THE AGB NEWSLETTER

An electronic publication dedicated to Asymptotic Giant Branch stars and related phenomena

Official publication of the IAU Working Group on Red Giants and Supergiants

No. 265 — 1 August 2019

http://www.astro.keele.ac.uk/AGBnews

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Editorial

Dear Colleagues,

It is a pleasure to present you the 265$^{\mathrm{th}}$ issue of the AGB Newsletter.

Looking for a postdoctoral position? Look no further but apply to the one advertised to work with the brilliant Rodolfo Smiljanic, in the beautiful country of Poland.

Last month's *Food for Thought*, "Do all stars start with the same carbon-to-oxygen ratio and should we care?" provoked a response from Elizabeth Griffin: "They can't, not if we think we understand element enrichment as coming from different supernovæ. Moreover, even if they did, there has to be a degree of chaos in the way stellar evolution proceeds, and we cannot unravel that history backwards. Therefore, if we think we can put stars in one and the same box we will be wrong, and if we think we can understand the C:O history we'd be just as much wrong, so either way we end up being mistaken, and it might be better to accept that we cannot care about it or we'll all become neurotics." Further discussion on this topic is welcome!

We nearly have our new organising committee of the IAU Working Group on Red Giants and Supergiants in place. You will see some changes on our webpage and newsletter. One of the first things the committee will want to do is submit a Letter of Intent for a Focus Meeting at the next IAU General Assembly, in South Korea in 2021. The longer term objective is to identify outstanding problems in our field of research and propose potential ways forward.

The next issue is planned to be distributed around the 1$^{\mathrm{st}}$ of September.

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

Food for Thought

This month's thought-provoking statement is:

What would be a good title for a focus meeting on red giants and supergiants at the 2021 IAU General Assembly?

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

NuGrid stellar data set – III. Updated low-mass AGB models and s-process nucleosynthesis with metallicities $Z = 0.01$, $Z = 0.02$ and $Z = 0.03$

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The production of the neutron-capture isotopes beyond iron that we observe today in the solar system is the result of the combined contribution of the r-process, the s- process and possibly the i-process. Low-mass AGB ($2 < M/\mathrm{M}_{\odot} < 3$) and massive ($M > 10\ \mathrm{M}_{\odot}$) stars have been identified as the sites of the s-process. In this work we consider the evolution and nucleosynthesis of low-mass AGB stars. We provide an update of the NuGrid Set models, adopting the same general physics assumptions but using an updated convective-boundary mixing model accounting for the contribution from internal gravity waves. The combined data set includes the initial masses $M_{\mathrm{ZAMS}}/\mathrm{M}_{\odot} = 2$, 3 for $Z = 0.03$, 0.02, 0.01. These models are computed with the MESA stellar code and the evolution is followed up to the end of the AGB phase. The nucleosynthesis was calculated for all isotopes in post-processing with the NuGrid MPPNP code. The convective boundary mixing model leads to the formation of a ^{13}C-pocket three times wider compared to the one obtained in the previous set of models, bringing the simulation results now in closer agreement with observations. We also discuss the potential impact of other processes inducing mixing, like rotation, adopting parametric models compatible with theory and observations. Complete yield data tables, derived data products and online analytic data access are provided.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1906.01952

Time variations of H_2O and SiO masers in the proto-Planetary Nebula OH 231.8+4.2

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H_2O (22 GHz) and SiO masers (43, 86, 129 GHz) in the bipolar proto-planetary nebula OH 231.8+4.2 were simultaneously monitored using the 21-m antennas of the Korean VLBI Network in 2009–2015. Both species exhibit periodic flux variations that correlate with the central star's optical light curve, with a phase delay of up to 0.15 for the maser flux variations with respect to the optical light curve. The flux densities of SiO $v = 2$, $J = 1$–0 and H_2O masers decrease with time, implying that they may disappear in 10–20 years. However, there seems to have been a transient episode of intense H_2O maser emission around 2010. We also found a systematic behaviour in the velocity profiles

of these masers. The velocities of the H_2O maser components appear to be remarkably constant, suggesting ballistic motion for the bipolar outflow in this nebula. On the other hand, those of the SiO maser clumps show a systematic radial acceleration of the individual clumps, converging to the outflow velocity of the H_2O maser clumps. Measuring the full widths at zero power of the detected lines, we estimated the expansion velocities of the compact bipolar outflow traced by H_2O maser and SiO thermal line, and discussed the possibility of the expanding SiO maser region in the equatorial direction. All of our analyses support that the central host star of OH 231.8 is close to the tip of the AGB phase, and that the mass-loss rate recently started to decrease because of incipient post-AGB evolution.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1907.01825
and from https://doi.org/10.1093/mnras/stz1830

