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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 290th issue of the AGB Newsletter. There's lots on planetary nebulæ, radio observations and more – the timescale analysis of detached carbon star shells is particularly elegant.

Looking for a Ph.D. position? Chalmers in Sweden might be just the right thing for you!

Change of the guards: Gioia Rau is now chairing the IAU Working Group on Red Giants and Supergiants, with the former chair assuming presidency of Commission G3 "Stellar Evolution", Franz Kerschbaum elected vice president and Carlos Abia joining the committee as well. If you have any ideas or suggestions don't hesitate to contact them.

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

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

Food for Thought

This month's thought-provoking statement is:

What do roAp stars turn into when they end core hydrogen burning?

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

SPH modelling of wind–companion interactions in eccentric AGB binary systems

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The late evolutionary stages of low- and intermediate-mass stars are characterised by mass loss through a dust-driven stellar wind. Recent observations reveal complex structures within these winds, which are believed to be formed primarily via an interaction with a companion. How these complexities arise, and which structures are formed in which type of systems, is still poorly understood. Particularly, there is a lack of studies investigating the structure formation in eccentric systems. We aim to improve our understanding of the wind morphology of eccentric asymptotic giant branch (AGB) binary systems by investigating the mechanism responsible for the different small-scale structures and global morphologies that arise in a polytropic wind with different velocities. Using the smoothed particle hydrodynamics (SPH) code Phantom, we generated nine different high-resolution, 3D simulations of an AGB star with a solar-mass companion with various wind velocity and eccentricity combinations. The models assume a polytropic gas, with no additional cooling. We conclude that for models with a high wind velocity, the short interaction with the companion results in a regular spiral morphology, which is flattened. In the case of a lower wind velocity, the stronger interaction results in the formation of a high-energy region and bow-shock structure that can shape the wind into an irregular morphology if instabilities arise. High-eccentricity models show a complex, phase-dependent interaction leading to wind structures that are irregular in three dimensions. However, the significant interaction with the companion compresses matter into an equatorial density enhancement, irrespective of eccentricity.

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Available from https://arxiv.org/abs/2107.01074

A new catalog of asymptotic giant branch stars in our Galaxy

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We present a new catalog of 11 209 O-rich AGB stars and 7 172 C-rich AGB stars in our Galaxy identifying more AGB stars in the bulge component and considering more visual carbon stars. For each object, we cross-identify the IRAS, AKARI, MSX, WISE, 2MASS, and AAVSO counterparts. We present the new catalog in two parts: one is based on the IRAS PSC for brighter or more isolated objects, the other one is based on the ALLWISE source catalog for less bright or objects in crowded regions. We present various infrared two-color diagrams (2CDs) for the sample stars. We find that the theoretical dust shell models can roughly explain the observations of AGB stars on the various IR 2CDs. We investigate IR properties of SiO and OH maser emission sources in the catalog. For Mira variables in the sample stars, we find that the IR colors get redder for longer pulsation periods. We also study infrared variability of the sample stars using the WISE photometric data in the last 12 years: the ALLWISE multiepoch data and the Near-Earth Object WISE Reactivation (NEOWISE-R) 2021 data release. We generate light curves using the WISE data at W1 and W2 bands and compute the Lomb–Scargle periodograms for all of the sample stars. From the WISE light curves, we have found useful variation parameters for 3 710 objects in the catalog, for which periods were either known or unknown in previous works.

Accepted for publication in ApJS
Available from https://arxiv.org/abs/2107.02350
and from http://web.chungbuk.ac.kr/∼kwsuh/

It remains a cage: ionization tolerance of C_{60} fullerene in planetary nebulæ

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We demonstrate that by combining two robust theoretical quantum chemistry calculation techniques, stepwise ionization of C_{60} fullerene by UV and extreme UV photons can in principle occur up to a limit as high as C_{60}^{26+} before coulomb explosion of the cage. Furthermore, these highly ionized forms exhibit a comparable structural and bonding stability as for the neutral fullerene. Certain astrophysical sources like the central stars of planetary nebulæ and the hottest white dwarf stars have sufficiently hard UV radiation fields that can result in a series of highly charged C_{60}^{q+} species from $q = 1$ up to $q = 16$. Harsher environments, like hot X-ray bubbles in planetary nebulæ, X-ray binaries and other sources, may further push the ionization right up to the $q = 26$ limit. These remarkable theoretical findings add new avenues to complex ion/molecule reactions, the chemistry of fragmentation products and additional pathways for spreading carbon throughout the universe. The implications for the emerging field of astrochemistry of C_{60} fullerene in all its possible states could be profound.

