THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 284th issue of the AGB Newsletter, full of rubidium, *i*-process, and (much) more.

This edition suffered a slight delay due to a malicious use of a webform elsewhere on the server (no personal data were accessed, the database itself was unaffected). As a result we had to switch off the e-mail facility, so you will not have had confirmation e-mails for the past few weeks. We are delighted that we have now resolved the issue, and you will see that recaptcha buttons have been added to the registration/update and submission webforms to prevent future bot attacks.

We would like to draw your attention to a fantastic initiative to hold virtual seminars in our field, the O-MESS series. See the announcement at the end of the newsletter for details, upcoming talks and how you too might give a talk.

Furthermore, there is a Ph.D. position in Bordeaux and there are meetings on chemical abundances in nebulæ (May) and on asymmetric post-main-sequence nebulæ (August).

We received no responses to last months' Food for Thoughts on convection and pulsation – perhaps because nobody knows? This month's should hopefully entice some reactions given this edition features several related articles.

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

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

Food for Thought

This month's thought-provoking statement is:

What is the main factor of uncertainty in predicting nucleo-synthetic surface enrichment?

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

Tomography of the unique on-going jet in the planetary nebula NGC 2392

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Jets (fast collimated outflows) are claimed to be the main shaping agent of the most asymmetric planetary nebulæ (PNe) as they impinge on the circumstellar material at late stages of the asymptotic giant branch (AGB) phase. The first jet detected in a PN was that of NGC 2392, yet there is no available image because its low surface brightness contrast with the bright nebular emission. Here we take advantage from the tomographic capabilities of GTC MEGARA high-dispersion integral field spectroscopic observations of the jet in NGC 2392 to gain unprecedented details of its morphology and kinematics. The jet of NGC 2392 is found to emanate from the central star, break through the walls of the inner shell of this iconic PN and extend outside the nebula's outermost regions with an S-shaped morphology suggestive of precession. At odds with the fossil jets found in mature PNe, the jet in NGC 2392 is currently being collimated and launched. The high nebular excitation of NGC 2392, which implies a He^{++}/He ionization fraction too high to be attributed to the known effective temperature of the star, has been proposed in the past to hint at the presence of a hot white dwarf companion. In conjunction with the hard X-ray emission from the central star, the present-day jet collimation would support the presence of such a double-degenerate system where one component undergoes accretion from a remnant circumbinary disk of the common envelope phase.

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Rubidium in barium stars

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Barium (Ba) stars are chemically peculiar stars that display in their atmospheres signatures of the *slow* neutron-capture (s-process) mechanism that operates within asymptotic giant branch (AGB) stars, an important contributor to the cosmic abundance. The observed chemical peculiarity in these objects is not due to self-enrichment, but to mass transfer between the components of a binary system. The atmospheres of Ba stars are therefore excellent astrophysical laboratories, providing strong constraints for the nucleosynthesis of the s-process in AGB stars. In particular, rubidium (Rb) is a key element for the s-process diagnostic because it is sensitive to the neutron density and hence its abundance points to the main neutron source of the s-process in AGB stars. We present Rb abundances for a large sample of 180 Ba stars from high-resolution spectra ($R = 48\,000$), and we compare the observed [Rb/Zr] ratios with theoretical predictions from s-process models in AGB stars. The target Ba stars in this study display [Rb/Zr] < 0,showing that

Rb was not efficiently produced by the activation of the branching points at ^{85}Kr and ^{86}Rb. Model predictions from the Monash and FRUITY datasets of low-mass ($\lesssim 4$ M$_\odot$) AGB stars are able to cover the Rb abundances observed in the program Ba stars. These observations indicate that the ^{13}C(α,n)^{16}O reaction is the main neutron source of the *s*-process in the low-mass AGB companions of the observed Ba stars. We have not found in the present study candidate companions for former OH/IR massive AGB stars.

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Investigating three Sirius-like systems with SPHERE