Evolution and pulsations of population I post-AGB stars

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Evolutionary calculations of population I stars with initial masses $M_0 = 1$ M$_\odot$, 1.5 M$_\odot$ and 2 M$_\odot$ were carried out up to the stage of the proto-planetary nebula. Selected models of post-AGB evolutionary sequences with effective temperatures 3.6×10^3 K $\lesssim T_{\rm eff} \lesssim 2 \times 10^4$ K were used as initial conditions in calculations of self-excited stellar oscillations. For the first time the sequences of hydrodynamic models of radially pulsating post-AGB stars were computed using the self-consistent solution of the equations of radiation hydrodynamics and time-dependent convection. Within this range of effective temperatures the post-AGB stars are the fundamental mode pulsators with period decreasing as the star evolves from $\Pi \approx 300$ day to several days. Period fluctuations are due to nonlinear effects and are most prominent at effective temperatures $T_{\rm eff} < 5000$ K. The amplitude of bolometric light variations is $\Delta M_{\rm bol} \approx 1$ mag at $T_{\rm eff} \lesssim 6000$ K and rapidly decreases with increasing $T_{\rm eff}$. The theoretical dependence of the pulsation period as a function of effective temperature obtained in the study can be used as a criterion for the evolutionary status of pulsating variables suspected to be post-AGB stars.

Accepted for publication in Astronomy Letters
Available from https://arxiv.org/abs/1907.01230

Study of CS, SiO, and SiS abundances in carbon star envelopes: Assessing their role as gas-phase precursors of dust

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Aims: We aim to determine the abundances of CS, SiO, and SiS in a large sample of carbon star envelopes covering a wide range of mass loss rates to investigate the potential role that these molecules could play in the formation of dust in the surroundings of the central AGB star.
Methods: We surveyed a sample of 25 carbon-rich AGB stars in the $\lambda = 2$ mm band, more concretely in the $J = 3$–2 line of CS and SiO, and in the $J = 7$–6 and $J = 8$–7 lines of SiS, using the IRAM 30-m telescope. We performed excitation and radiative transfer calculations based on the large velocity gradient (LVG) method to model the observed lines of the molecules and to derive their fractional abundances in the observed envelopes. We also assessed the effect of infrared pumping in the excitation of the molecules.
Results: We detected CS in all 25 targeted envelopes, SiO in 24 of them, and SiS in 17 sources. Remarkably, SiS is not detected in any envelope with a mass loss rate below 10^{-6} M yr^{-1} while it is detected in all envelopes with mass loss rates above that threshold.We found that CS and SiS have similar abundances in carbon star envelopes, while SiO is present with a lower abundance. We also found a strong correlation in which the denser the envelope,

the less abundant are CS and SiO. The trend is however only tentatively seen for SiS in the range of high mass loss rates. Furthermore, we found a relation in which the integrated flux of the MgS dust feature at 30 μm increases as the fractional abundance of CS decreases.
Conclusions: The decline in the fractional abundance of CS with increasing density could be due to gas-phase chemistry in the inner envelope or to adsorption onto dust grains. The latter possibility is favored by a correlation between the CS fractional abundance and the 30-μm feature, which suggests that CS is efficiently incorporated onto MgS dust around C-rich AGB stars. In the case of SiO,the observed abundance depletion with increasing density is most likely caused by an efficient incorporation onto dust grains. We conclude that CS, SiO (very likely), and SiS (tentatively) are good candidates to act as gas-phase precursors of dust in C-rich AGB envelopes.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1906.09461

A catalog of known Galactic K–M star of class I, candidate RSGs, in Gaia DR2

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We investigate individual distances and luminosities of a sample of 889 nearby candidate red supergiants with reliable parallaxes ($\bar{\omega}/\sigma_{\bar{\omega}} > 4$ and $RUWE < 2.7$) from Gaia DR2. The sample was extracted from the historical compilation of spectroscopically derived spectral types by Skiff (2014), and consists of K–M stars that are listed with class I at least once. The sample includes well-known red supergiants from Humphreys (1978), Elias et al. (1985), Jura & Kleinmann (1990), and Levesque et al. (2005). Infrared and optical measurements from the 2MASS, CIO, MSX, WISE, MIPSGAL, GLIMPSE, and NOMAD catalogs allow us to estimate the stellar bolometric magnitudes. We analyze the stars in the luminosity versus effective temperature plane and confirm that 43 sources are highly-probably red supergiants with $M_{\rm bol} < -7.1$ mag. 43% of the sample is made of stars with masses > 7 M$_\odot$. Another $\approx 30\%$ of the sample consists of giant stars.

Published in The Astronomical Journal, 158, 20 (2019)
Available from https://arxiv.org/abs/1905.03744
and from https://somethingaboutrsgstars.wordpress.com/
and from http://staff.ustc.edu.cn/~messineo/

Electron capture rates in ^{20}Ne for a forbidden transition to the ground state of ^{20}F relevant to final evolution of high density O–Ne–Mg cores

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Electron capture on ^{20}Ne is critically important for the final stage of evolution of stars with the initial masses of 8–10 $M_\odot$. In the present paper, we evaluate electron capture rates for a forbidden transition ^{20}Ne ($0^+_{\rm g.s.}$) $\rightarrow$ ^{20}F ($2^+_{\rm g.s.}$) in stellar environments by the multipole expansion method with the use of shell-model Hamiltonians. These rates have not been accurately determined in theory as well as in experiments. Our newly evaluated rates are compared with those obtained by a prescription that treats the transition as an allowed Gamow–Teller (GT) transition with the strength determined from a recent β-decay experiment for ^{20}F ($2^+_{\rm g.s.}$) $\rightarrow$ ^{20}Ne ($0^+_{\rm g.s.}$) (Kirsebom et al. 2018, arXiv:1805.08149).