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The infrared evolution of dust in V838 Monocerotis

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Luminous Red Variables (LRVs) are most likely eruptions that are the outcome of stellar mergers. V838 Mon is one of the best-studied members of this class, representing an archetype for stellar mergers resulting from B-type stars. As result of the merger event, 'nova-like' eruptions occur driving mass-loss from the system. As the gas cools considerable circumstellar dust is formed. V838 Mon erupted in 2002 and is undergoing very dynamic changes in its dust composition, geometry, and infrared luminosity providing a real-time laboratory to validate mineralogical condensation sequences in stellar mergers and evolutionary scenarios. We discuss recent NASA Stratospheric Observatory for Infrared Astronomy (SOFIA) 5 to 38 μm observations combined with archival NASA *Spitzer* spectra that document the temporal evolution of the freshly formed (within the last ≤ 20 yrs) circumstellar material in the environs of V838 Mon. Changes in the 10 μm spectral region are strong evidence that we are witnessing a 'classical' dust condensation sequence expected to occur in oxygen-rich environments where alumina formation is followed by that of silicates at the temperature cools.

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The 2019 outburst of the 2005 classical nova V1047 Cen: a record breaking dwarf nova outburst or a new phenomenon?

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We present a detailed study of the 2019 outburst of the cataclysmic variable V1047 Cen, which hosted a classical nova eruption in 2005. The peculiar outburst occurred 14 years after the classical nova event, lasted for more than 400 days, and reached an amplitude of around 6 magnitudes in the optical. Early spectral follow-up revealed what could be a dwarf nova (accretion disk instability) outburst in a classical nova system. However, the outburst duration, high velocity (> 2000 km s^{-1}) features in the optical line profiles, luminous optical emission, and the presence of prominent long-lasting radio emission, together suggest a phenomenon more exotic and energetic than a dwarf nova outburst. There are striking similarities between this V1047 Cen outburst and those of 'combination novæ' in classical symbiotic stars. We suggest that the outburst may have started as a dwarf nova that led to the accretion of a massive disk, which in turn triggered enhanced nuclear shell burning on the white dwarf and eventually led to generation of a wind/outflow. From optical photometry we find a *possible* orbital period of 8.36 days, which supports the combination nova scenario and makes the system an intermediate case between typical cataclysmic variables and classical symbiotic binaries. If true, such a phenomenon would be the first of its kind to occur in a system that has undergone a classical nova eruption and is intermediate between cataclysmic variables and symbiotic binaries.

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Constraining red supergiant mass-loss prescriptions through supernova radio properties

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Supernova (SN) properties in radio strongly depend on their circumstellar environment and they are an important probe to investigate the mass-loss of SN progenitors. Recently, core-collapse SN observations in radio have been assembled and the rise time and peak luminosity distribution of core-collapse SNe at 8.4 GHz has been estimated. In this paper, we constrain the mass-loss prescriptions for red supergiants (RSGs) by using the rise time and peak luminosity distribution of Type II SNe in radio. We take the de Jager and van Loon mass-loss rates for RSGs, calculate the rise time and peak luminosity distribution based on them, and compare the results with the observed distribution. We found that the de Jager mass-loss rate explains the widely spread radio rise time and peak luminosity distribution of Type II SNe well, while the van Loon mass-loss rate predicts a relatively narrow range for the rise time and peak luminosity. We conclude that the mass-loss prescriptions of RSGs should have strong dependence on the luminosity as in the de Jager mass-loss rate to reproduce the widely spread distribution of the rise time and peak luminosity in radio observed in Type II SNe.

