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. 295 — 6 February 2022

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 295$^{\rm th}$ issue of the AGB Newsletter.

Note the imminent deadline for participation in a SOFIA meeting (14 February). There's a lot to enjoy, especially on interactions, post-AGB phases and supernova progenitor systems. But note also several contributions from serious amateur astronomers.

See also the advertisement for a job as staff astronomer at the European Southern Observatory (feeling very envious!).

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

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

Food for Thought

This month's thought-provoking statement is:

If we had not had eyes we would not have known of AGB stars

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

Refereed Journal Papers

The post-common-envelope binary central star of the planetary nebula Ou 5: a doubly-eclipsing post-red-giant-branch system

David Jones[1,2], *James Munday*[3], *Romano L.M. Corradi*[4,1], *Pablo Rodríguez-Gil*[1,2], *Henri M.J. Boffin*[5], *Jiři Zak*[5], *Paulina Sowicka*[6], *Steven G. Parsons*[7], *Vik S. Dhillon*[7,1], *S.P. Littlefair*[7], *T.R. Marsh*[3,1], *Nicole Reindl*[8] *and Jorge García-Rojas*[1,2]

[1]IAC, Spain
[2]ULL, Spain
[3]Univ. of Warwick, UK
[4]GTC, Spain
[5]ESO, Germany
[6]NCAC, Poland
[7]Univ. of Sheffield, UK
[8]Univ. of Potsdam, Germany

We present a detailed study of the stellar and orbital parameters of the post-common envelope binary central star of the planetary nebula Ou 5. Low-resolution spectra obtained during the primary eclipse – to our knowledge the first isolated spectra of the companion to a post-common-envelope planetary nebula central star – were compared to catalogue spectra, indicating that the companion star is a late K- or early M-type dwarf. Simultaneous modelling of multi-band photometry and time-resolved radial velocity measurements was then used to independently determine the parameters of both stars as well as the orbital period and inclination. The modelling indicates that the companion star is low mass (~ 0.25 $M_\odot$) and has a radius significantly larger than would be expected for its mass. Furthermore, the effective temperature and surface gravity of nebular progenitor, as derived by the modelling, do not lie on single-star post-AGB evolutionary tracks, instead being more consistent with a post-RGB evolution. However, an accurate determination of the component masses is challenging. This is principally due to the uncertainty on the locus of the spectral lines generated by the irradiation of the companion's atmosphere by the hot primary (used to derive companion star's radial velocities), as well as the lack of radial velocities of the primary.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2112.09505
and from https://doi.org/10.1093/mnras/stab3736

Abundance discrepancy factors in high density planetary nebulæ

Francisco Ruiz-Escobedo[1] *and Miriam Peña*[1]

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70264, Ciudad Universitaria, 04510, Ciudad de México

From high-resolution spectra, chemical abundances from collisionally excited lines (CELs) and optical recombination lines (ORLs) have been determined for planetary nebulæ Cn 3-1, Vy 2-2, Hu 2-1, Vy 1-2 and IC 4997, which are young and dense objects. The main aim of this work is to derive their O^{+2}/H^{+} Abundance Discrepancy Factors, ADFs, between CELs and ORLs. He, O, N, Ne, Ar, S, and Cl abundances were obtained and our values are in agreement with those previously reported. We found that Cn 3-1, Hu 2-1, and Vy 1-2 have O abundances typical of disc PNe, while Vy 2-2 and IC 4997 are low O abundance objects ($12 + \log(O/H) \sim 8.2$), which can be attributed to possible O depletion into dust grains. ADFs(O^{+2}) of $4.30^{+1.00}_{-1.16}$, 1.85 ± 1.05, $5.34^{+1.27}_{-1.08}$ and $4.87^{+4.34}_{-2.71}$ were determined for Vy 2-2, Hu 2-1, Vy 1-2 and IC 4997, respectively. The kinematics of CELs and ORLs was analysed for each case to study the possibility that different coexisting plasmas in the nebula emit them. Expansion velocities of [O III] and O II are equal within uncertainties in three PNe, providing no evidence for these lines being emitted in different zones. Exception

are Hu 2-1 and Vy 2-2, where ORLs might be emitted in different zones than CELs. For Vy 2-2 and IC 4997 we found that nebular and auroral lines of the same ion (S^+, N^+, Ar^{+2}, Ar^{+3}, O^{+2}) might present different expansion velocities. Auroral lines show lower $v_{\rm exp}$ which might indicate that they are emitted in a denser and inner zone than the nebular ones.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2201.00902