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Context: Sirius-like systems are relatively wide binaries with a separation from a few to hundreds of au; they are composed of a white dwarf (WD) and a companion of a spectral type earlier than M0. Here we consider main sequence (MS) companions, where the WD progenitor evolves in isolation, but its wind during the former asymptotic giant branch (AGB) phase pollutes the companion surface and transfers some angular momentum. They are rich laboratories to constrain stellar models and binary evolution.
Aims: Within the SpHere INfrared survey for Exoplanet (SHINE) survey that uses the Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) instrument at the Very Large Telescope (VLT), our goal is to acquire high contrast multi-epoch observations of three Sirius-like systems, HD 2133, HD 114174, and CD −56°7708 and to combine this data with archive high resolution spectra of the primaries, TESS archive, and literature data.
Methods: These WDs are easy targets for SPHERE and were used as spectrophotometric standards. We performed very accurate abundance analyses for the MS stars using methods considered for solar analogs. Whenever possible, WD parameters and orbits were obtained using Monte Carlo Markov chain methods.
Results: We found brighter J and K magnitudes for HD 114174 B than obtained previously and extended the photometry down to 0.95 μm. Our new data indicate a higher temperature and then shorter cooling age (5.57 ± 0.02 Gyr) and larger mass (0.75 ± 0.03 M$_\odot$) for this WD than previously assumed. Together with the oldest age for the MS star connected to the use of the Gaia DR2 distance, this solved the discrepancy previously found with the age of the MS star. The two other WDs are less massive, indicating progenitors of ~ 1.3 M$_\odot$ and 1.5–1.8 M$_\odot$ for HD 2133 B and CD −56°7708 B, respectively. In spite of the rather long periods, we were able to derive useful constraints on the orbit for HD 114174 and CD −56°7708. They are both seen close to edge-on, which is in agreement with the inclination of the MS stars that are obtained coupling the rotational periods, stellar radii, and the projected rotational velocity from spectroscopy. The composition of the MS stars agrees fairly well with expectations from pollution by the AGB progenitors of the WDs: HD 2133 A has a small enrichment of n-capture elements, which is as expected for pollution by an AGB star with an initial mass < 1.5 M$_\odot$; CD −56°7708 A is a previously unrecognized mild Ba-star, which is also expected due to pollution by an AGB star with an initial mass in the range of 1.5–3.0 M$_\odot$; and HD 114174 has a very moderate excess of n-capture elements, which is in agreement with the expectation for a massive AGB star to have an initial mass > 3.0 M$_\odot$.
Conclusions: On the other hand, none of these stars show the excesses of C that are expected to go along with those of n-capture elements. This might be related to the fact that these stars are at the edges of the mass range where we expect nucleosynthesis related to thermal pulses. More work, both theoretical and observational, is required to better understand this issue.

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Multiplicity among the cool supergiants in the Magellanic Clouds

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The characterisation of multiplicity among of high-mass stars is of fundamental importance to understand their evolution, the diversity of observed core-collapse supernovae and the formation of gravitational wave progenitor systems. Despite that, until recently, one of the final phases of massive star evolution – the cool supergiant phase – has received comparatively little attention. In this study we aim to explore the multiplicity among the cool supergiant (CSG) population in the Large and Small Magellanic Clouds (LMC and SMC, respectively). To do this we compile extensive archival radial velocity (RV) measurements for over 1 000 CSGs from the LMC and SMC, spanning a baseline of over 40 years. By statistically correcting the RV measurements of each stellar catalogue to the Gaia DR2 reference frame we are able to effectively compare these diverse observations. We identify 45 CSGs where RV variations cannot be explained through intrinsic variability, and are hence considered binary systems. We obtain a minimum binary fraction of $15 \pm 4\%$ for the SMC and of $14 \pm 5\%$ for the LMC, restricting our sample to objects with at least 6 and 5 observational epochs, respectively. Combining these results, we determine a minimum binary fraction of $15 \pm 3\%$ for CSGs. These results are in good agreement with previous results which apply a correction to account for observational biases. These results add strength to the hypothesis that the binary fraction of CSGs is significantly lower than their main-sequence counterparts. Going forward, we stress the need for long-baseline multi-epoch spectroscopic surveys to cover the full parameter space of CSG binary systems.

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Rubidium abundances in solar metallicity stars

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Rubidium is one of the few elements produced by the neutron capture *s*- and *r*-processes almost in equally proportions. Recently, a Rb deficiency ([Rb/Fe] < 0.0) by a factor of about two with respect to the Sun has been found in M dwarfs of near solar metallicity. This contrasts with the close to solar [Sr,Zr/Fe] ratios derived in the same stars. This deficiency is difficult to understand from both the observational and nucleosynthesis point of views. To test the reliability of this Rb deficiency, we study the Rb and Zr abundances in a sample of KM-type giant stars in a similar metallicity range extracted from the AMBRE project. We use high resolution and high signal-to-noise spectra to derive Rb and Zr abundances in a sample of 54 bright giant stars with metallicity in the range $-0.6 \lesssim \mathrm{[Fe/H]} \lesssim +0.4$ dex by spectral synthesis in both local and non-local thermodynamic equilibrium (LTE and NLTE, respectively). The impact of the Zeeman broadening in the profile of the Rb I at 7800 Å line is also studied. The LTE analysis also results in a Rb deficiency in giant stars although considerably lower than that obtained in M dwarfs. However, when NLTE corrections are done the [Rb/Fe]ratios are very close to solar (average -0.01 ± 0.09 dex) in the full metallicity range studied.This contrasts with the figure found in M dwarfs. The [Zr/Fe] ratios derived are in excellent agreement with those obtained in previous studies in FGK dwarf stars with a similar metallicity. We investigate the effect of gravitational settling and magnetic activity as possible causes of the Rb deficiency found in M dwarfs. While, the former phenomenon has a negligible impact on the surface Rb abundance, the existence of an average magnetic field with intensity typical of that observed in M dwarfs may result in systematic Rb abundance underestimations if the Zeeman broadening is not considered in the spectral synthesis. This can explain the Rb deficiency in M dwarfs, but