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Heavy elements in barium stars

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New elemental abundances for the neutron-capture elements Sr, Nb, Mo, Ru, La, Sm, and Eu are presented for a large sample of 180 barium (Ba) giant stars, a class of chemically peculiar objects that exhibit in their spectra enhancements of the elements created by the s-process, as a consequence of mass transfer between the components of a binary system. The content of heavy elements in these stars, in fact, points to nucleosynthesis mechanisms that took place within a former asymptotic giant branch (AGB) companion, now an invisible white dwarf. From high-resolution ($R = 48\,000$) spectra in the optical, we derived the abundances either by equivalent width measurements or synthetic spectra computations, and compared them with available data for field giant and dwarf stars in the same range of metallicity. A re-determination of La abundances resulted in [La/Fe] ratios up to 1.2 dex lower than values previously reported in literature. The program Ba stars show overabundance of neutron-capture elements, except for Eu, for which the observational data set behave similarly to field stars. Comparison to model predictions are satisfactory for second-to-first s-process peak ratios (e.g., [La/Sr]) and the ratios of the predominantly r-process element Eu to La. However, the observed [Nb,Mo,Ru/Sr] and [Ce,Nd,Sm/La] ratios show median values higher or at the upper limits of the ranges of the model predictions. This unexplained feature calls for new neutron capture models to be investigated.

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The binary central star of the bipolar pre-planetary nebula IRAS 08005−2356 (V510 Pup)

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Current models predict that binary interactions are a major ingredient for the formation of bipolar planetary nebulæ (PNe) and pre-planetary nebulæ (PPNe). Despite years of radial velocity (RV) monitoring, the paucity of known binaries amongst the latter systems is insufficient to examine this relationship in detail. In this paper, we report on the discovery of a long period ($P = 2654 \pm 124$ d) binary at the centre of the Galactic bipolar PPN, IRAS 08005−2356 (V510 Pup) determined from long-term spectroscopic and near-infrared time series data. The spectroscopic orbit is fit with an eccentricity of 0.36 ± 0.05 that is similar to other long period post-AGB binaries. Time resolved Hα profiles reveal high-velocity outflows (jets) with de-projected velocities up to 231^{+31}_{-27} km s^{-1} seen at phases when the luminous primary is behind the jet. The outflow traced by Hα is likely produced via accretion onto a main sequence companion for which we calculate a mass of 0.63 ± 0.13 M$_{\odot}$. This discovery is one of the first cases of a confirmed binary PPN and demonstrates the importance of high-resolution spectroscopic monitoring surveys on large telescopes in revealing binarity among these systems.

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Synthetic observables for electron-capture supernovæ and low-mass core collapse supernovæ

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Stars in the mass range from 8 to 10 solar masses are expected to produce one of two types of supernovæ (SNe), either electron-capture supernovæ (ECSNe) or core-collapse supernovæ (CCSNe), depending on their previous evolution. Either of the associated progenitors retain extended and massive hydrogen-rich envelopes and the observables of these SNe are, therefore, expected to be similar. In this study, we explore the differences in these two types of SNe. Specifically, we investigate three different progenitor models: a solar-metallicity ECSN progenitor with an initial mass of 8.8 solar masses, a zero-metallicity progenitor with 9.6 solar masses, and a solar-metallicity progenitor with 9 solar masses, carrying out radiative transfer simulations for these progenitors. We present the resulting light curves for these models. The models exhibit very low photospheric velocity variations of about 2000 km s^{-1}; therefore, this may serve as a convenient indicator of low-mass SNe. The ECSN has very unique light curves in broad-bands, especially the U band, and does not resemble any currently observed SN. This ECSN progenitor being part of a binary will lose its envelope for which reason the light curve becomes short and undetectable. The SN from the 9.6 solar masses

progenitor exhibits also quite an unusual light curve, explained by the absence of metals in the initial composition. The artificially iron-polluted 9.6 solar masses model demonstrates light curves closer to normal SNe IIP. The SN from the 9 solar masses progenitor remains the best candidate for so-called low-luminosity SNe IIP like SN 1999br and SN 2005cs.