The most metal-rich stars in the Universe: chemical contributions of low and intermediate mass asymptotic giant branch stars with metallicities between $0.04 \leq Z \leq 0.10$

Giulia C. Cinquegrana[1,2] *and Amanda I. Karakas*[1,2]

[1]School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia
[2]ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D)

Low and intermediate mass stars with super solar metallicities comprise a known portion of the universe. Yet yields for asymptotic giant branch (AGB) stars with metallicities greater than $Z = 0.04$ do not exist in the literature. This contributes a significant uncertainty to galactic chemical evolution simulations. We present stellar yields of AGB stars for M = 1–8 $M_\odot$) and Z = 0.04–0.10. We also weight these yields to represent the chemical contribution of a metal-rich stellar population. We find that as metallicity increases, the efficiency of the mixing episodes (known as the third dredge up) on the thermally pulsing AGB (TP-AGB) decrease significantly. Consequently, much of the nucleosynthesis that occurs on the TP-AGB is not represented on the surface of very metal-rich stars. It instead remains locked inside the white dwarf remnant. The temperatures at the base of the convective envelope also decrease with increasing metallicity. For the intermediate mass models, this results in the occurrence of only partial hydrogen burning at this location, if any burning at all. We also investigate heavy element production via the slow neutron capture process (s-process) for three 6-$M_\odot$ models: Z = 0.04, 0.05 and 0.06. There is minor production at the first s-process peak at strontium, which decreases sharply with increasing metallicity. We find the chemical contributions of our models are dominated by proton capture nucleosynthesis, mixed to the surface during first and second dredge up events. This conclusion is mirrored in our stellar population yields, weighted towards the lower mass regime to reflect the mass distribution within a respective galaxy.

Published in MNRAS
Available from https://arxiv.org/abs/2111.09527

The temperatures of red supergiants in low metallicity environments

Gemma González-Torà[1], *Ben Davies*[1], *Rolf-Peter Kudritzki*[2,3] *and Bertrand Plez*[4]

[1]Astrophysics Research Institute, Liverpool John Moores University, Liverpool Science Park IC2, 146 Brownlow Hill, Liverpool, L3 5RF, UK
[2]LMU München, Universitätssternwarte, Scheinerst. 1, 81679 München, Germany
[3]Institute for Astronomy, University of Hawai'i at Manoa, 2580 Woodlawn Drive, Honolulu, HI 96822, USA
[4]LUPM, UMR 5299, Université de Montpellier, CNRS, 34095 Montpellier, France

The temperatures of red supergiants (RSGs) are expected to depend on metallicity (Z) in such a way that lower-Z RSGs are warmer. In this work, we investigate the Z-dependence of the Hayashi limit by analysing RSGs in the low-Z galaxy Wolf–Lundmark–Mellote (WLM), and compare with the RSGs in the higher-Z environments of the Small Magellanic Cloud (SMC) and Large Magellanic Cloud (LMC). We determine the effective temperature ($T_{\rm eff}$) of each star by fitting their spectral energy distributions, as observed by VLT+SHOOTER, with MARCS model atmospheres. We find average temperatures of $T_{\rm eff}(\rm WLM) = 4400 \pm 202$ K, $T_{\rm eff}(\rm SMC) = 4130 \pm 103$ K, and $T_{\rm eff}(\rm LMC) = 4140 \pm 148$

K. From population synthesis analysis, we find that although the Geneva evolutionary models reproduce this trend qualitatively, the RSGs in these models are systematically too cool. We speculate that our results can be explained by the inapplicability of the standard solar mixing length to RSGs.