not completely. On the other hand, the new [Rb/Fe] and [Rb/Zr] vs. [Fe/H]relationships can be explained when the Rb production by rotating massive stars and low-and-intermediate mass stars (these later also producing Zr) are considered, without the need of any deviation from the standard *s*-process nucleosynthesis in AGB stars as suggested previously.

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Li-rich K giants, dust excess, and binarity

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The origin of the Li-rich K giants is still highly debated. Here, we investigate the incidence of binarity among this family from a nine-year radial-velocity monitoring of a sample of 11 Li-rich K giants using the HERMES spectrograph attached to the 1.2m Mercator telescope. A sample of 13 non-Li-rich giants (8 of them being surrounded by dust according to IRAS, WISE, and ISO data) was monitored alongside. When compared to the binary frequency in a reference sample of 190 K giants (containing 17.4% of definite spectroscopic binaries "SB" and 6.3% of possible spectroscopic binaries "SB?"), the binary frequency appears normal among the Li-rich giants (2/11 definite binaries plus 2 possible binaries, or 18.2% SB + 18.2% SB?), after taking account of the small sample size through the hypergeometric probability distribution. Therefore, there appears to be no causal relationship between Li enrichment and binarity. Moreover, there is no correlation between Li enrichment and the presence of circumstellar dust, and the only correlation that could be found between Li enrichment and rapid rotation is that the most Li-enriched K giants appear to be fast-rotating stars. However, among the dusty K giants, the binary frequency is much higher (4/8 definite binaries plus 1 possible binary). The remaining 3 dusty K giants suffer from a radial-velocity jitter, as is expected for the most luminous K giants, which these are.

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Low-mass low-metallicity AGB stars as an efficient *i*-process site explaining CEMP-*rs* stars

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We analyse high-resolution spectra of 24 CEMP stars and one *r*-process enriched star without carbon-enrichment. Stars are re-classified as CEMP-*s* or -*rs* according to a new classification scheme using eight heavy element abundances. Within our sample of 25 objects, the literature classification is globally confirmed, except for HE 1429−0551 and HE 2144−1832, previously classified as CEMP-*rs* and now as CEMP-*s* stars. The abundance profiles of CEMP-*s* and CEMP-*rs* stars are compared in detail, and no clear separation is found between the two groups; it seems instead that there is an abundance continuum between the two stellar classes. There is an even larger binarity rate among CEMP-*rs* stars than among CEMP-*s* stars, indicating that CEMP-*rs* stars are extrinsic stars as well. The second peak *s*-process elements (Ba, La, Ce) are slightly enhanced in CEMP-*rs* stars with respect to first-peak *s*-process elements

(Sr, Y, Zr), when compared to CEMP-s stars. Models of radiative s-process nucleosynthesis during the interpulse phases reproduce well the abundance profiles of CEMP-s stars, whereas those of CEMP-rs stars are explained well by low-metallicity 1 $M_\odot$ models experiencing proton ingestion. The global fitting of our i-process models to CEMP-rs stars is as good as the one of our s-process models to CEMP-s stars. In conclusion, CEMP-rs stars present most of the characteristics of extrinsic stars such as CEMP-s, CH, barium, and extrinsic S stars; they can be explained as being polluted by a low-mass, low-metallicity thermally-pulsing asymptotic giant branch (TP-AGB) companion experiencing i-process nucleosynthesis after proton ingestion during its first convective thermal pulses. As such, they could be renamed CEMP-sr stars, since they represent a particular manifestation of the s-process at low-metallicities. For these objects a call for an exotic i-process site may not necessarily be required anymore. Finally, we stress that stellar evolutionary tracks of an enhanced carbon composition (consistent with our abundance determinations) are necessary to explain the position of CEMP-s and CEMP-rs stars in the Hertzsprung–Russell diagram using Gaia DR2 parallaxes; they are found to lie mostly on the red giant branch (RGB).

