}) to be between 2.6 and 3.5.

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Available from https://arxiv.org/abs/2206.10663

Interacting planetary nebulæ – III: Verification and Galactic population based on the measurements of Gaia EDR3

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The phenomenon of interaction between planetary nebulæ (PNe) and the interstellar medium (ISM) is one of the significant issues in the field of astrophysics. The main objective of this paper is to verify the interaction process for objects that have been known as interacting PNe (IPNe) in the literature. This study is based on parallax and proper motion observations facilitated recently by the early third data release of the Gaia space mission. Based on the proper nebular central star (CS) motion towards the region of interaction between the PN and ISM, we were able to verify the interaction process for a group of 68 PNe and disprove the interaction process for a group of 33 PNe. The members of both groups were confirmed as genuine PN–ISM interacting objects in the literature. The members belonging to the 33 PNe group are false PN–ISM interacting objects that mimic the structure of IPNe. Moreover, we calculated the physical and kinematic properties of the verified group and analyzed their Galactic population classification using reliable and precise measurements of the proper motion and parallax of the CS. We find that 41% and 41% of this group are associated with Galactic thin and thick disks, respectively, while 18% are members of thin or thick disks. The kinematical results show that the Galactic thin-disk members have smaller vertical Galactic heights, space velocities, and peculiar velocities than those belonging to the Galactic thick disk.

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A new statistical distance scale for planetary nebulæ, based on Gaia EDR3

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The present work aims to build a new statistical distance scale for planetary nebulæ (PNe) based on a rigorous calibration sample. The distances of the calibration sample are derived from the trigonometric parallax method using the recent measurements of Gaia's early third data release (Gaia EDR3). The new distance scale is created by applying the well known linear relationship between the radio surface brightness temperature and the nebular radius. The calibration sample is made up of 96 PNe of accurately computed distances with uncertainties less than 20%. Earlier ground- and space-based trigonometric parallaxes of PNe display inconsistency with those of Gaia, particularly the *Hipparcos* results. In addition, these measurements have appreciably lower precision than that of Gaia. When compared to the trigonometric technique, the expansion and kinematic methods exhibited more consistency than the spectroscopic, extinction, gravity, and photo-ionization methods. Furthermore, contrary to earlier results in the literature, the extinction and gravity methods, on average, underestimate and slightly overestimate the PN distances. As a byproduct of extracting the Gaia parallaxes, we detect the radial velocity and variability for 14 and 3 PN central stars (CSs), respectively. To our knowledge, the variability of Hen 2-447 CS has been determined for the first time.

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The common envelope origins of the fast jet in the planetary nebula M 3-38

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We present the analysis of Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía (MEGARA) high-dispersion integral field spectroscopic observations of the bipolar planetary nebula (PN) M 3-38. These observations unveil the presence of a fast outflow aligned with the symmetry axis of M 3-38 that expands with a velocity up to ±225 km s^{-1}. The deprojected space velocity of this feature can be estimated to be $\approx 320^{+130}_{-60}$ km s^{-1}, which together with its highly collimated morphology suggests that it is one of the fastest jet detected in a PN. We have also used *Kepler* observations of the central star of M 3-38 to unveil variability associated with a dominant period of 17.7 days. We attribute this to the presence of a low-mass star with an orbital separation of ≈ 0.12–0.16 au. The fast and collimated ejection and the close binary system point towards a common envelope formation scenario for M 3-38.

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APOGEE Net: an expanded spectral model of both low-mass and high-mass stars

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We train a convolutional neural network, APOGEE Net, to predict $T_{\rm eff}$, $\log g$, and, for some stars, [Fe/H], based on the APOGEE spectra. This is the first pipeline adapted for these data that is capable of estimating these parameters in a self-consistent manner not only for low-mass stars, (such as main-sequence dwarfs, pre-main-sequence stars, and red giants), but also high-mass stars with $T_{\rm eff}$ in excess of 50,000 K, including hot dwarfs and blue supergiants. The catalog of $\sim 650,000$ stars presented in this paper allows for a detailed investigation of the star-forming history of not just the Milky Way, but also of the Magellanic clouds, as different type of objects tracing different parts of these galaxies can be more cleanly selected through their distinct placement in $T_{\rm eff}$–$\log g$ parameter space than in previous

APOGEE catalogs produced through different pipelines.