We find that different electron energy dependence of the transition strengths between the two methods leads to sizable differences in the weak rates of the two methods. We also find that the Coulomb effects, that is, the effects of screening on ions and electrons are non-negligible. We apply our e-capture rates on ^{20}Ne to the calculation of the evolution of high-density O–Ne–Mg cores of 8–10 $M_\odot$ stars. We find that our new rates affect the abundance distribution and the central density at the final stage of evolution.

Accepted for publication in The Astrophysical Journal
Available from https://arxiv.org/abs/1905.10400

ExoMol line list XXXIV: A rovibrational line list for phosphinidene (PH) in its $X\,^3\Sigma^-$ and $a\,^1\Delta$ electronic states

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A rovibronic line list for the ground ($X\,^3\Sigma^-$) and first excited ($a\,^1\Delta$) states of phosphinidene, ^{31}PH, is computed. The line list is designed for studies of exoplanetary and cool stellar atmospheres with temperatures up to 4000 K. A combination of empirical and *ab initio* data are used to produce the line list: potential energy curves (PECs) are fitted using experimental transition frequencies; these transitions are reproduced with a root mean square error of 0.01 cm^{-1}. The nuclear Schrödinger equation is solved using these PECs plus Born–Oppenheimer and spin splitting correction terms. Line intensities and Einstein A coefficients are computed using *ab initio* Dipole Moment Curves (DMC) X–X and a–a. The resulting LaTY line list, which contains 65 055 transitions for 2528 rovibronic states up to 24500 cm^{-1} and $J = 80$, is used to simulate spectra in emission and absorption at a range of temperatures. The line list is made available in electronic form at the CDS and ExoMol databases.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/1907.03367

NGC 6388 reloaded: some like it hot, but not too much. New constraints on the first-generation polluters

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Multiple stellar populations in globular clusters (GCs) are defined and recognized by their chemical signature. Second-generation stars show the effects of nucleosynthesis in the more massive stars of the earliest component that formed in the first star formation burst. High-temperature H-burning produces the whole pattern of (anti-) correlations in proton-capture elements that are widely found in GCs. However, it is still debated where this burning occurred. Here we introduce new powerful diagnostic plots to detect evidence (if any) of products from proton-capture reactions that occur at very high temperatures. To test these detectors of high-temperature H-burning plots, we show that stringent constraints can be placed on the temperature range of the first-generation polluters that contributed to shaping the chemistry of multiple stellar population in the massive bulge GC NGC 6388. Using the largest sample to date (185 stars) of giants with detailed abundance ratios in a single GC (except ω Cen), we may infer that the central temperature of part of the polluters must have been comprised between about 100 and about 150 MK if we consider hydrostatic H-burning in the core of massive stars. A much more narrow range (110 to 120 MK) is inferred if the polluters can be identified in massive asymptotic giant branch stars.

Accepted for publication in A&A Letters
Available from https://arxiv.org/abs/1906.11458

Metallicity gradients in M 31, M 33, NGC 300 and the Milky Way using abundances of different elements

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Metallicity gradients derived from planetary nebulæ (PNe) using O, Ne, and Ar abundances are studied and compared to those from H II regions in the galaxies M 31, M 33, NGC 300 and the Milky Way. Galactocentric radii and chemical abundances were collected from the literature, carefully selecting a homogeneous sample for each galaxy. Metallicity gradients shown by PNe are flatter than those of H II regions in all cases. The extreme case is M 31 where PN abundances are not related to galactocentric distances and the gradients are consistent with zero. To analyze the evolution of gradients with time we build gradients for Peimbert Type I and non-Type I PNe finding that Type I PNe show steeper gradients than non-Type I PNe and more similar to the ones of H II regions indicating that the chemical gradients might steepen with time. Alternatively, the flat gradients for old PNe show that radial migration could have an important role in the evolution of galaxies.

Accepted for publication in RevMexAA, vol. 55, No. 2, (2019)
Available from https://arxiv.org/abs/1907.05797