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SiO, ^{29}SiO, and ^{30}SiO emission from 67 oxygen-rich stars. A survey of 61 maser lines from 7 to 1 mm

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Circumstellar environments of oxygen-rich stars are among the strongest SiO maser emitters. Physical processes such as collisions, infrared pumping and overlaps favors the inversion of level population and produce maser emission at different vibrational states. Despite numerous observational and theoretical efforts, we still do not have an unified picture including all the physical processes involved in the SiO maser emission. The aim of this work is to provide homogeneous data in a large sample of oxygen-rich stars. We present a survey of 67 oxygen-rich stars from 7 to 1 mm, in their rotational transitions from $J = 1 \rightarrow 0$ to $J = 5 \rightarrow 4$, for vibrational numbers v from 0 to 6 in the three main SiO isotopologues. We have used one of the 34-m NASA antennas at Robledo and the IRAM 30-m radio telescope. The first tentative detection of a $v = 6$ line is reported, as well as the detection of new maser lines. The highest vibrational levels seem confined to small volumes, presumably close to the stars. The $J = 1 \rightarrow 0$, $v = 2$ line flux is greater than the corresponding $v = 1$ in almost half of the sample, which may confirm a predicted dependence on the pulsation cycle. This database is potentially useful in models which should consider most of the physical agents, time dependency, and mass-loss rates. As by-product, we report detections of 27 thermal rotational lines from other molecules, including isotopologues of SiS, H_2S, SO, SO_2, and NaCl.

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Hard X-ray emission associated with white dwarfs – IV. Signs of accretion from sub-stellar companions

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KPD 0005+5106, with an effective temperature of $\simeq 200,000$ K, is one of the hottest white dwarfs (WDs). ROSAT

unexpectedly detected :hard" (~ 1 keV) X-rays from this apparently single WD. We have obtained *Chandra* observations that confirm the spatial coincidence of this hard X-ray source with KPD 0005+5106. We have also obtained XMM–*Newton* observations of KPD 0005+5106, as well as PG 1159−035 and WD 0121−756, which are also apparently single and whose hard X-rays were detected by ROSAT at 3σ–4σ levels. The XMM–*Newton* spectra of the three WDs show remarkably similar shapes that can be fitted by models including a blackbody component for the stellar photospheric emission, a thermal plasma emission component, and a power-law component. Their X-ray luminosities in the 0.6–3.0 keV band range from 4×10^{29} to 4×10^{30} erg s^{-1}. The XMM–*Newton* EPIC-pn soft-band (0.3–0.5 keV) lightcurve of KPD 0005+5106 is essentially constant, but the hard-band (0.6–3.0 keV) lightcurve shows periodic variations. An analysis of the generalized Lomb–Scargle periodograms for the XMM–*Newton* and *Chandra* hard-band lightcurves finds a convincing modulation (false alarm probability of 0.41%) with a period of 4.7 ± 0.3 hr. Assuming that this period corresponds to a binary orbital period, the Roche radii of three viable types of companion have been calculated: M9 V star, T brown dwarf, and Jupiter-like planet. Only the planet has a size larger than its Roche radius, although the M9 V star and T brown dwarf may be heated by the WD and inflate past the Roche radius. Thus, all three types of companion may be donors to fuel accretion-powered hard X-ray emission.

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Mysterious, variable, and extremely hot: white dwarfs showing ultra-high excitation lines – I. Photometric variability

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Context: About 10% of all stars exhibit absorption lines of ultra-high excited (UHE) metals (e.g., O VIII) in their optical spectra when entering the white dwarf cooling sequence. This is something that has never been observed in any other astrophysical object, and challenges our understanding of the late stages of stellar evolution since decades. The recent discovery of a both spectroscopic and photometric variable UHE white dwarf led to the speculation that the UHE lines might be created in a shock-heated circumstellar magnetosphere.
Aims: We aim to gain a better understanding of these mysterious objects by studying the photometric variability of the whole population of UHE white dwarfs, and white dwarfs showing only the He II line problem, as both phenomena are believed to be connected.
Methods: We investigate (multi-band) light curves from several ground- and space-based surveys of all 16 currently known UHE white dwarfs (including one newly discovered) and eight white dwarfs that show only the He II line problem.
Results: We find that 75^{+8}_{-13}% of the UHE white dwarfs, and 75^{+9}_{-19}% of the He II line problem white dwarfs are significantly photometrically variable, with periods ranging from 0.22 d to 2.93 d and amplitudes from a few tenth to a few hundredth mag. The high variability rate is in stark contrast to the variability rate amongst normal hot white dwarfs (we find 9^{+4}_{-2}%), marking UHE and He II line problem white dwarfs as a new class of variable stars. The period distribution of our sample agrees with both the orbital period distribution of post-common envelope binaries and the rotational period distribution of magnetic white dwarfs if we assume that the objects in our sample will spin-up as a consequence of further contraction.
Conclusions: We found further evidence that UHE and He II line problem white dwarfs are indeed related, as concluded from their overlap in the Gaia HRD, similar photometric variability rates, light curve shapes and amplitudes, as well as period distributions. The lack of increasing photometric amplitudes towards longer wavelengths, as well as the non-detection of optical emission lines arising from the highly irradiated face of a hypothetical secondary in the optical spectra of our stars, makes it seem unlikely that an irradiated late type companion is the origin of the photometric variability. Instead, we believe that spots on the surfaces of these stars and/or geometrical effects of circumstellar material might be responsible.