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A common envelope jets supernova (CEJSN) impostor scenario for fast blue optical transients

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I propose a new scenario, the polar common envelope jets supernova (CEJSN) impostor scenario, to account for AT2018cow-like fast blue optical transients (FBOTs). The polar CEJSN impostor scenario evolves through four main phases. (1) A red supergiant (RSG) star expands to tidally interact with a neutron star (NS) companion (or a black hole). The interaction increases the RSG mass loss rate to form a circumstellar matter (CSM) halo to $r \simeq 0.1$ pc. (2) Shortly before the onset of a common envelope evolution (CEE) and about a year before explosion the NS accretes mass from the RSG envelope and launches jets that inflate two opposite lobes in the CSM within ≈ 100 au. (3) The NS–RSG system enters a CEE phase during which the system ejects most of the envelope mass in a dense equatorial outflow. (4) At the termination of the CEE the leftover envelope forms a circumbinary disk around the NS-core system. The NS accretes mass from the circumbinary disk and launches energetic jets that, when colliding with the fronts of the CSM lobes, power an FBOT event. The low mass of the jets–lobes interaction zones and their large distance, of about 100 au, from the center account for the fast transient. In the future the core collapses to form a second NS. In the far future the two NSs might merge. I suggest that FBOTs and similar fast transients are CEJSN impostors which compose a large fraction of the progenitors of NS–NS merger binaries.

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and from https://ui.adsabs.harvard.edu/abs/2022RAA....22e5010S/abstract

Probing infrared excess connection with Li enhancement among red clump giants

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We have performed a search among low-mass red giants for finding evidence for merger scenario for triggering He-flash and subsequent Li enhancement. We chose a sample of red giants from GALAH survey with well-measured Li abundances, and near- and mid-IR fluxes from 2MASS and WISE surveys, respectively. The sample contains 418 cool red clump giants and 359 upper red giant branch (RGB) giants. Most of the giants and majority of super Li-rich giants show no IR excess. Only five red clump giants and one RGB giant show IR excess. Notably, of the five red clump giants with IR excess, three are super Li-rich (A(Li) ≥ 3.2 dex) and two are Li-rich (A(Li) ≥ 1.0 dex). Results suggest that Li enhancement among red clump giants may be due to two channels: one resulting from in situ He-flash in single-star evolution and the other due to He-flash triggered by events like merger of He-white dwarfs with giants' He-inert core on RGB. In the latter case, IR excess, as a result of mass-loss, is expected from merger events. We have modelled IR excess in all six giants using Dusty code and derived dust parameters. The estimated kinematic ages and time-scales of dust envelopes of the super Li-rich phase suggest that Li enhancement took place very recently. Further, the analysis shows a significantly higher proportion (four out of five red clump giants) of rapid rotators ($v \sin i \geq 8$ km s^{-1}) among Li-rich giants with IR excess compared to Li-normal and Li-rich giants with no IR excess.

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Did a close tidal encounter cause the Great Dimming of Betelgeuse?

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We assess whether gravity darkening, induced by a tidal interaction during a stellar fly-by, might be sufficient to explain the Great Dimming of Betelgeuse. Adopting several simple approximations, we calculate the tidal deformation and associated gravity darkening in a close tidal encounter, as well as the reduction in the radiation flux as seen by a distant observer. We show that, in principle, the duration and degree of the resulting stellar dimming can be used to estimate the minimum pericenter separation and mass of a fly-by object, which, even if it remains undetected otherwise, might be a black hole, neutron star, or white dwarf. Our estimates show that, while such fly-by events may occur in other astrophysical scenarios, where our analysis should be applicable, they likely are not large enough to explain the Great Dimming of Betelgeuse by themselves.