A rotating fast bipolar wind and disk system around the B[e]-type star MWC 922

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We present interferometric observations with the Atacama Large Millimeter Array (ALMA) of the free–free continuum and recombination line emission at 1 and 3mm of the "Red Square Nebula" surrounding the B[e]-type star MWC 922. The unknown distance to the source is usually taken to be $d = 1.7$–3 kpc. The unprecedented angular resolution (up to $\sim 0\farcs02$) and exquisite sensitivity of these data unveil, for the first time, the structure and kinematics of the emerging, compact ionized region at its center. We imaged the line emission of H30α and H39α, previously detected with single-dish observations, as well as of H51ϵ, H55γ, and H63δ, detected for the first time in this work. The line emission is seen over a full velocity range of ~ 180 km s^{-1} arising in a region of diameter $< 0\farcs14$ (less than a few hundred au) in the maser line H30α, which is the most intense transition reported here. We resolve the spatio-kinematic structure of a nearly edge-on disk rotating around a central mass of ~ 10 M$_\odot$ ($d = 1.7$ kpc) or ~ 18 M$_\odot$ ($d = 3$ kpc), assuming Keplerian rotation. Our data also unveil a fast (~ 100 km s^{-1}) bipolar ejection (a jet?) orthogonal to the disk. In addition, a slow (< 15 km s^{-1}) wind may be lifting off the disk. Both, the slow and the fast winds are found to be rotating in a similar manner to the ionized layers of the disk. This represents the first empirical proof of rotation in a bipolar wind expanding at high velocity (~ 100 km s^{-1}). The launching radius of the fast wind is found to be < 30–51 au, i.e. smaller than the inner rim of the ionized disk probed by our observations. We believe that the fast wind is actively being launched, probably by a disk-mediated mechanism in a (accretion?) disk around a possible compact companion. We have modelled our observations using the radiative transfer code MORELI. This has enabled us to describe with unparalleled detail the physical conditions and kinematics in the inner layers of MWC 922, which has revealed itself as an ideal laboratory for studying the interplay of disk rotation and jet-launching. Although the nature of MWC 922 remains unclear, we believe it could be a ~ 15 M$_\odot$ post-main sequence star in a mass-exchanging binary system. If this is the case, a more realistic value of the distance may be $d \sim 3$ kpc.

Accepted for publication in Astronomy & Astrophysics
Available from https://cloud.cab.inta-csic.es/index.php/s/3WZfdJEkA95f5yg

Evolved massive stars at low metallicity I. A source catalog for the Small Magellanic Cloud

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We present a clean, magnitude-limited (IRAC1 or WISE1 $\leq$ 15.0 mag) multiwavelength source catalog for the Small Magellanic Cloud (SMC) with 45,466 targets in total, with the purpose of building an anchor for future studies, especially for the massive star populations at low metallicity. The catalog contains data in 50 different bands including 21 optical and 29 infrared bands, retrieved from SEIP, VMC, IRSF, Akari, HERITAGE, Gaia, SkyMapper, NSC, Massey et al. (2002), and GALEX, ranging from the ultraviolet to the far-infrared. Additionally, radial velocities and spectral classifications were collected from the literature, as well as infrared and optical variability statistics were retrieved from WISE, SAGE-Var, VMC, IRSF, Gaia, NSC, and OGLE. The catalog was essentially built upon a 1″ crossmatching and a 3″ deblending between the *Spitzer* Enhanced Imaging Products (SEIP) source list and Gaia Data Release 2 (DR2) photometric data. Further constraints on the proper motions and parallaxes from Gaia DR2 allowed us to remove the foreground contamination. We estimated that about 99.5% of the targets in our catalog were most likely genuine members of the SMC. By using the evolutionary tracks and synthetic photometry from MESA Isochrones & Stellar Tracks and the theoretical $J - K_{\rm s}$ color cuts, we identified 1,405 red supergiant, 217 yellow supergiant and 1,369 blue supergiant candidates in the SMC in five different color–magnitude diagrams (CMDs), where attention should also be paid to the incompleteness of our sample. We ranked the candidates based on the intersection of different CMDs. A comparison between the models and observational data shows that the lower limit of initial mass for the RSGs population may be as low as 7 or even 6 $M_{\odot}$ and the RSG is well separated from the asymptotic giant branch star (AGB) population even at faint magnitude, making RSGs a unique population connecting the evolved massive and intermediate stars, since stars with initial mass around 6 to 8 $M_{\odot}$ are thought to go through a second dredge-up to become AGBs. We encourage the interested reader to further exploit the potential of our catalog.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1907.06717

GK Car and GZ Nor: Two low-luminous, depleted RV Tauri stars

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We performed a photometric and spectroscopic analysis of two RV Tauri stars GK Car and GZ Nor. Both objects are surrounded by hot circumstellar dust. Their pulsation periods, derived from ASAS photometric time series, have been used to derive their luminosities and distances via the PLC relation. In addition, for both objects, GAIA distances are available. The Gaia distances and luminosities are consistent with the values obtained from the PLC relationship. GK Car is at distance of 4.5$\pm$1.3 kpc and has a luminosity of 1520$\pm$840 L$_{\odot}$, while GZ Nor is at distance of 8.4$\pm$2.3 kpc and has a luminosity of 1240 ± 690 L$_{\odot}$. Our abundance analysis reveals that both stars show depletion of refractory elements with [Fe/H] = -1.3 and [Zn/Ti] = $+1.2$ for GK Car and [Fe/H] = -2.0 and [Zn/Ti] = $+0.8$ for GZ Nor. In the WISE colour–colour diagram, GK Car is located in the RV Tauri box as originally defined by Lloyd Evans (1985) and updated by Gezer et al. (2015), while GZ Nor is not. Despite this, we argue that both objects are surrounded

by a gravitationally bound disc. As depletion is observed in binaries, we postulate that both stars are binaries as well. RV Tauri stars are generally acknowledged to be post-AGB stars. Recent studies show that they might be either indeed post-AGB or post-RGB objects depending on their luminosity. For both objects, the derived luminosities are relatively low for post-AGB objects, however, the uncertainties are quite large. We conclude that they could be either post-RGB or post-AGB objects.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/1907.07937