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Cluster analysis of presolar silicon carbide grains: evaluation of their classification and astrophysical implications

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Cluster analysis of presolar silicon carbide grains based on literature data for ^{12}C/^{13}C, ^{14}N/^{15}N, δ^{30}Si/^{28}Si, and δ^{29}Si/^{28}Si including or not inferred initial ^{26}Al/^{27}Al data, reveals nine clusters agreeing with previously defined grain types but also highlighting new divisions. Mainstream grains reside in three clusters probably representing different parent star metallicities. One of these clusters has a compact core, with a narrow range of composition, pointing to an enhanced production of SiC grains in asymptotic giant branch (AGB) stars with a narrow range of masses and metallicities. The addition of ^{26}Al/^{27}Al data highlights a cluster of mainstream grains, enriched in ^{15}N and ^{26}Al, which cannot be explained by current AGB models. We defined two AB grain clusters, one with ^{15}N and ^{26}Al excesses, and the other with ^{14}N and smaller ^{26}Al excesses, in agreement with recent studies. Their definition does not use the solar N isotopic ratio as a divider, and the contour of the ^{26}Al-rich AB cluster identified in this study is in better agreement with core-collapse supernova models. We also found a cluster with a mixture of putative nova and AB grains, which may have formed in supernova or nova environments. X grains make up two clusters, having either strongly correlated Si isotopic ratios or deviating from the 2/3 slope line in the Si 3-isotope plot. Finally, most Y and Z grains are jointly clustered, suggesting that the previous use of ^{12}C/^{13}C = 100 as a divider for Y grains was arbitrary. Our results show that cluster analysis is a powerful tool to interpret the data in light of stellar evolution and nucleosynthesis modeling and highlight the need of more multi-element isotopic data for better classification.

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Nucleosynthetic yields of $Z = 10^{-5}$ intermediate-mass stars

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Observed abundances of extremely metal-poor stars in the Galactic halo hold clues for understanding the ancient universe. Interpreting these clues requires theoretical stellar models in a wide range of masses in the low-metallicity regime. The existing literature is relatively rich with extremely metal-poor massive and low-mass stellar models. However, relatively little information is available on the evolution of intermediate-mass stars of $Z \lesssim 10^{-5}$, and the impact of the uncertain input physics on the evolution and nucleosynthesis has not yet been systematically analysed. We aim to provide the nucleosynthetic yields of intermediate-mass $Z = 10^{-5}$ stars between 3 and 7.5 M$_{\odot}$, and quantify the effects of the uncertain wind rates. We expect these yields could eventually be used to assess the contribution to the chemical inventory of the early universe, and to help interpret abundances of selected C-enhanced extremely metal-poor (CEMP) stars.

We compute and analyse the evolution of surface abundances and nucleosynthetic yields of $Z = 10^{-5}$ intermediate-mass stars from their main sequence up to the late stages of their thermally pulsing (Super) AGB phase, with different prescriptions for stellar winds. We use the postprocessing code MONSOON to compute the nucleosynthesis based on the evolution structure obtained with the Monash-Mount Stromlo stellar evolution code MONSTAR. By comparing our models and others from the literature, we explore evolutionary and nucleosynthetic trends with wind prescriptions and with initial metallicity (in the very low-Z regime). We also compare our nucleosynthetic yields to observations of CEMP-s stars belonging to the Galactic halo.
The yields of intermediate-mass extremely metal-poor stars reflect the effects of very deep or corrosive second dredge-up (for the most massive models), superimposed with the combined signatures of hot-bottom burning and third dredge-up. Specifically, we confirm the reported trend that models with initial metallicity $Z_{\rm ini} \lesssim 10^{-3}$ give positive yields of ^{12}C, ^{15}N, ^{16}O, and ^{26}Mg. The ^{20}Ne, ^{21}Ne, and ^{24}Mg yields, which were reported to be negative at $Z_{\rm ini} \gtrsim 10^{-4}$, become positive for $Z = 10^{-5}$. The results using two different prescriptions for mass-loss rates differ widely in terms of the duration of the thermally pulsing (Super) AGB phase, overall efficiency of the third dredge-up episode, and nucleosynthetic yields. We find that the most efficient of the standard wind rates frequently used in the literature seems to favour agreement between our yield results and observational data. Regardless of the wind prescription, all our models become N-enhanced EMP stars.