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Dissecting the central regions of OH 231.8+4.2 with ALMA: a salty rotating disk at the base of a young bipolar outflow

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We present Atacama Large Millimeter/submillimeter Array (ALMA) continuum and molecular line emission maps at ~ 1 mm wavelength of OH 231.8+4.2, a well studied bipolar nebula around an Asymptotic Giant Branch (AGB) star, which is key to investigate the origin of the remarkable changes in nebular morphology and kinematics during the short transition from the AGB to the Planetary Nebula (PN) phase. The excellent angular resolution of our maps (~ 20 mas ≈ 30 au) allows us to scrutinise the central nebular regions of OH 231.8+4.2, which hold the clues to unravel how this iconic object assembled its complex nebular architecture. We report, for the first time in this object and others of its kind (i.e. pre-PN with massive bipolar outflows), the discovery of a rotating circumbinary disk selectively traced by NaCl, KCl, and H_2O emission lines. This represents the first detection of KCl in an oxygen-rich (O-rich) AGB circumstellar envelope (CSE). The rotating disk, of radius ~ 30 au, lies at the base of a young bipolar wind traced by SiO and SiS emission (referred to as the SS-outflow), which also presents signs of rotation at its base. The NaCl equatorial structure is characterised by a mean rotation velocity of $v_{\rm rot} \sim 4$ km s^{-1} and extremely low expansion speeds, $v_{\rm exp} \sim 3$ km s^{-1}. The SS-outflow has a predominantly expansive kinematics characterised by a constant radial velocity gradient of ~ 65 km s^{-1} arcsec^{-1} at its base. Beyond $r \sim 350$ au, the gas in the SS-outflow continues radially flowing at a constant terminal speed of $v_{\rm exp} \sim 16$ km s^{-1}. Our continuum maps reveal a spatially resolved dust disk-like structure perpendicular to the SS-outflow, with the NaCl, KCl and H_2O emission arising from the disk's surface layers. Within the disk, we also identify an unresolved point continuum source, which likely represents the central Mira-type star QX Pup enshrouded by a $\sim 3\ R_\star$ component of hot (~ 1400 K) freshly formed dust. The point source is slightly off-centered (by ~ 6.6 mas) from the disk centroid, enabling us for the first time to place constraints to the orbital separation and period of the central binary system, $a \sim 20$ au and $P_{\rm orb} \sim 55$ yr, respectively. The formation of the dense rotating equatorial structure at the core of OH 231.8+4.2 is most likely the result of wind Roche lobe overflow (WRLOF) mass transfer from QX Pup to the main-sequence companion; this scenario is greatly favored by the extremely low AGB wind velocity, the relatively high mass of the companion, and the comparable sizes of the dust condensation radius and the Roche lobe radius deduced from our data. The $v_{\rm exp} \approx r$ kinematic pattern

observed within the $r \lesssim 350$ au inner regions of the SS-outflow suggest that we are witnessing the active acceleration of the companion-perturbed wind from QX Pup as it flows through low-density polar regions.

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Vibrationally excited HCN transitions in circumstellar envelopes of carbon-rich AGB stars

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Context: HCN is the most abundant molecule after H_2 and CO in the circumstellar envelopes (CSEs) of carbon-rich asymptotic giant branch (AGB) stars. Its rotational lines within vibrationally excited states are exceptional tracers of the innermost region of carbon-rich CSEs.
Aims: We aim to constrain the physical conditions of CSEs of carbon-rich stars using thermal lines of the HCN molecule. Additionally, we also search for new HCN masers and probe the temporal variations for HCN masers, which should shed light on their pumping mechanisms.
Methods: We observed 16 carbon-rich AGB stars in various HCN rotational transitions within the ground and 12 vibrationally excited states with the Atacama Pathfinder EXperiment (APEX) 12 meter submillimeter telescope.
Results: We detect 68 vibrationally excited HCN lines from 13 carbon-rich stars, including 39 thermal transitions and 29 maser lines, which suggests that vibrationally excited HCN lines are ubiquitous in carbon-rich stars. Population diagrams constructed, for two objects from the sample, for thermal transitions from different vibrationally excited states give excitation temperature around 800–900 K, confirming that they arise from the hot innermost regions of CSEs (i.e. $r < 20$ $R_\star$). Among the detected masers, 23 are newly detected, and the results expand the total number of known HCN masers lines toward carbon-rich stars by 47%. In particular, the $J = 2$–1 (0, 3^{1e}, 0), $J = 3$–2 (0, 2, 0), $J = 4$–3 (0, 1^{1f}, 0) masers are detected in an astronomical source for the first time. Our observations confirm temporal variations of the 2–1 (0, 1^{1e}, 0) maser on a timescale of a few years. Our analysis of the data suggests that all detected HCN masers are unsaturated. A gas kinetic temperature of $\gtrsim 700$ K and an H_2 number density of $> 10^8$ cm^{-3} are required to excite the HCN masers. In some ways, HCN masers in carbon-rich stars might be regarded as an analogy of SiO masers in oxygen-rich stars.