Elemental abundances in the remnant of the ancient eruption of CK Vulpeculæ

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CK Vul or Nova 1670 is an enigmatic eruptive object which underwent a stellar-merger event recorded by seventeenth-century observers. Its remnant was recently recovered at submillimeter wavelengths, revealing gas of an extraordinary isotopic composition indicative of past processing in the CNO cycles and partial He burning. Here, we present long-slit optical spectra of the remnant acquired with X-shooter at the Very Large Telescope at an unprecedented sensitivity and spectral coverage. The spectra cover features of key elements – including H, He, C, N, and O – at ionization degrees I–III. A classical analysis of the spectra allows us to identify several spatio-kinematic components in the probed part of the nebula at electron temperatures of 10–15 kK and densities of 200–600 cm^{-3}. We find that the nebula is most likely excited by shocks rather than by direct radiation of the stellar remnant. We provide a detailed analysis of the elemental abundances in the remnant and find that helium is twice more abundant than in the Sun. Nitrogen is also overabundant with a N/O ratio ten times larger than the solar one. These anomalous abundances strongly indicate that the observed gas was processed in CNO cycles of H burning, consistent with the submillimeter studies. Additionally, sub-solar abundances of heavier elements, such as Ne, S, and Ar, suggest that the progenitor of CK Vul was formed from material poorer in metals than the Sun and was therefore an old stellar system before the 1670 eruption.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1907.05998

Do evolved stars in the LMC show dual dust chemistry?

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We study a group of evolved M-stars in the Large Magellanic Cloud, characterized by a peculiar spectral energy distribution. While the 9.7-μm feature arises from silicate particles, the whole infrared data seem to suggest the presence of an additional featureless dust species. We propose that the circumstellar envelopes of these sources are characterized by a dual dust chemistry, with an internal region, harbouring carbonaceous particles, and an external zone, populated by silicate, iron and alumina dust grains. Based on the comparison with results from stellar modelling that describe the dust formation process, we deduce that these stars descend from low-mass ($M < 2\ \mathrm{M}_{\odot}$) objects, formed 1–4 Gyr ago, currently evolving either in the post-AGB phase or through an after-pulse phase, when the shell CNO nuclear activity is temporarily extinguished. Possible observations able to confirm or disregard the present hypothesis are discussed.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/1907.02459

Compact planetary nebulæ: Improved IR diagnostic criteria based on classification tree modelling

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Planetary nebulæ (PNe) are strong Hα line-emitters and a lot of new PNe discoveries have been made by the SuperCOSMOS AAO/UKST Hα Survey (SHS) and the *Isaac Newton* Telescope Photometric Hα Survey (IPHAS). However, their resulting list of candidates turned out to be heavily contaminated from Hα-line mimics like young stellar objects (YSOs) and/or H II regions. The aim of this work is to find new infrared criteria that can better distinguish compact PNe from their mimics using a machine learning approach and the photometric data from the Two-Micron All-Sky Survey and Wide-field Infrared Survey Explorer. Three classification tree models have been developed with the following colour criteria: $(W1-W4) \geq 7.87$ mag and $(J-H) < 1.10$ mag; $(H-W2) \geq 2.24$ mag and $(J-H) < 0.50$ mag; and $(K_\mathrm{s}-W3) \geq 6.42$ mag and $(J-H) < 1.31$ mag providing a list of candidates, characterized by a high probability to be genuine PNe. The contamination of this list of candidates from Hα mimics is low but not negligible. By applying these criteria to the IPHAS list of PN candidates and the entire IPHAS and VPHAS+ DR2 catalogues, we find 141 sources, from which 92 are known PNe, 39 are new very likely compact PNe (without an available classification or uncertain) and 10 are classified as H II regions, Wolf–Rayet stars, AeBe stars and YSOs. The occurrence of false positive identifications in this technique is between 10 and 15 per cent.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1907.10026

Stellar atmospheric parameters for 754 spectra from the X-shooter Spectral Library

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The X-shooter Spectral Library (XSL) is an empirical stellar library at medium spectral resolution covering the wavelength range from 3000 Å to 24 800 Å. This library aims to provide a benchmark for stellar population studies.