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Cool, luminous, and highly variable stars in the Magellanic Clouds from ASAS-SN: implications for Thorne–Żytkow objects and super-asymptotic giant branch stars

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Stars with unusual properties can provide a wealth of information about rare stages of stellar evolution and exotic physics. However, determining the true nature of peculiar stars is often difficult. In this work, we conduct a systematic search for cool and luminous stars in the Magellanic Clouds with extreme variability, motivated by the properties of the unusual SMC star and Thorne–Żytkow Object (TŻO) candidate HV 2112. Using light curves from ASAS-SN we identify 38 stars with surface temperatures $T < 4800$ K, luminosities $\log(L/{\rm L}_\odot) > 4.3$, variability periods > 400 days, and variability amplitudes $\Delta V > 2.5$ mag. Eleven of these stars possess the distinctive double-peaked light curve morphology of HV 2112. We use the pulsation properties and derived occurrence rates for these 12 objects to constrain their nature. From comparisons to stellar populations and models, we find that one star may be a red supergiant with large amplitude pulsations. For the other 11 stars we derive current masses of $\sim$ 5–10 M$_\odot$, below the theoretical minimum mass of $\sim$ 15 M$_\odot$ for TŻOs to be stable, casting doubt on this interpretation. Instead, we find that the temperatures, luminosities, mass-loss rates, and periods of these stars are consistent with predictions for super-Asymptotic Giant Branch (s-AGB) stars that have begun carbon burning but have not reached the superwind phase. We infer lifetimes in this phase of $\sim$ 1–7 $\times 10^4$ years, also consistent with an s-AGB interpretation. If confirmed, these objects would represent the first identified population of s-AGB stars, illuminating the transition between low-

and high-mass stellar evolution.

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The intermediate neutron capture process – I. Development of the *i*-process in low-metallicity low-mass AGB stars

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Context: Gathering observations report a growing number of metal-poor stars showing an abundance pattern midway between the *s*- and *r*-processes. These so called *r/s*-stars raise the need for an intermediate neutron capture process (*i*-process), which is thought to result from the ingestion of protons in a convective helium-burning region, but whose astrophysical site is still largely debated.
Aims: We investigate whether an *i*-process during the asymptotic giant branch (AGB) phase of low-metallicity low-mass stars can develop and whether it can explain the abundances of observed *r/s*-stars. Methods. With the stellar evolution code STAREVOL, we computed a 1-$M_\odot$ model at [Fe/H] = −2.5 using a nuclear network of 1091 species (at maximum) coupled to the transport processes. The impact of the temporal and spatial resolutions on the resulting abundances was assessed. We also identified key elements and isotopic ratios that are specific to *i*-process nucleosynthesis and carried out a detailed comparison between our model and a sample of *r/s*-stars.
Results: At the beginning of the AGB phase, during the third thermal pulse, the helium driven convection zone is able to penetrate in the hydrogen rich layers. The subsequent proton ingestion leads to a strong neutron burst with neutron densities of $\approx 4.3 \times 10^{14}$ cm^{-3} at the origin of the synthesis of *i*-process elements. The nuclear energy released by proton burning in the helium-burning convective shell strongly affects the internal structure: the thermal pulse splits and after ≈ 10 yr the upper part of the convection zone merges with the convective envelope. The surface carbon abundance is enhanced by more than 3 dex, leading to an increase of the opacity which triggers a strong mass loss and prevents any further thermal pulse. Our numerical tests indicate that the *i*-process elemental distribution is not strongly affected by the temporal and spatial resolution used to compute the stellar models but typical uncertainties of ±0.3 dex on individual abundances are found. We show that specific isotopic ratios of Ba, Nd, Sm and Eu can represent good tracers of *i*-process nucleosynthesis. Finally, an extended comparison with 14 selected *r/s*-stars show that the observed composition patterns can be well reproduced by our *i*-process AGB model.
Conclusions: A rich *i*-process nucleosynthesis can take place during the early AGB phase of low-metallicity low-mass stars and explain the elemental distribution of most of the *r/s* stars but cannot account for the high level of enrichment of the giant stars in a scenario involving pollution by a former AGB companion.

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Carbon dust in the evolved born-again planetary nebulæ A 30 and A 78