Published in MNRAS, 505, 4422 (2021)
Available from https://arxiv.org/abs/2106.01807
and from https://doi.org/10.1093/mnras/stab1611

Simulating highly-eccentric common envelope jets supernova (CEJSN) impostors

Ron Schreier[1], *Shlomi Hillel*[2], *Sagiv Shiber*[1] *and Noam Soker*[1]

[1]Department of Physics, Technion, Israel

[2]Department of Physics and Astronomy, Louisiana State University, USA

We conduct three-dimensional hydrodynamical simulations of eccentric common envelope jets supernova (CEJSN) impostors, i.e. a neutron star (NS) that crosses through the envelope of a red supergiant star on a highly eccentric orbit and launches jets as it accretes mass from the envelope. Because of numerical limitations we apply a simple prescription where we inject the assumed jets' power into two opposite conical regions inside the envelope. We find the outflow morphology to be very complicated, clumpy, and non-spherical, having a large-scale symmetry only about the equatorial plane. The outflow morphology can substantially differ between simulations that differ by their jets' power. We estimate by simple means the light curve to be very bumpy, to have a rise time of one to a few months, and to slowly decay in about a year to several years. These eccentric CEJSN impostors will be classified as 'gap' objects, i.e. having a luminosity between those of classical novae and typical supernovæ (termed also ILOTs for intermediate luminosity optical transients). We strengthen a previous conclusion that CEJSN impostors might account for some peculiar ILOTs, in particular those that might repeat over timescales of months to years.

Published in MNRAS, 508, 2386 (2021)
Available from https://arxiv.org/abs/2106.11601

A red giant branch common envelope evolution scenario for the exoplanet WD 1856 b

Ariel Merlov[1], *Ealeal Bear*[1] *and Noam Soker*[1]

[1]Department of Physics, Technion, Israel

We propose a common envelope evolution (CEE) scenario where a red giant branch (RGB) star engulfs a planet during its core helium flash to explain the puzzling system WD 1856+534 where a planet orbits a white dwarf (WD) of mass 0.52 $M_{\odot}$ with an orbital period of 1.4 day. At the heart of the scenario is the recently proposed assumption that the vigorous convection that core helium flash of RGB stars drive in the core excite waves that propagate and deposit their energy in the envelope. Using the binary-MESA stellar evolution code we show that this energy deposition substantially reduces the binding energy of the envelope and causes its expansion. We propose that in some cases RGB stars might engulf massive planets of $\sim 0.01\ M_{\odot}$ during their core helium flash phase, and that the planet can unbind most of the mass of the bloated envelope. We show that there is a large range of initial orbital radii for which this scenario might take place under our assumptions. This scenario is relevant to other systems of close sub-stellar objects orbiting white dwarfs, like the brown dwarf–WD system ZTF J003855.0+203025.5.

Published in The Astrophysical Journal Letters, 915, L34 (2021)
Available from https://arxiv.org/abs/2106.07521
and from https://ui.adsabs.harvard.edu/abs/2021ApJ...915L..34M/abstract

3D MHD astrospheres: applications to IRC $-10^{\circ}414$ and Betelgeuse

D.M.-A. Meyer[1], *A. Mignone*[2], *M. Petrov*[3], *K. Scherer*[4,5], *P.F. Velázquez*[6] *and P. Boumis*[7]

[1]Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Straße 24/25, D-14476 Potsdam, Germany
[2]Dipartimento di Fisica Generale Facolta di Scienze M.F.N., Università degli Studi di Torino, Via Pietro Giuria 1, I-10125 Torino, Italy
[3]Max Planck Computing and Data Facility (MPCDF), Gießenbachstraße 2, D-85748 Garching, Germany
[4]Institut für Theoretische Physik, Lehrstuhl IV: Plasma-Astroteilchenphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany
[5]Research Department, Plasmas with Complex Interactions, Ruhr-Universität Bochum, D-44780 Bochum, Germany
[6]Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico, CP 04510, Mexico City, Mexico
[7]Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, 15236, Penteli, Greece