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The composition of massive white dwarfs and their dependence on C-burning modeling

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Context: Recent computations of the interior composition of ultra-massive white dwarfs (WDs) have suggested that some WDs could be composed of neon (Ne)-dominated cores. This result is at variance with our previous understanding of the chemical structure of massive WDs, where oxygen is the predominant element. In addition, it is not clear whether some hybrid carbon (C) oxygen (O)–Ne WDs might form when convective boundary mixing is accounted for during the propagation of the C-flame in the C-burning stage. Both the Ne-dominated and hybrid CO–Ne core would have

measurable consequences for asteroseismological studies based on evolutionary models.
Aims: In this work, we explore in detail to which extent differences in the adopted micro- and macro-physics can explain the different final WD compositions that have been found by different authors. Additionally, we explore the impact of such differences on the cooling times, crystallization, and pulsational properties of pulsating WDs.
Methods: We performed numerical simulations of the evolution of intermediate massive stars from the zero age main sequence to the WD stage varying the adopted physics in the modeling. In particular, we explored the impact of the intensity of convective boundary mixing during the C-flash, extreme mass-loss rates, and the size of the adopted nuclear networks on the final composition, age, as well crystallization and pulsational properties of WDs.
Results: In agreement with previous authors, we find that the inclusion of convective boundary mixing quenches the carbon flame leading to the formation of hybrid CO–Ne cores. Based on the insight coming from 3D hydrodynamical simulations, we expect that the very slow propagation of the carbon flame will be altered by turbulent entrainment affecting the inward propagation of the flame. Also, we find that Ne-dominated chemical profiles of massive WDs recently reported appear in their modeling due to a key nuclear reaction being overlooked. We find that the inaccuracies in the chemical composition of the ultra-massive WDs recently reported lead to differences of 10% in the cooling times and degree of crystallization and about 8% in the period spacing of the models once they reach the ZZ Ceti instability strip.

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The wind temperature and mass-loss rate of Arcturus (K1.5 III)

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In this paper we aim to constrain the wind temperature, outflow and turbulent velocities, ionization state, and mass-loss rate of the single red giant Arcturus (α Boo, K1.5 III) using high spectral resolution *Hubble* Space Telescope Space Telescope Imaging Spectrograph profiles of Si III 1206.5Å, O I 1304Å and 1306Å, C II 1334Å and 1335Å, and Mg II h 2802Å. The use of the E140-H setting for α Boo allows the Si III 1206.5Å line to be cleanly extracted from the échelle format for the first time. The ratios of the wind optical depths of lines from different species constrain the temperature at the base of the wind to $T_{\rm wind} \sim 15,400$ K. The mass-loss rate derived is 2.5×10^{-11} M$_\odot$ yr^{-1} for epoch 2018–2019, smaller than previous semi-empirical estimates. These results can be reconciled with multi-wavelength Very Large Array radio continuum fluxes for epoch 2011–2012 by increasing the temperature to $T_{\rm wind} \sim 18,000$ K, or increasing the mass-loss rate to 4.0×10^{-11} M$_\odot$ yr^{-1}. Interpreting the wind acceleration and turbulence in terms of a steady WKB Alfvén wave-driven wind reveals that the wave energy damping length increases with increasing radius, opposite to the trend expected for ion-neutral damping of monochromatic waves, confirming a previous result by Kuin & Ahmad derived for ζ Aur binaries. This implies that a spectrum of waves is required in this framework with wave periods in the range of hours to days, consistent with the photospheric granulation timescale. Constraints on a radial magnetic field (B) at 1.2 $R_\star$ are an upper limit of $B \leq 2$ G from the implied wave heating, and $B \geq 0.3$ G to avoid excessive wave amplitudes.