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We present an infrared (IR) characterization of the born-again planetary nebulæ (PNe) A 30 and A 78 using IR images

and spectra. We demonstrate that the carbon-rich dust in A 30 and A 78 is spatially coincident with the H-poor ejecta and coexists with hot X-ray-emitting gas up to distances of $50''$ from the central stars (CSPNs). Dust forms immediately after the born-again event and survives for 1000 yr in the harsh environment around the CSPN as it is destroyed and pushed away by radiation pressure and dragged by hydrodynamical effects. *Spitzer* IRS spectral maps showed that the broad spectral features at 6.4 and 8.0 μm, attributed to amorphous carbon formed in H-deficient environments, are associated with the disrupted disk around their CSPN, providing an optimal environment for charge exchange reactions with the stellar wind that produces the soft X-ray emission of these sources. Nebular and dust properties are modeled for A 30 with CLOUDY taking into account different carbonaceous dust species. Our models predict dust temperatures in the 40–230 K range, five times lower than predicted by previous works. Gas and dust masses for the born-again ejecta in A 30 are estimated to be $M_{\rm gas} = 4.41^{+0.55}_{-0.14} \times 10^{-3}$ M$_\odot$ and $M_{\rm dust} = 3.20^{+3.21}_{-2.06} \times 10^{-3}$ M$_\odot$, which can be used to estimate a total ejected mass and mass-loss rate for the born-again event of $7.61^{+3.76}_{-2.20} \times 10^{-3}$ M$_\odot$ and $\dot{M} = (5\text{–}60) \times 10^{-5}$ M$_\odot$ yr^{-1}, respectively. Taking into account the carbon trapped into dust grains, we estimate that the C/O mass ratio of the H-poor ejecta of A 30 is larger than 1, which favors the very late thermal pulse model over the alternate hypothesis of a nova-like event.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2102.12884

Job Advert

Ph.D. position: a study of the winds of evolved cold stars

Evolved cool stars are major cosmic engines, providing strong mechanical, chemical, and radiative feedback to their host environments. Through strong stellar winds, still poorly understood, they enrich their environment with chemical elements, which are the building blocks of planets and life. A complete understanding of their evolution in the near and distant Universe can only be achieved with detailed knowledge of wind physics over the life cycle of these stars as well as in relation to their circumstellar environment. A complete picture of all the physical processes that simultaneously trigger and shape the strong winds of evolved cold stars is still missing. This thesis is part of Project PEPPER (https://lagrange.oca.eu/fr/welcome-to-anr-pepper), funded by the French Agence Nationale pour la Recherche, aiming to build a coherent and comprehensive description of the mass-loss mechanism, in close collaboration with the ATOMIUM project (https://fys.kuleuven.be/ster/research-projects/aerosol/atomium/atomium). The main questions we endeavour to tackle in this project are: How are the winds launched and which physical processes determine their properties? How do the mass-loss rate and other wind properties depend on fundamental stellar parameters? What is the origin of the detected magnetic field on the stellar surface? What chemical processes dominate in the winds? Where does the interaction between dynamics and chemical phenomena lie? The core of our approach is the synergy between theory and observation in order to obtain a global, coherent vision of the evolved cool stars, from the bottom of the atmosphere up to the circumstellar environment. We will use high-angular resolution observations with SPHERE and MATISSE and observations made quasi-simultaneously with ALMA (all already in hand). For the interpretation, the student will actively participate in the modeling using various codes.

The Ph.D. student will work together with Fabrice Herpin and other PEPPER team members, in close collaboration with the ATOMIUM team. More information on the Laboratoire d'Astrophysique de Bordeaux can be found at https://astrophy.u-bordeaux.fr

The position is a 3-year appointment and requires a University degree in Astronomy or Physics at an advanced level (e.g., a M.Sc. degree), completed by the time of employment. The earliest starting date is 1 October 2021. Applications should include a brief description of research interests and relevant experience, CV, copies of Master's University grades, certificates and diplomas, B.Sc./M.Sc. thesis/internship (or draft thereof), and contact details for the Master director and internship supervisors. Practical experience with python, numerical simulations of gas dynamics, or with observational data on AGB and RSG stars, will be considered a merit.

The complete announcement is posted at https://lagrange.oca.eu/fr/welcome-to-anr-pepper and the application deadline is 1 June 2021. Applications should be sent to Fabrice Herpin (fabrice.herpin@u-bordeaux.fr).

For further information, please contact Fabrice Herpin (fabrice.herpin@u-bordeaux.fr).

See also https://lagrange.oca.eu/fr/welcome-to-anr-pepper

Announcements

III Workshop: chemical abundances in gaseous nebulæ: from the Milky Way to the early Universe

1st announcement

We are pleased to announce the Third Workshop on "Chemical abundances in gaseous nebulæ: from the Milky Way to the early Universe", to be held virtually on May 24–28, 2021.

The purpose of the workshop is to bring together scientists and students to share our knowledge and collaboratively discuss crucial issues related to the chemical abundances in gaseous nebulæ and in AGN, including implications from recent surveys.

The workshop is hosted in the Universidade do Vale do Paraiba, São José dos Campos (Brazil) and due to the current worldwide situation will be held virtually (ZOOM platform). The proceedings will be published in the Workshop Series of the Asociación Argentina de Astronomía.

Registration and abstract submission are now open. There are no registration fees.