A significative fraction of all massive stars in the Milky Way move supersonically through their local interstellar medium (ISM), producing bow shock nebulae by wind-ISM interaction. The stability of these observed astrospheres around cool massive stars challenges precedent 2D (magneto-)hydrodynamical (MHD) simulations of their surroundings. We present 3DMHD simulations of the circumstellar medium of runaway M-type red supergiant stars moving with velocity $v_{\star} = 50$ km s^{-1}. We treat the stellar wind with a Parker spiral and assume a 7 μG magnetization of the ISM. Our free parameter is the angle $\theta_{\rm mag}$ between ISM flow and magnetization, taken to 0°, 45°, and 90°. It is found that simulation dimension, coordinate systems, and grid effects can greatly affect the development of the modelled astrospheres. Nevertheless, as soon as the ISM flow and magnetization directions differs by more than a few degrees ($\theta_{\rm mag} \geq 5^{\circ}$), the bow shock is stabilized, most clumpiness and ragged structures vanishing. The complex shape of the bow shocks induce important projection effects, e.g., at optical Hα line, producing complex of astrospheric morphologies. We speculate that those effects are also at work around earlier-type massive stars, which would explain their diversity of their observed arc-like nebula around runaway OB stars. Our 3D MHD models are fitting well observations of the astrospheres of several runaway red supergiant stars. The results interpret the smoothed astrosphere of IRC $-10^{\circ}414$ and Betelgeuse (α Ori) are stabilized by an organized non-parallel ambient magnetic field. Our findings suggest that IRC $-10^{\circ}414$ is currently in a steady state of its evolution, and that Betelgeuses bar is of interstellar origin.

Published in Monthly Notices of the Royal Astronomical Society, 506, 5170 (2021)
Available from https://arxiv.org/abs/2107.05513

Deriving ages and horizontal branch properties of integrated stellar populations

Ivan Cabrera-Ziri[1,2,3] *and Charlie Conroy*[3]

[1]Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Mönchhofstraße 12–14, D-69120 Heidelberg, Germany
[2]Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool L3 5RF, UK
[3]Center for Astrophysics, Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA

A major source of uncertainty in the age determination of old (~ 10 Gyr) integrated stellar populations is the presence of hot horizontal branch (HB) stars. Here, we describe a simple approach to tackle this problem, and show the performance of this technique that simultaneously models the age, abundances and HB properties of integrated stellar populations. For this we compare the results found during the fits of the integrated spectra of a sample of stellar population benchmarks, against the values obtained from the analysis of their resolved CMDs. We find that the ages derived from our spectral fits for most (26/32) of our targets are within 0.1 dex to their CMDs values. Similarly, for the majority of the targets in our sample we are able to recover successfully the flux contribution from hot HB stars (within ~ 0.15 dex for 18/24 targets) and their mean temperature (14/24 targets within $\sim 30\%$). Finally, we present a diagnostic that can be used to detect spurious solutions in age, that will help identify the few cases when this method fails. These results open a new window for the detailed study of globular clusters beyond the Local Group.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2112.07562

New infrared spectral indices of luminous cold stars: from early-K to M types

Maria Messineo [1], *Donald F. Figer*[2], *Rolf-Peter Kudritzki*[3], *Quingfeng Zhu*[1], *Karl M. Menten*[4], *Valentin D. Ivanov*[5] *and C-H. Rosie Chen*[4]

[1]USTC, China
[2]RIT, USA
[3]Univ. of Hawai'i, USA
[4]MPIfR, Germany
[5]ESO, Germany