In this work, we present a uniform set of stellar atmospheric parameters, effective temperatures, surface gravities, and iron abundances for 754 spectra of 616 XSL stars. We used the full-spectrum fitting package ULySS with the empirical MILES library as reference to fit the ultraviolet–blue (UVB) and visible (VIS) spectra. We tested the internal consistency and we compared our results with compilations from the literature. The stars cover a range of effective temperature $2900 < T_{\rm eff} < 38\,000$ K, surface gravity $0 < \log g < 5.7$, and iron abundance $-2.5 <$ [Fe/H] $< +1.0$, with a couple of stars extending down to [Fe/H] $= -3.9$. The precisions of the measurements for the G- and K-type stars are 0.9%, 0.14, and 0.06 in $T_{\rm eff}$, $\log g$, and [Fe/H], respectively. For the cool giants with $\log g < 1$, the precisions are 2.1%, 0.21, and 0.22, and for the other cool stars these values are 1%, 0.14, and 0.10. For the hotter stars ($T_{\rm eff} > 6500$ K), these values are 2.6%, 0.20, and 0.10 for the three parameters.

Published in A&A
Available from https://arxiv.org/abs/1907.06391
and from 10.1051/0004-6361/201834273

Spectral analysis of the hybrid PG 1159-type central stars of the planetary nebulæ Abell 43 and NGC 7094

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Stellar post asymptotic giant branch (post-AGB) evolution can be completely altered by a final thermal pulse (FTP) which may occur when the star is still leaving the AGB (AFTP), at the departure from the AGB at still constant luminosity (late TP, LTP) or after the entry to the white-dwarf cooling sequence (very late TP, VLTP). Then convection mixes the He-rich material with the H-rich envelope. According to stellar evolution models the result is a star with a surface composition of H $\approx$ 20% by mass (AFTP), $\approx$ 1% (LTP), or (almost) no H (VLTP). Since FTP stars exhibit intershell material at their surface, spectral analyses establish constraints for AGB nucleosynthesis and stellar evolution. We performed a spectral analysis of the so-called hybrid PG 1159-type central stars (CS) of the planetary nebulæ Abell 43 and NGC 7094 by means of non-local thermodynamical equilibrium models. We confirm the previously determined effective temperatures of $T_{\rm eff} = 115\,000 \pm 5\,000$ K and determine surface gravities of $\log(g/{\rm cm/s^2}) = 5.6 \pm 0.1$ for both. From a comparison with AFTP evolutionary tracks, we derive stellar masses of $0.57^{+0.07}_{-0.04}$ $M_\odot$ and determine the abundances of H, He, and metals up to Xe. Both CS are likely AFTP stars with a surface H mass fraction of 0.25 ± 0.03 and 0.15 ± 0.03, respectively, and a Fe deficiency indicating subsolar initial metallicities. The light metals show typical PG 1159-type abundances and the elemental composition is in good agreement with predictions from AFTP evolutionary models. However, the expansion ages do not agree with evolution timescales expected from the AFTP scenario and alternatives should be explored.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1907.07049

The inner dust shell of Betelgeuse detected by polarimetric aperture-masking interferometry

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Theory surrounding the origin of the dust-laden winds from evolved stars remains mired in controversy. Characterizing the formation loci and the dust distribution within approximately the first stellar radius above the surface is crucial for understanding the physics that underlie the mass-loss phenomenon. By exploiting interferometric polarimetry, we derive the fundamental parameters that govern the dust structure at the wind base of a red supergiant.

We present near-infrared aperture-masking observations of Betelgeuse in polarimetric mode obtained with the NACO/ SAMPol instrument. We used both parametric models and radiative transfer simulations to predict polarimetric differential visibility data and compared them to SPHERE/ZIMPOL measurements. Using a thin dust shell model, we report the discovery of a dust halo that is located at only 0.5 $R_\star$ above the photosphere (i.e. an inner radius of the dust halo of 1.5 $R_\star$). By fitting the data under the assumption of Mie scattering, we estimate the grain size and density for various dust species. By extrapolating to the visible wavelengths using radiative transfer simulations, we compare our model with SPHERE/ZIMPOL data and find that models based on dust mixtures that are dominated by forsterite are most favored. Such a close dusty atmosphere has profound implications for the dust formation mechanisms around red supergiants.

Accepted for publication in A&A

Available from https://arxiv.org/abs/1907.08594

Constraining stellar parameters and atmospheric dynamics of the carbon AGB star V Oph

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Molecules and dust produced by the atmospheres of cool evolved stars contribute to a significant amount of the total material found in the interstellar medium. To understand the mechanism behind the mass loss of these stars, it is of pivotal importance to investigate the structure and dynamics of their atmospheres.

Our goal is to verify if the extended molecular and dust layers of the carbon-rich asymptotic giant branch (AGB) star V Oph, and their time variations, can be explained by dust-driven winds triggered by stellar pulsation alone, or if other mechanisms are operating.

We model V Oph mid-infrared interferometric VLTI-MIDI data (8–13 μm), at phases 0.18, 0.49, 0.65, together with literature photometric data, using the latest-generation self-consistent dynamic atmosphere models for carbon-rich stars: DARWIN.