The deadline for abstract submission is March 15th, 2021. Please also note that the registration will be closed when the maximum number of 300 participants is reached.

The homepage of the workshop is http://www.univap.br/abundances If you have any queries, please do not hesitate to contact us (abundances@univap.br).

Best regards,
Oli Dors (UNIVAP, Brazil) & Anna Feltre (INAF–OAS, Italy) on behalf of the SOC.

See also www.univap.br/abundances

Asymmetrical Post-main-sequence Nebulæ 8 e2021 The Shaping of Stellar Outflows

Asymmetrical Post-main-sequence Nebulae 8 e2021

The Shaping of Stellar Outflows

A virtual meeting hosted in Granada, Spain to be held in October 4–8, 2021.
The meeting is devoted to the shaping effects of stellar outflows from evolved stars in the formation of asymmetrical

post-main-sequence nebulae including planetary nebulae, nebulae around massive stars, nova remnants, symbiotic stars, ...

Three main topics will be covered:

I Nebular architecture: morphologies and dynamics across stellar mass and wavelength.

- Multi-wavelength properties of planetary nebulæ and related nebulæ, including nebulæ around evolved massive stars, symbiotic stars, nova remnants, ...
- Morphological diversity and statistics.
- Accreting and circumbinary disks: getting closer to the launching engine of collimated outflows and jets.

II Nebular sequences: time-evolving morphologies and physical structures.

- Nebular evolution from the ejection time to its dilution into the ISM.
- Comparative studies between proto-PNe and PNe and between pre-explosion shells and post-explosion remnants in CVs and evolved massive stars.
- Transient nebulæ: born-again PNe, nova shells, and other eruptive objects and transients

III The engine of the nebular shaping: mass-loss mechanisms and their effects on the winds symmetry.

- Post-MS binary interactions: wide, close and interacting binaries, common envelopes, planets.
- Magnetic fields: strength, structure, effects, statistics.
- Mass-loss mechanisms: radiation pressure on dust, convection, rotation, non-radial pulsations.
- Collateral effects on stellar evolution, planetary nebula population, chemistry.

This APN8e virtual meeting will be followed by a full traditional meeting in Granada, Spain, October 2–6, 2023.

We are now accepting proposals for oral contributions and e-Posters (videos with a maximum duration of 2 minutes) for the APN 8-e2021.

The registration deadline requesting contributed talks is July 15.

The registration deadline is September 4. No fee will be required.

The website listed below will become active in the coming days. Until that time, the web page can be found at https://sites.google.com/view/apn8-e2021/home

See also http://apn8.iaa.csic.es

Online Meetings on Evolved Stars and Systems (O-MESS)

Dear all

We are delighted to announce the online seminar series: Online Meetings on Evolved Stars and Systems (O-MESS), which aims to alleviate the cancellation of many in-person meetings on our beloved compact stars and systems. We hope that O-MESS will bring us, at least virtually, closer together and get you up-to-date on the newest findings in the field of white dwarfs, hot subdwarfs, central stars of planetary nebulæ, and related systems. In addition, we expect that O-MESS will inspire you to new ideas, foster collaboration, and, importantly, offer a platform to promote the research of Ph.D. students and non-permanent position holders.

O-MESS will take place bi-weekly at 16:00 Central European Time (CET) on alternate Tuesdays and Wednesdays to enable the largest possible global participation. In exceptional cases when, e.g., these times are not convenient for the scheduled speaker, we might reschedule the seminar to another time, but that will always be announced in advance. For those who cannot participate live, we will – with the permission of the speaker – record the talks and upload them to YouTube. We will also offer the option of distributing the videos using a password-protected page.

The first two O-MESS will take place on March 9 (Tuesday) and March 24 (Wednesday). The talks will be held by invited speakers and the program can be found in the website of the meeting. Please check this page regularly for updates. In the following meetings, we want to give you the opportunity to share your research. You can present a recently published work, but also preliminary results for which you would like feedback from the communities are welcome. If you would like to give a talk at O-MESS, please have a look in the website. The deadline for abstract submission is March 15, 2021.

The meetings will run via Zoom and we will share the login details the day before the meeting. For this we ask you to please subscribe to our mailing list. All contact information and the details for abstract submission can be found at the website of the meeting.

After the talks and questions, we offer to have a 15-minute virtual coffee-break, where you are invited to join separate rooms and chat if you wish.

Finally, we would like to encourage you to also make your students, other institute members, or whoever else might be interested aware of O-MESS. We hope this seminar series will provide an enjoyable environment where everybody, who is eager to learn about what is going on in our field, is welcome.

The O-MESS organizing committee
Marcelo Miller Bertolami, Ingrid Pelisoli, Roberto Raddi, Nicole Reindl

See also http://www.astro.physik.uni-potsdam.de/∼o-mess/index.html