We present infrared spectral indices (1.0–2.3 μm) of Galactic late-type giants and red supergiants (RSGs). We used existing and new spectra obtained at resolving power $R = 2000$ with SpeX on the IRTF telescope. While a large CO equivalent width (EW), at 2.29 μm ([CO, 2.29] $\gtrsim$ 45 Å) is a typical signature of RSGs later than spectral type M0, [CO] of K-type RSGs and giants are similar. In the [CO, 2.29] versus [Mg I, 1.71] diagram, RSGs of all spectral types can be distinguished from red giants because the Mg I line weakens with increasing temperature and decreasing gravity. We find several lines that vary with luminosity, but not temperature: Si I (1.59 μm), Sr (1.033 μm), Fe+Cr+Si+CN (1.16 μm), Fe+Ti (1.185 μm), Fe+Ti (1.196 μm), Ti+Ca (1.28 μm), and Mn (1.29 μm). Good markers of CN enhancement are the Fe+Si+CN line at 1.087 μm and CN line at 1.093 μm. Using these lines, at the resolution of SpeX, it is possible to separate RSGs and giants. Contaminant O-rich Mira and S-type AGBs are recognized by strong molecular features due to water vapor features, TiO band heads, and/or ZrO absorption. Among the 42 candidate RSGs that we observed, all but one were found to be late types. Twenty-one have EWs consistent with those of RSGs, 16 with those of O-rich Mira AGBs, and one with an S-type AGB. These infrared results open new, unexplored, potential for searches at low resolution of RSGs in the highly obscured innermost regions of the Milky Way.

Published in AJ, 162, 187 (2021)
Available from https://arxiv.org/abs/2107.03707
and from https://ui.adsabs.harvard.edu/abs/2021AJ....162..187M/abstract

Short-term spectroscopic variability of the early post-AGB stage star IRAS 22272+5435

Laimons Začs[1] *and Kārlis Puķītis*[1]

[1]Laser Center, Faculty of Physics, Mathematics and Optometry, University of Latvia, Latvia

High-resolution spectra gathered during an extensive monitoring of IRAS 22272+5435 are inspected to search for spectroscopic variability in the time span less than two weeks. Significant variation are found both in the intensity and position of CN (1,0) Red System lines near the light maximum, when the star is the hottest. The intensity of variable CN lines correlates with their Doppler redshift − increase of the radial velocity leads to decrease of its equivalent width. The inward flow of increasing velocity from $\simeq$ 14.4 to 21.6 km s^{-1} was confirmed in the atmosphere, propagating $\sim$ 25 R$_\odot$ towards the mass center of the star in 11 days. The variability of CN (1,0) lines are accompanied by changes in red wings of strong low excitation lines. The observed short-term variations are attributed to large scale convective flows and shock waves in the extended atmosphere of cool pulsating post-AGB star.

Published in The Astrophysical Journal
Available from https://iopscience.iop.org/article/10.3847/1538-4357/ac1671

V4334 Sgr (Sakurai's Object): still churning out the dust

A. Evans[1], *D.P.K. Banerjee*[2], *T.R. Geballe*[3], *R.D. Gehrz*[4], *C.E. Woodward*[4], *K. Hinkle*[5], *R.R. Joyce*[5] *and M. Shahbandeh*[6]

[1]Astophysics Group, Keele University, Keele, Staffordshire, ST5 5BG, UK

[2]Physical Research Laboratory, Ahmedabad, Gujarat 380009, India

[3]Gemini Observatory/NSF's NOIRLab, 670 N. A'ohoku Place, Hilo, Hawai'i, 96720, USA

[4]Minnesota Institute for Astrophysics, School of Physics & Astronomy, 116 Church Street SE, University of Minnesota, Minneapolis, MN 55455, USA

[5]National Optical-Infrared Astronomy Research Laboratory, 950 N. Cherry Avenue, Tucson, AZ 85719, USA

[6]Department of Physics, Florida State University, 77 Chieftain Way, Tallahassee, FL 32306-4350, USA