We determine the fundamental stellar parameters: $T_{\rm eff} = 2600$ K, $L_{\rm bol} = 3585$ L$_\odot$, $M = 1.5$ M$_\odot$, $C/O = 1.35$, $\dot{M} = 2.50 \cdot 10^{-6}$ M$_\odot$ yr^{-1}. We calculate the stellar photospheric radii at the three phases: 479, 494, 448 R$_\odot$; and the dust radii: 780, 853, 787 R$_\odot$. The dynamic models can fairly explain the observed N-band visibility and spectra, although there is some discrepancy between the data and the models, which is discussed in the text.
We discuss the possible causes of the temporal variations of the outer atmosphere, deriving an estimate of the magnetic field strength, and computing upper limits for the Alfvén waves velocity. In addition, using period–luminosity sequences, and interferometric modeling, we suggest V Oph as a candidate to be reclassified as a semi-regular star.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1907.08693

Circumstellar envelopes of semi-regular long-period variables: mass-loss rate estimates and general model-fitting of the molecular gas

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Aims: We aim to study the main properties of a volume-limited unbiased sample of well characterized semi-regular variables (SRs) in order to clarify important issues that need to be further explained, such as the formation of axially symmetric planetary nebulae (PNe) from spherical circumstellar envelopes (CSEs) that takes place during the mass loss process along the AGB phase.
Methods: We present new high S/N IRAM 30m observations of the ^{12}CO $J = 2$–1, ^{12}CO $J = 1$–0, and ^{13}CO $J = 1$–0 lines, in a volume-limited sample of SRs for which the *Hipparcos* distances are between 100–500 pc and declinations above $-25°$. We analyzed the data by characterizing the main properties of the CSEs. The ^{12}CO $J = 2$–1 data have been used to study the profiles, while the ^{12}CO $J = 1$–0 data have been used to estimate mass-loss rates for the complete sample. Moreover, the ^{12}CO $J = 2$–1 line has been used to determine the possible structures responsible for such profiles.
Results: We have classified the sources into four groups according to the different profiles and final gas expansion velocities. Type 1 and 2 profiles are broad and narrow symmetric lines, respectively. Type 1 profiles, furthermore, are more related to standard spherically symmetric envelopes already studied. Type 3 profiles, on the contrary, are strange profiles with very pronounced asymmetries. Type 4 profiles, finally, are those which show two different components: a narrow line profile superimposed on a broad pedestal component. We find that for sources which show this kind of profile, with two different components, the variation amplitude is very low, what means that these SRs do not have a well developed inner envelope differentiated from the outer one. Interestingly, we report a moderate correlation between mass-loss rates and ^{12}CO $J = 1$–0/^{12}CO $J = 2$–1 line intensity ratios for O-rich SRs, suggesting a different behaviour between C- and O-rich SRs. By using SHAPE+SHAPEMOL, we find a unified simple model based on an oblate spheroid, placed in different orientations, that may explain all the ^{12}CO profiles in the sample, indicating that the gas expansion is, in general, predominantly equatorial. Moreover, in order to explain the type 4 profiles, we define an extra component which may somehow be a biconical structure or similar according to the structures already found in this kind of sources. Type 1 and 2 profiles, curiously, may also be explained by standard spherically symmetric envelopes, but often requiring anomalously low velocities. Type 3 and 4 profiles, however, need axial symmetry to be explained. We conclude that most circumstellar shells around SRs show axial, strongly non-spherical symmetry. More interferometric observations are needed in order to make firm conclusions about mass-loss processes and possible morphologies of SRs.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1907.09175

AtomNeb: IDL library for atomic data of ionized nebulæ

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Spectra emitted from ionized nebulæ typically contain collisionally excited and recombination lines, which can be used to trace physical conditions and chemical abundances of the interstellar medium in our Galaxy and other galaxies. "AtomNeb" is a database containing atomic data stored in the Flexible Image Transport System (FITS) file format, including the data for collisionally excited and recombination lines generally observed in nebular astrophysics. The AtomNeb interface library is equipped with several application programming interface (API) functions developed in the Interactive Data Language (IDL), which can be also used in the GNU Data Language (GDL). This IDL library relies on the FITS file related IDL procedures from the IDL Astronomy User's library. The AtomNeb IDL library, together with the "proEQUIB" IDL library, can be used to perform plasma diagnostics and abundance analysis of emission lines from ionized gaseous nebulæ.

Published in Journal of Open Source Software, 4(35), 898 (2019)
Available from https://arxiv.org/abs/1907.02528
and from https://doi.org/10.21105/joss.00898

Density conversion between 1-D and 3-D stellar models with $^{\mathrm{1D}}$MESA**2**HYDRO$^{\mathrm{3D}}$

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We present $^{\mathrm{1D}}$MESA2HYDRO$^{\mathrm{3D}}$, an open source, Python-based software tool that provides an accessible means of generating physically motivated initial conditions (ICs) for hydrodynamical simulations from 1-D stellar structure models.
We test $^{\mathrm{1D}}$MESA2HYDRO$^{\mathrm{3D}}$ on five stellar models generated with the MESA stellar evolution code and verify its capacity as an IC generator with the Phantom smoothed-particle hydrodynamics code (Paxton et al. 2018; Price et al. 2018). Consistency between the input density profiles, the $^{\mathrm{1D}}$MESA2HYDRO$^{\mathrm{3D}}$-rendered particle distributions, and the state of the distributions after evolution over 10 dynamical timescales is found for model stars ranging in structure and density from a radially extended supergiant to a white dwarf.