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Available from https://iopscience.iop.org/article/10.3847/1538-4357/ac69d6/pdf

Pulsating red giants in a globular cluster: ω Centauri

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We have carried out light-curve and time-series analysis of a sample of 16 pulsating red giants (PRGs) in the globular

cluster ω Cen, using observations from the ASAS-SN database, and the AAVSO software package VStar. Of the 16 stars, 1 was classified by ASAS-SN as Mira (M), 5 as semiregular (SR), and 10 as "long secondary period" (LSP), i.e. the dominant period was an LSP. We have determined pulsation periods (P) for all of them, secondary pulsation periods for 3, possible secondary pulsation periods for 4, and LSPs for 8. This confirms that LSPs are common in Population II stars. In the context of a recent model for LSPs, this implies that many Population II PRGs had planetary companions which accreted gas and dust to become brown dwarfs or low-mass stars, now enshrouded by dust. In this model, the LSP is the orbital period of the hypothetical companion. The amplitudes of the pulsation periods vary by up to a factor of 3.4 on a median time scale of 18 pulsation periods, for reasons unknown. The ratios of LSP/P cluster around 4 and 8, presumably depending on whether P is a fundamental mode or first overtone period. We have augmented our sample with a few stars from the literature to plot period–luminosity relations. Sequences for LSPs, fundamental, and first-overtone pulsation periods are visible. Our results show that the complex variability of the PRGs in ω Cen is similar to that of red giants in other stellar systems, and in the field. In Appendix 1, we give results for a few red giants in NGC 6712, which we obtained as a prelude to the ω Cen project.

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A massive AGB donor in Scutum X-1: Identification of the first Mira variable in an X-ray binary

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The symbiotic X-ray binary Sct X-1 was suggested as the first known neutron star accreting from a red supergiant companion. Although known for nearly 50 years, detailed characterization of the donor remains lacking, particularly due to the extremely high reddening towards the source ($A_V \gtrsim 25$ mag). Here, we present i) improved localization of the counterpart using Gaia and *Chandra* observations, ii) the first broadband infrared spectrum ($\approx$ 1–5 μm; $R \approx 2000$) obtained with SpeX on the NASA Infrared Telescope Facility and iii) J-band light curve from the Palomar Gattini-IR survey. The infrared spectrum is characterized by i) deep water absorption features (H_2O index $\approx$ 40%), ii) strong TiO, VO and CO features, and iii) weak/absent CN lines. We show that these features are inconsistent with known red supergiants, but suggest a M8–9 III type O-rich Mira donor star. We report the discovery of large amplitude ($\Delta J \approx 3.5$ mag) periodic photometric variability suggesting a pulsation period of 621±36 (systematic) ±8 (statistical) days, which we use to constrain the donor to be a relatively luminous Mira ($M_K = -8.6 \pm 0.3$ mag) at a distance of $3.6^{+0.8}_{-0.7}$ kpc. Comparing these characteristics to recent models, we find the donor to be consistent with a $\approx$ 3–5 $M_\odot$ star at an age of $\approx$ 0.1–0.3 Gyr. Together, we show that Sct X-1 was previously mis-classified as an evolved High Mass X-ray Binary; instead it is an intermediate mass system with the first confirmed Mira donor in an X-ray binary. We discuss the implications of Mira donors in symbiotic X-ray binaries, and highlight the potential of wide-field infrared time domain surveys and broadband infrared spectroscopy to unveil their demographics.