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Detached shell carbon stars: tracing thermal pulses on the asymptotic giant branch

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We consider whether the subset of carbon-rich asymptotic giant branch (AGB) stars that exhibit detached, expanding circumstellar shells may reveal the past histories of these stars as having undergone helium shell flashes (thermal pulses) on the AGB. We exploit newly available Gaia parallaxes and photometry, along with archival infrared photometry, to obtain refined estimates of the luminosities of all (12) known detached shell carbon stars. We examine the relationship between these luminosities and the estimated dynamical ages (ejection times) of the detached shells associated with the 12 stars, which range from ~ 1000 to $\sim 30\,000$ yr. When arranged according to detached shell dynamical age, the (implied) luminosity evolution of the known detached shell carbon stars closely follows the predicted "light curves" of individual thermal pulses obtained from models of AGB stars. The comparison between data and models suggests that detached shell carbon stars are descended from ~ 2.5–$4.0\ M_{\odot}$ progenitors. We conclude that detached shell carbon stars may serve as effective tracers of the luminosity evolution of AGB thermal pulses.

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Hunting for planetary nebulæ toward the Galactic center

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We present near-infrared (IR) spectra of two planetary nebula (PN) candidates in close lines of sight toward the Galactic center (GC) using the Gemini Near-Infrared Spectrograph (GNIRS) at Gemini North. High-resolution images from radio continuum and narrow-band IR observations reveal ringlike or barrel-shaped morphologies of these objects, and their mid-IR spectra from the *Spitzer* Space Telescope exhibit rich emission lines from highly-excited species such as [S IV], [Ne III], [Ne V], and [O IV]. We also derive elemental abundances using the Cloudy synthetic models, and find an excess amount of the *s*-process element krypton in both targets, which supports their nature as PN. We estimate foreground extinction toward each object using near-IR hydrogen recombination lines, and find significant visual extinctions ($A_V > 20$ mag). The distances inferred from the size versus surface brightness relation of other PNe are 9.0 ± 1.6 kpc and 7.6 ± 1.6 kpc for SSTGC 580183 and SSTGC 588220, respectively. These observed properties along with abundance patterns and their close proximity to Sgr A* (projected distances < 20 pc) make it highly probable that these objects are the first confirmed PN objects in the nuclear stellar disk. The apparent scarcity of such objects resembles the extremely low rate of PN formation in old stellar systems, but is in line with the current rate of the sustained star formation activity in the Central Molecular Zone.

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20 yr of observations of PM 1-188: its chemical abundances and extraordinary kinematics

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The analysis of 20 yr of spectrophotometric data of the double-shell planetary nebula (PN) PM 1-188 is presented, aiming to determine the time evolution of the emission lines and the physical conditions of the nebula, as a consequence of the systematic fading of its [WC 10] central star whose brightness has declined by about 10 mag in the past 40 yr. Our main results include that the [O III], [O II], and [N II] line intensities are increasing with time in the inner nebula as a consequence of an increase in electron temperature from 11 000 K in 2005 to more than 14 000 K in 2018, due to shocks. The intensities of the same lines are decreasing in the outer nebula, due to a decrease in temperature, from 13 000 to 7000 K, in the same period. The chemical compositions of the inner and outer shells are derived and they are similar. Both nebulæ present subsolar O, S, and Ar abundances, while they are He, N, and Ne rich. For the outer nebula, the values are $12 + \log \mathrm{He/H} = 11.13 \pm 0.05$, $12 + \log \mathrm{O/H} = 8.04 \pm 0.04$, $12 + \log \mathrm{N/H} = 7.87 \pm 0.06$, $12 + \log \mathrm{S/H} = 7.18 \pm 0.10$, and $12 + \log \mathrm{Ar/H} = 5.33 \pm 0.16$. The O, S, and Ar abundances are several times lower than the average values found in disc non-Type I PNe, and are reminiscent of some halo PNe. From high-resolution spectra, an outflow in the N–S direction was found in the inner zone. Position-velocity diagrams show that the outflow expands at velocities in the -150 to 100 km s^{-1} range, and both shells have expansion velocities of about 40 km s^{-1}.