We present a 0.8–2.5-μm spectrum of the Very Late Thermal Pulse object V4334 Sgr (Sakurai's Object), obtained in 2020 September. The spectrum displays a continuum that rises strongly to longer wavelengths, and is considerably brighter than the most recent published spectrum obtained seven years earlier. At the longer wavelengths the continuum is well fitted by a blackbody with a temperature of 624 ± 8 K. However, there is excess continuum at the shortest wavelengths that we interpret as being due to hot dust that has very recently formed in an environment with C/O $\simeq 2.5$. Other possible sources for this excess continuum are discussed – such as the stellar photosphere dimly seen through the dust shell, and light scattered off the inner wall of the dust torus – but these interpretations seem unlikely. Numerous emission lines are present, including those of He I, C I, [C I], and O I. Our observations confirm that emission in the He I 1.083-μm and [C I] 0.9827/0.9852-μ lines is spatially extended. The [C I] line fluxes suggest that the electron density increased by an order of magnitude between 2013 and 2020, and that these two lines may soon disappear from the spectrum. The flux ratio of the 1.083-μm and 2.058-μm He I lines is consistent with the previously-assumed interstellar extinction. The stellar photosphere remains elusive, and the central star may not be as hot as suggested by current evolutionary models.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2201.04004

Evidence for cold plasma in planetary nebulæ from radio observations with the LOwFrequency ARray (LOFAR)

Marcin Hajduk[1], *Marijke Haverkorn*[2], *Timothy Shimwell*[3,4], *Mateusz Olech*[1], *Joseph R. Callingham*[3,4], *Harish K. Vedantham*[3,5], *Glenn J. White*[6,7], *Marco Iacobelli*[3] *and Alexander Drabent*[8]

[1]Space Radio-Diagnostics Research Centre, University of Warmia and Mazury, ul. Oczapowskiego 2, 10-719 Olsztyn, Poland

[2]Department of Astrophysics/IMAPP, Radboud University, P.O. Box 9010, 6500 GL Nijmegen, The Netherlands

[3]ASTRON, Netherlands Institute for Radio Astronomy, Oude Hoogeveensedijk 4, Dwingeloo, 7991 PD, The Netherlands

[4]Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA, Leiden, The Netherlands

[5]Kapteyn Astronomical Institute, University of Groningen, P.O. Box 72, 97200 AB, Groningen, The Netherlands

[6]Department of Physics and Astronomy, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK

[7]RAL Space, STFC Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX, UK

[8]Thüringer Landessternwarte, Sternwarte 5, D-07778 Tautenburg, Germany

We present observations of planetary nebulæ with the LOw Frequency ARray (LOFAR) between 120 and 168 MHz. The images show thermal free–free emission from the nebular shells. We have determined the electron temperatures for spatially resolved, optically thick nebulæ. These temperatures are 20–60% lower than those estimated from collisionally excited optical emission lines. This strongly supports the existence of a cold plasma component, which co-exists with hot plasma in planetary nebulæ. This cold plasma does not contribute to the collisionally excited lines, but does contribute to recombination lines and radio flux. Neither of the plasma components are spatially resolved in our images, although we infer that the cold plasma extends to the outer radii of planetary nebulæ. However, more cold plasma appears to exist at smaller radii. The presence of cold plasma should be taken into account in modeling of radio emission of planetary nebulæ. Modelling of radio emission usually uses electron temperatures calculated from collisionally excited optical and/or infrared lines. This may lead to an underestimate of the ionized mass and

an overestimate of the extinction correction from planetary nebulæ when derived from the radio flux alone. The correction improves the consistency of extinction derived from the radio fluxes when compared to estimates from the Balmer decrement flux ratios.

Published in The Astrophysical Journal
Available from https://arxiv.org/abs/2107.01112
and from https://iopscience.iop.org/article/10.3847/1538-4357/ac0fda/pdf

A population of transition disks around evolved stars: fingerprints of planets. Catalog of disks surrounding Galactic post-AGB binaries

J. Kluska[1], *H. Van WInckel*[1], *Q. Coppée*[1], *G.-M. Oomen*[1], *K. Dsilva*[1], *D. Kamath*[2,3], *V. Bujarrabal*[4] *and M. Min*[5]