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Available from https://arxiv.org/abs/2201.09906

Abundance analysis of the J4 equatorial knot of the born-again planetary nebula A 30

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A 30 belongs to a class of planetary nebulæ identified as "born-again", containing dense, hydrogen-poor ejecta with extreme abundance discrepancy factors (ADFs), likely associated with a central binary system. We present intermediate-dispersion spectroscopy of one such feature – the J4 equatorial knot. We confirm the apparent physical and chemical segregation of the polar and equatorial knots observed in previous studies, and place an upper limit on the ADF for O^{2+} of 35, significantly lower than that of the polar knots. These findings further reinforce the theory that the equatorial and polar knots originate from different events.

Published in Research Notes of the AAS
Available from https://arxiv.org/abs/2201.05627
and from https://ui.adsabs.harvard.edu/abs/2022RNAAS...6....4S

The dawn of a new era for dustless HdC stars with Gaia eDR3

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Decades after their discovery, only four hydrogen-deficient carbon (HdC) stars were known to have no circumstellar dust shell. This is in complete contrast to the $\sim$ 130 known Galactic HdC stars that are notorious for being heavy dust producers, i.e. the R Coronæ Borealis (RCB) stars. Together they form a rare class of supergiant stars that are thought to originate from the merger of CO/He white dwarf binary systems, otherwise known as the double-degenerate scenario. We searched for new dustless HdC (dLHdC) stars. We used primarily the 2MASS and Gaia eDR3 catalogues to select candidates that were followed-up spectroscopically. We discovered 27 new dLHdC stars, one new RCB star and two new EHe stars. Surprisingly, 20 of the new dLHdC stars share a characteristic of the known dLHdC star HD 148839, having lower atmospheric hydrogen deficiencies. The uncovered population of dLHdC stars exhibit a Bulge-like distribution, like the RCB stars, but show multiple differences from those that indicate they are a different population of HdC stars following its own evolutionary sequence with a fainter luminosity and also a narrow range of effective temperature. We found indication of a current low dust production activity for four of the new dLHdC stars which could be typical RCB stars passing through a transition time. We have evidence for the first time of a large range of absolute magnitudes in the overall population of HdC stars, spanning over 3 mag. In the favoured formation framework, this is explained by a large range in the initial total WD binary mass which leads to a series of evolutionary sequences with distinct maximum brightness and initial temperature. The cold Galactic RCB stars are also noticeably fainter than the Magellanic ones, possibly due to a difference in metallicity resulting in different WD mass ratio. In our Galaxy, there could be as many dLHdC stars as RCB stars.

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Available from https://arxiv.org/abs/2112.07693

Slow neutron-capture process: low-mass asymptotic giant branch stars and presolar silicon–carbide grains

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Presolar grains are microscopic dust grains that formed in the stellar winds or explosions of ancient stars that died before the formation of the solar system. The majority ($\sim 90\%$ in number) of presolar silicon–carbide (SiC) grains, including types mainstream (MS), Y, and Z, came from low-mass C-rich asymptotic giant branch (AGB) stars, which is supported by the ubiquitous presence of SiC dust observed in the circumstellar envelope of AGB stars and the signatures of slow neutron-capture process preserved in these grains. Here, we review the status of isotope studies of presolar AGB SiC grains with an emphasis on heavy element isotopes and highlight the importance of presolar grain studies for nuclear astrophysics. We discuss the sensitives of different types of nuclei to varying AGB stellar parameters and how their abundances in presolar AGB SiC grains can be used to provide independent, detailed constraints on stellar parameters, including ^{13}C formation, stellar temperature, and nuclear reaction rates.