Accepted for publication in The Astrophysical Journal
Available from https://arxiv.org/abs/1907.09062

Changes: the past, present, and future of the nearby dwarf galaxy NGC 55

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Spectra that cover wavelengths from 0.6 to 1.1 μm are used to examine the behavior of emission and absorption features in a contiguous $22'' \times 300''$ region centered on the nearby dwarf galaxy NGC 55. Based on the relative strengths of various emission features measured over spatial scales of many tens of parsecs, it is concluded that the ionization states and sulphur abundances in most of the star-forming regions near the center of NGC 55 are similar. A large star-forming region is identified in the north–west part of the disk at a projected distance of ~ 1 kpc from the galaxy center that has distinct ionization properties. Fossil star-forming regions are also identified using the depth of the near-infrared Ca triplet. One such area is identified near the intersection of the major and minor axes, and it is suggested that this area is a proto-nucleus. The spectra of bright unresolved sources that are blended stellar asterisms, compact H II regions, and star clusters are also discussed. The spectra of some of the H II regions contain Ca triplet absorption lines, signalling a concentration of stars in the resolution element that span many Myr. Six of the unresolved sources have spectroscopic characteristics that are indicative of C stars embedded in intermediate age clusters. The peculiar properties of NGC 55 have been well documented in the literature, and it is argued that these may indicate that NGC 55 is transforming into a dwarf lenticular galaxy.

Accepted for publication in The Astronomical Journal
Available from https://arxiv.org/abs/1907.08296

Modeling rotational disruption of grains and microwave emission from spinning dust in AGB envelopes

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Radio observations of Asymptotic Giant Branch (AGB) star envelopes frequently show some excess emission at frequencies below 100 GHz which cannot be explained by thermal dust emission (hereafter anomalous microwave emission – AME). Moreover, AGB envelopes are a common place where gas molecules condense to form nanoparticles (e.g., polycyclic aromatic hydrocarbons) and large grains. In this paper, we will study whether electric dipole emission from rapidly spinning nanoparticles can reproduce the AME observed toward AGB stars. To properly model the size distribution of nanoparticles in the AGB envelope, we take into account both the increase of nanoparticles due to rotational disruption of large grains spun-up by radiative torques and the decrease of smallest nanoparticles due to rotational disruption driven by stochastic gas collisions. We then perform detailed modeling of microwave emission from rapidly spinning nanoparticles from both C-rich and O-rich AGB envelopes using the grain size distribution constrained by rotational disruption. We find that spinning dust emission is dominant over thermal dust emission at frequencies below 100 GHz. We attempt to fit the observational data of AME using our spinning dust model and demonstrate that spinning dust can reproduce the observed AME in six AGB stars. Finally, we discuss that microwave emission from spinning dust in AGB envelopes could be observed with high-resolution upcoming radio telescopes such as ngVLA and ALMA Band 1. This would be a major leap for understanding AGB envelopes, formation, evolution, and internal structures of dust. Observations would help to distinguish the carrier of AME from comparing C-rich to O-rich stars, because PAHs are formed in C-rich AGB stars while silicates are formed in O-rich stars.

Submitted to ApJ
Available from https://arxiv.org/abs/1907.10654

Review Paper

Formation and delivery of complex organic molecules to the Solar System and early Earth

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The late stages of stellar evolution from asymptotic giant branch stars to planetary nebulae are now known to be an active phase of molecular synthesis. Over 80 gas-phase molecules have been detected through rotational transitions in the mm/submm region. Infrared spectroscopy has also detected inorganic minerals, fullerenes, and organic solids. The synthesis of these molecules and solids take place over very low density ($< 10^6$ cm^{-3}) and short ($\sim 10^3$ yr) time scales. The complex organics are observed to have mixed aromatic/aliphatic structures and may be related to the complex organics found in meteorites, comets, interplanetary dust particles, and planetary satellites. The possible links between stellar and solar system organics is discussed.

Published in "Handbook of Astrobiology", ed. Vera Kolb, CRC Press, Chapter 4.2, p165
Available from https://arxiv.org/abs/1907.06127

Job Advert

Nicolaus Copernicus Astronomical Center, Warsaw, Poland
Postdoctoral position on stars in globular clusters

Applications are invited for one postdoctoral position at the Nicolaus Copernicus Astronomical Center (NCAC), in Warsaw, Poland, to work on the near-UV photometric and spectroscopic properties of stars from the multiple stellar populations of globular clusters. This work might also be potentially important for the development of a new near-UV spectrograph for the ESO VLT.

The successful applicant will work with Dr. Rodolfo Smiljanic on the project "Near-UV stellar spectroscopy: uncovering the past and building the future" funded by the Polish National Science Center.

The position will be for 2 years with a possible extension for a third year, depending on performance. The starting date is to some extent negotiable but could be as early as November 2019. Deadline for applications is August 31$^{\text{st}}$.

Additional information and instructions on how to apply are available via the website below.

See also https://www.camk.edu.pl/en/archiwum/2019/07/05/postdoctoral-position-stars-globular-clusters/