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Radio spectral index analysis of Southern Hemisphere symbiotic stars

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Symbiotic stars show emission across the electromagnetic spectrum from a wide array of physical processes. At cm-waves both synchrotron and thermal emission is seen, often highly variable and associated with outbursts in the optical and X-rays. Most models of the radio emission include an ionized region within the dense wind of the red giant star, that is kept ionized by activity on the white dwarf companion or its accretion disk. In some cases there is on-going shell burning on the white dwarf due to its high mass accretion rate or a prior nova eruption, in other cases nuclear fusion occurs only occasionally as recurrent nova events. In this study we measure the spectral indices of a sample of symbiotic systems in the Southern Hemisphere using the Australia Telescope Compact Array. Putting our data together with results from other surveys, we derive the optical depths and brightness temperatures of some well-known symbiotic stars. Using parallax distances from Gaia Data Release 3, we determine the sizes and characteristic electron densities in the radio emission regions.The results show a range of a factor of 10^4 in radio luminosity, and a factor of 100 in linear size. These numbers are consistent with a picture where the rate of shell burning on the white dwarf determines the radio luminosity. Therefore, our findings also suggest that radio luminosity can be used to determine whether a symbiotic star is powered by accretion alone or also by shell burning.

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The excess of cool supergiants from contemporary stellar evolution models defies the metallicity-independent Humphreys–Davidson limit

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The Humphreys–Davidson (HD) limit empirically defines a region of high luminosities ($\log L > 5.5$) and low effective temperatures ($T < 20$ kK) on the Hertzsprung–Russell Diagram in which hardly any supergiant stars are observed. Attempts to explain this limit through instabilities arising in near- or super-Eddington winds have been largely unsuccessful. Using modern stellar evolution we aim to re-examine the HD limit, investigating the impact of enhanced mixing on massive stars. We construct grids of stellar evolution models appropriate for the Small and Large Magellanic Clouds (SMC, LMC), as well as for the Galaxy, spanning various initial rotation rates and convective overshooting parameters. Significantly enhanced mixing apparently steers stellar evolution tracks away from the region of the HD limit. To quantify the excess of over-luminous stars in stellar evolution simulations we generate synthetic populations of massive stars, and make detailed comparisons with catalogues of cool ($T < 12.5$ kK) and luminous ($\log L > 4.7$) stars in the SMC and LMC. We find that adjustments to the mixing parameters can lead to agreement between the observed and simulated red supergiant populations, but for hotter supergiants the simulations always over-predict the number of very luminous ($\log L > 5.4$) stars compared to observations. The excess of luminous supergiants decreases for enhanced mixing, possibly hinting at an important role mixing has in explaining the HD limit. Still, the HD limit remains unexplained for hotter supergiants.

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Towards the global magnetic field of the planet-hosting red giant ϵ Tau

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We present the results of a search for the magnetic field inhomogeneity for the red giant ϵ Tau. This research is based on observations obtained over 10 nights in 2008–2010 with the ESPaDOnS CFHT spectropolarimeter. We found a previously undescribed instrumental effect in the ESPaDOnS spectra, consisting in random polarization outliers. Therefore, to measure the magnetic field from the unblended individual lines, we preliminarily cleared the initial array of spectral lines from the lines distorted by polarization outliers. On only one date from ten, the magnetic field of ϵ Tau was found to exceed 3σ. We also revealed that during two nights the time series of the magnetic field values shows a distribution that is different from the normal distribution. A hypothesis was put forward that this may be due to the inhomogeneity of the magnetic field of this star.

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Determination of planetary nebulæ angular diameters from radio continuum spectral energy distribution modeling

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Powerful new, high resolution, high sensitivity, multi-frequency, wide-field radio surveys such as the Australian Square Kilometre Array Pathfinder (ASKAP) Evolutionary Map of the Universe (EMU) are emerging. They will offer fresh opportunities to undertake new determinations of useful parameters for various kinds of extended astrophysical phenomena. Here, we consider specific application to angular size determinations of Planetary Nebulæ (PNe) via a new radio continuum Spectral Energy Distribution (SED) fitting technique. We show that robust determinations of angular size can be obtained, comparable to the best optical and radio observations but with the potential for consistent application across the population. This includes unresolved and/or heavily obscured PNe that are extremely faint or even non-detectable in the optical.