[1]Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[2]Department of Physics and Astronomy, Macquarie University, Sydney, NSW 2109, Australia
[3]Astronomy, Astrophysics and Astrophotonics Research Centre, Macquarie University, Sydney, NSW 2109, Australia
[4]Observatorio Astronómico Nacional (OAN–IGN), Apartado 112, E-28803 Alcalá de Henares, Spain
[5]SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

Context: Post-asymptotic giant branch (post-AGB) binaries are surrounded by massive disks of gas and dust that are similar to the protoplanetary disks that are known to surround young stars.
Aims: We assembled a catalog of all known Galactic post-AGB binaries featuring disks. We explore the correlations between the different observables with the aim of learning more about potential disk–binary interactions.
Methods: We compiled spectral energy distributions of 85 Galactic post-AGB binary systems. We built a color–color diagram to differentiate between the different disk morphologies traced by the characteristics of the infrared excess. We categorized the different disk types and searched for correlations with other observational characteristics of these systems.
Results: Between 8 and 12% of our targets are surrounded by transition disks, that is, disks having no or low near-infrared excess. We find a strong link between these transition disks and the depletion of refractory elements seen on the surface of the post-AGB star. We interpret this correlation as evidence of the presence of a mechanism that stimulates the dust and gas separation within the disk and that also produces the transition disk structure. We propose that such a mechanism is likely to be due to a giant planet carving a hole in the disk, effectively trapping the dust in the outer disk parts. We propose two disk evolutionary scenarios, depending on the actual presence of such a giant planet in the disk.
Conclusions: We advocate that giant planets can successfully explain the correlation between the transition disks and the depletion of refractory materials observed in post-AGB binaries. If the planetary scenario is confirmed, disks around post-AGB binaries could be a unique laboratory for testing planet–disk interactions and their influence on the late evolution of binary stars. The question of whether such planets are first- or second-generation bodies also remains to be considered. We argue that these disks are ideal for studying planet formation scenarios in unprecedented parameter space.

Published in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2201.13155
and from https://www.aanda.org/articles/aa/pdf/2022/02/aa41690-21.pdf

Simulating the negative jet feedback mechanism in common envelope jets supernovæ

Aldana Grichener[1], *Coral Cohen*[2] *and Noam Soker*[1]

[1]Department of Physics, Technion, Haifa, 3200003, Israel
[2]Department of Education in Science and Technology, Technion, Haifa, 3200003, Israel

We use the stellar evolution code MESA to study the negative jet feedback mechanism in common envelope jets supernovæ (CEJSNe) where a neutron star (NS) launches jets in the envelope of a red supergiant (RSG), and find

that the feedback reduces the mass accretion rate to be $\chi_{\rm j} \simeq 0.04$–0.3 times the mass accretion rate without the operation of jets. We mimic the effect of the jets on the RSG envelope by depositing the energy that the jets carry into the envelope zones outside the NS orbit. The energy deposition inflates the envelope, therefore reducing the density in the NS vicinity, which in turn reduces the mass accretion rate in a negative feedback cycle. In calculating the above values for the negative jet feedback coefficient (the further reduction in the accretion rate) $\chi_{\rm j}$, we adopt the canonical ratio of jets power to actual accretion power of 0.1, and the results of numerical simulations that show the actual mass accretion rate to be a fraction of 0.1–0.5 of the Bondi–Hoyle–Lyttleton mass accretion rate.

Published in ApJ
Available from https://arxiv.org/abs/2107.07856
and from 10.3847/1538-4357/ac23dd

Asteroseismology of evolved stars with EGGMiMoSA – I. Theoretical mixed-mode patterns from the subgiant to the RGB phase

Martin Farnir[1], *Charly Pinçon*[1], *Marc-Antoine Dupret*[1], *Arlette Noels*[1] *and Richard Scuflaire*[1]