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and from https://www.mdpi.com/2218-1997/8/7/362

Characterising the AGB bump and its potential to constrain mixing processes in stellar interiors

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In the 90s, theoretical studies motivated the use of the asymptotic-giant branch bump (AGBb) as a standard candle given the weak dependence between its luminosity and stellar metallicity. Because of the small size of observed asymptotic-giant branch (AGB) samples, detecting the AGBb is not an easy task. However, this is now possible thanks to the wealth of data collected by the CoRoT, *Kepler*, and TESS space-borne missions. It is well-known that the AGB bump provides valuable information on the internal structure of low-mass stars, particularly on mixing processes such as core overshooting during the core He-burning phase. Here, we investigate the dependence with stellar mass and metallicity of the calibration of stellar models to observations. In this context, we analysed $\sim 4,000$ evolved giants observed by *Kepler* and TESS, including red-giant branch (RGB) stars and AGB stars, for which asteroseismic and spectrometric data are available. By using statistical mixture models, we detected the AGBb both in frequency at maximum oscillation power $\nu_{\max}$ and in effective temperature $T_{\rm eff}$. Then, we used the Modules for Experiments in Stellar Astrophysics (MESA) stellar evolution code to model AGB stars and match the AGBb occurrence with observations. From observations, we could derive the AGBb location in 15 bins of mass and metallicity. We noted that the higher the mass, the later the AGBb occurs in the evolutionary track, which agrees with theoretical works. Moreover, we found a slight increase of the luminosity at the AGBb when the metallicity increases. By fitting those observations with stellar models, we noticed that low-mass stars ($M < 1.0$ $M_\odot$) require a small core overshooting region during the core He-burning phase. This core overshooting extent increases toward high mass, but above $M > 1.5$ $M_\odot$ we found that the AGBb location cannot be reproduced with a realistic He-core overshooting alone, and instead additional mixing processes have to be invoked. The observed dependence on metallicity complicates the use of the AGBb as a standard candle. Moreover, different mixing processes may occur according to the stellar mass. At low

mass ($M < 1.5$ M$_\odot$), the AGBb location can be used to constrain the He-core overshooting. At high mass ($M > 1.5$ M$_\odot$), an additional mixing induced for instance by rotation is needed to reproduce observations.

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Available from https://arxiv.org/abs/2207.00571

Conference Paper

Distance of optically obscured evolved stars

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As intermediate-mass stars, precursors of planetary nebulae, head towards their final fate, they pass through the red-giant stage where they experience an increase of mass loss. This induces the creation of a circumstellar envelope of dust and gas. By the very end of this evolutionary stage, for those objects exhibiting the highest mass-loss rate, the amount of dust in the circumstellar envelope is such that it blocks optical radiation, turning them into so-called OH/IR stars. These stars are commonly observed throughout the Galaxy and are also observed in the Magellanic Clouds. Since optically obscured, the measurement of their distances using optical parallaxes as, e.g., delivered by Gaia, is not possible. This issue can be circumvented thanks to maser emission. As their name gives it away, the physical conditions turn out to be ideal for a strong (1612 MHz) OH maser emission to be produced in the outer layers of the radially-expanding spherical circumstellar envelope. Combining single-dish monitoring and interferometric mapping of this OH maser emission, the "phase-lag" method provides a way to measure their distance. We have been revisiting this method through a project called "NRT phase-lag distance". Here we present the method itself and the modus operandi of our project. We also present an analysis of the faint emission in the outer OH maser shell of OH 83.4−0.9 and use this analysis to discuss the limitations of the "phase-lag" method. Finally we compare the distances obtained from this method with those obtained from optical and radio astrometry.

Oral contribution, published in European VLBI Network Mini-Symposium and Users Meeting 2021. Based on the EVN online seminar https://www.youtube.com/watch?v=KMZxi_qapOY
Available from https://pos.sissa.it/399/012/

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See P4 of the following link: https://www.kasi.re.kr/eng/recruit/post/recruitNotice/29187

Group of recruitment: Radio Astronomy Research Group
Supervisor: Hyosun Kim
Area of recruitment: Evolved stars
Number of recruitment: 1
Purpose of recruitment: Understanding the structure and evolution of material ejected from evolved stars
Beginning date: 1 October 2022
Deadline of submission: 29 July 2022 15:00(KST)
Contact: enquiries can be addressed to Dr. Hyosun Kim (hkim@kasi.re.kr)

Project abstract:

- Research on the dynamical evolution of matter ejected from evolved stars through observations and simulations

- Research on the last evolutionary stages of binary stars

Details:

Key duties:

- Study on the evolved stars and their circumstellar media
- Study on the roles of companions in the transition from AGB stars to planetary nebulæ

Details of duties:

- Hydrodynamical simulations for symbiotic stars
- ALMA observational data analyses for the spatio-kinematical structures of circumstellar envelopes of evolved stars
- Development of analysis methods

Knowledge & skills required:

- More than one experiment among hydrodynamical simulations, molecular line observations with interferometry, and radiative transfer calculations
- Background knowledge on evolved stars (AGB, PN, ...)
- Skills on astronomical data analysis, image processing, and statistics

Attitude:

- Clear self-motivation for the job to be performed
- Concentration, patience, and responsibility for problem solving
- Attitude required for collaborations

Basic ability:

- Good English communication, logical thinking, and interpersonal relations

Announcements

Hot Stars in the Gaia Era splinter at the International Annual Meeting of the German Astronomical Society

We are happy to announce the Hot Stars in the Gaia Era splinter, which will be part of the International Annual Meeting of the German Astronomical Society, taking place September 12–16, 2022, in Bremen, Germany.

This splinter meeting will focus on hot stars, including both massive and luminous objects like OB-type stars, Wolf–Rayet stars, and B[e] stars, as well as intermediate mass stars in their late hot evolutionary stages, like sdOB stars, central stars of planetary nebulæ, and hot white dwarfs. Studying those stars and their environment is essential for understanding key problems of current astrophysics like the formation of massive stars, radiation-driven winds, close binary interactions, and the final stages of stellar evolution. Hot, massive stars and their feedback are important drivers for the evolution and chemical enrichment in galaxies. Hot evolved stars are key objects to disentangle the various evolutionary pathways of intermediate mass stars, to find out about the fate of exosolar planets, or to search for progenitors and survivors of SN Ia.

The Gaia space mission has allowed us now for the first time to search for these special objects in a targeted manner, to derive their radii and masses and hence, to critically test evolutionary models. In this splinter meeting we wish to gather the hot star community to present and discuss recent advances made possible by the Gaia mission and how upcoming Gaia data releases will impact the research in our field. We are welcoming contributions in the form of talks and posters from both observers and theorists, and encourage in particular early career scientists to apply.

Important dates:

- Early registration: 15 July 2022
- Regular registration: 31 August 2022
- Abstract submission: 15 August 2022

Notes:
If you are a member of the German Astronomical Society you may be able to request travel assistance from the German Astronomical Society (see here for further information).
Remote participation will be likely possible in exceptional cases.

The Scientific Organizing Committee
Nicole Reindl
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IAU Symposium 384
Planetary nebulæ: a universal toolbox in the era of precision astrophysics

We are pleased to announce the IAU Symposium "Planetary nebulæ: a universal toolbox in the era of precision astrophysics" to be held in Cracow, Poland from September 4th to September 8th 2023. The symposium aims to put the research of planetary nebulæ into the context of modern, integrated astrophysics.

Topics to be covered:

- Planetary nebulæ as tracers of stellar evolution: the giant branch–white dwarf connection; mass loss and stellar winds; binary interactions; eruptive events and transients
- Planetary nebulæ as hydrodynamics events: shaping of stellar winds, dusty winds, jet launching, jet–nebula interaction; the asterosphere; outflow shaping by binary interactions
- Planetary nebulæ as astrochemistry laboratories: molecular evolution; polycyclic aromatic hydrocarbons and fullerenes; dust formation and destruction; photo-dissociation regions
- Planetary nebulæ as abundances decoders: atomic physics; photo-ionization and shocks; the forbidden-line vs. recombination line abundance discrepancy; primary elemental production and ISM enrichment
- Planetary nebulæ as unique tools to study the structure and evolution of galaxies: star formation histories, abundance gradients, structural components and dark matter, galaxy dynamics, hierarchical mass assembly

Registration will be open in due time (please check the conference website: https://iaus384-pne.ncac.torun.pl.

Hoping to see you in Cracow, Poland in September, 2023!

Ryszard Szczerba on behalf the organizing committees

See also https://iaus384-pne.ncac.torun.pl