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Physical and chemical properties of Wolf–Rayet planetary nebulæ

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Wolf–Rayet ([WR]) and weak emission-line (*wels*) central stars of planetary nebulæ (PNe) have hydrogen-deficient atmospheres, whose origins are not well understood. In the present study, we have conducted plasma diagnostics and abundance analyses of 18 Galactic PNe surrounding [WR] and *wels* nuclei, using collisionally excited lines (CELs) and optical recombination lines (ORLs) measured with the Wide Field Spectrograph on the ANU 2.3-m telescope at the Siding Spring Observatory complemented with optical archival data. Our plasma diagnostics imply that the electron densities and temperatures derived from CELs are correlated with the intrinsic nebular Hβ surface brightness and excitation class, respectively. Self-consistent plasma diagnostics of heavy element ORLs of N^{2+} and O^{2+} suggest that a small fraction of cool ($\lesssim$7000 K), dense ($\sim 10^4$–10^5 cm^{-3}) materials may be present in some objects, though with large uncertainties. Our abundance analyses indicate that the abundance discrepancy factors (ADF $\equiv$ ORLs/CELs) of O^{2+} are correlated with the dichotomies between forbidden-line and He I temperatures. Our results likely point to the presence of a tiny fraction of cool, oxygen-rich dense clumps within the diffuse warm ionized nebulæ. Moreover, our elemental abundances derived from CELs are mostly consistent with AGB models in the range of initial masses from 1.5 to 5 $M_\odot$. Further studies are necessary to understand better the origins of abundance discrepancies in PNe around [WR] and *wels* stars.

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Dust production around carbon-rich stars: the role of metallicity

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Background: Most of the stars in the Universe will end their evolution by losing their envelope during the thermally pulsing asymptotic giant branch (TP-AGB) phase, enriching the interstellar medium of galaxies with heavy elements, partially condensed into dust grains formed in their extended circumstellar envelopes. Among these stars, carbon-rich TP-AGB stars (C-stars) are particularly relevant for the chemical enrichment of galaxies. We here investigated the role of the metallicity in the dust formation process from a theoretical viewpoint.
Methods: We coupled an up-to-date description of dust growth and dust-driven wind, which included the time-averaged effect of shocks, with FRUITY stellar evolutionary tracks. We compared our predictions with observations of C-stars in our Galaxy, in the Magellanic Clouds (LMC and SMC) and in the Galactic Halo, characterised by metallicity between solar and 1/10 of solar.
Results: Our models explained the variation of the gas and dust content around C-stars derived from the IRS *Spitzer* spectra. The wind speed of the C-stars at varying metallicity was well reproduced by our description. We predicted the wind speed at metallicity down to 1/10 of solar in a wide range of mass-loss rates.

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Multiple stellar populations in asymptotic giant branch stars of Galactic globular clusters

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Multiple stellar populations (MPs) are a distinct characteristic of Globular Clusters (GCs). Their general properties have been widely studied among main sequence, red giant branch (RGB) and horizontal branch (HB) stars, but a common framework is still missing at later evolutionary stages. We studied the MP phenomenon along the AGB sequences in 58 GCs, observed with the *Hubble* Space Telescope in ultraviolet (UV) and optical filters. By using UV-optical color–magnitude diagrams, we selected the AGB members of each cluster and identified the AGB candidates of the metal-enhanced population in type II GCs. We studied the photometric properties of AGB stars and compared them to theoretical models derived from synthetic spectra analysis. We observe the following features: i) the spread of AGB stars in photometric indices sensitive to variations of light-elements and helium is typically larger than that expected from photometric errors; ii) the fraction of metal-enhanced stars in the AGB is lower than in the RGB in most of the type II GCs; iii) the fraction of 1G stars derived from the chromosome map of AGB stars in 15 GCs is larger than that of RGB stars; iv) the AGB/HB frequency correlates with the average mass of the most helium-enriched population. These findings represent a clear evidence of the presence of MPs along the AGB of Galactic GCs and indicate that a significant fraction of helium-enriched stars, which have lower mass in the HB, does not evolve to the AGB phase, leaving the HB sequence towards higher effective temperatures, as predicted by the AGB-manqué scenario.

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The missing link? Discovery of pulsations in the nitrogen-rich PG 1159 star PG 1144+005

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Up to 98% of all single stars will eventually become white dwarfs – stars that link the history and future evolution of the Galaxy, and whose previous evolution is engraved in their interiors. Those interiors can be studied using asteroseismology, utilizing stellar pulsations as seismic waves. The pulsational instability strips of DA and DB white dwarf stars are pure, allowing for the important generalization that their interior structure represents that of all DA and DB white dwarfs. This is not the case for the hottest pulsating white dwarfs, the GW Vir stars: only about 50% of white dwarfs in this domain pulsate. Several explanations for the impurity of the GW Vir instability strip have been proposed, based on different elemental abundances, metallicity, and helium content. Surprisingly, there is a dichotomy that only stars rich in nitrogen, which by itself cannot cause pulsation driving, pulsate – the only previous exception being the nitrogen-rich nonpulsator PG 1144+005. Here, we report the discovery of pulsations in PG 1144+005 based on new observations. We identified four frequency regions: 40, 55, 97, and 112 day^{-1} with low and variable amplitudes of about 3–6 mmag and therefore confirm the nitrogen dichotomy. As nitrogen is a trace element revealing the previous occurrence of a very late thermal pulse (VLTP) in hot white dwarf stars, we speculate that it is this VLTP that provides the interior structure required to make a GW Vir pulsator.

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Tidal effects on the radial velocities of V723 Mon: additional evidence for a dark 3-M$_\odot$ companion

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Jayasinghe et al. identified a dark $\approx$ 3-M$_\odot$ companion on a nearly edge-on $\approx$ 60-day orbit around the red giant star V723 Monoceros as a black hole candidate in the mass gap. This scenario was shown to explain most of the data presented by Jayasinghe et al., except for periodic radial velocity (RV) residuals from the circular Keplerian model. Here we show that the RV residuals are explained by orbital phase-dependent distortion of the absorption line profile associated with changing visible fractions of the approaching and receding sides of the red giant star, whose surface is tidally deformed by and rotating synchronously with the dark companion. Our RV model constrains the companion mass $M_\bullet = 2.95 \pm 0.17$ M$_\odot$ and orbital inclination $i = 82.9^{+7.0}_{-3.3}$ deg (medians and 68.3% highest density intervals of the marginal posteriors) adopting the radius of the red giant 24.0 ± 0.9 R$_\odot$ as constrained from its SED and distance. The analysis provides independent support for the companion mass from ellipsoidal variations and the limits on the companion's luminosity from the absence of eclipses both derived by Jayasinghe et al. We also show that a common scheme to evaluate the tidal RV signal as the flux-weighted mean of the surface velocity field can significantly underestimate its amplitude for RVs measured with a cross-correlation technique, and present a modified prescription that directly models the distorted line profile and its effects on the measured RVs. The formulation will be useful for estimating the component masses and inclinations in other similar binaries.

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On the nature of organic dust in novæ

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Recent astronomical observations and planetary missions have found that complex organics are prevalent throughout the universe, from the solar system to distant galaxies. However, the detailed chemical composition and the synthesis pathway of these organics are still unclear. Circumstellar envelopes represent excellent laboratories to study the abiological synthesis of extraterrestrial organics. Novæ, having very short dynamical lifetimes, can put severe constraints on the chemical pathway of organic synthesis. Here, we report a laboratory simulation of carbonaceous dust with inclusion of nitrogen in the form of Quenched Nitrogen-included Carbonaceous Composite (QNCC). QNCC is produced by the quenched condensation of plasma gas generated from the nitrogen gas, and aromatic and/or aliphatic hydrocarbon solids by applying microwave discharge (2.45 GHz, 300 W). We have shown that the spectra of QNCC have a close resemblance to the observed infrared spectra of novæ. The results of the infrared and X-ray analyses suggest that the nitrogen inclusion in the form of amine plays an important role in the origin of the broad 8-μm feature of dusty novæ. We conclude that QNCC is at present the best laboratory analog of organic dust formed in the circumstellar medium of dusty classical novæ, which carries the unidentified infrared bands in novæ via thermal emission process.

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Job Advert

Ph.D. position on the study of AGB stars at Chalmers University of Technology in Sweden

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