[1]Université de Liège, Belgium

Context: In the context of an ever increasing amount of highly precise data, thanks to the numerous space-borne missions, came a revolution in stellar hysics. This data allowed asteroseismology to thrive and improve our general knowledge of stars. Important results were obtained about giant stars owing to the presence of "mixed modes" in their oscillation spectra. These modes carry information about the whole stellar interior, enabling the comprehensive characterisation of their structure.
Aims: The current study is part of a series of papers that provide a technique to coherently and robustly analyse the mixed-modes frequency spectra and characterise the stellar structure of stars on both the subgiant branch and red-giant branch (RGB). In this paper we aim at defining seismic indicators, relevant of the stellar structure, as well as studying their evolution along a grid of models.
Methods: The proposed method, EGGMiMoSA, relies on the asymptotic description of mixed modes. It defines appropriate initial guesses for the parameters of the asymptotic formulation and uses a Levenberg–Marquardt minimisation scheme in order to adjust the complex mixed-modes pattern in a fast and robust way.
Results: We are able to follow the evolution of the mixed-modes parameters along a grid of models from the subgiant phase to the RGB bump, therefore extending previous works. We show the impact of the stellar mass and composition on the evolution of these parameters. We observe that the evolution of the period spacing $\Delta\pi_1$, pressure offset $\epsilon_{\rm p}$, gravity offset $\epsilon_{\rm g}$, and coupling factor q as a function of the large frequency separation $\Delta\nu$ is little affected by the chemical composition and that it follows two different regimes depending on the evolutionary stage. On the subgiant branch, the stellar models display a moderate core–envelope density contrast. Therefore, the evolution of $\Delta\pi_1$, $\epsilon_{\rm p}$, $\epsilon_{\rm g}$, and q significantly changes with the stellar mass. Furthermore, we demonstrate that, for a given metallicity and with proper measurements of the period spacing $\Delta\pi_1$ and large frequency separation $\Delta\nu$, we may unambiguously constrain the stellar mass, radius and age of a subgiant star. Conversely, as the star reaches the red-giant branch, the core–envelope density contrast becomes very large. Consequently, the evolution of $\epsilon_{\rm p}$, $\epsilon_{\rm g}$ and q as a function of $\Delta\nu$ becomes independent of the stellar mass. This is also true for $\Delta\pi_1$ in stars with masses $\lesssim 1.8\ {\rm M}_\odot$ because of core electron degeneracy. This degeneracy in $\Delta\pi_1$ is lifted for higher masses, again allowing for a precise measurement of the stellar age. Overall, our computations qualitatively agree with previous observed and theoretical studies.
Conclusions: The method provides automated measurements of the adjusted parameters along a grid of models and opens the way to the precise seismic characterisation of both subgiants and red giants. In the following papers of the series, we will explore further refinements to the technique as well as its application to observed stars.

Published in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2107.08021
and from https://www.aanda.org/articles/aa/abs/2021/09/aa41317-21/aa41317-21.html

White dwarf–main sequence binaries from Gaia EDR3: the unresolved 100 pc volume-limited sample

A. Rebassa-Mansergas[1,2], *E. Solano*[3,4], *F.M. Jiménez-Esteban*[3,4], *S. Torres*[1,2], *C. Rodrigo*[3,4], *A. Ferrer-Burjachs*[1], *L.M. Calcaferro*[5,6], *L.G. Althaus*[5,6] *and A.H. Córsico*[5,6]

[1]Departament de Física, Universitat Politècnica de Catalunya, c/Esteve Terrades 5, 08860 Castelldefels, Spain

[2]Institut d'Estudis Espacials de Catalunya, Ed. Nexus-201, c/Gran Capitá 2-4, 08034 Barcelona, Spain

[3]Departmento de Astrofísica, Centro de Astrobiología (CSIC–INTA), ESAC Campus, Camino Bajo del Castillo s/n, E-28692 Villanueva de la Cañada, Madrid, Spain

[4]Spanish Virtual Observatory, E-28692 Villanueva de la Cañada, Madrid, Spain

[5]Grupo de Evolución Estelar y Pulsaciones, Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina

[6]Instituto de Astrofísica La Plata, CONICET–UNLP, Paseo del Bosque s/n, 1900, La Plata, Argentina

We use the data provided by the Gaia Early Data Release 3 to search for a highly-complete volume-limited sample of unresolved binaries consisting of a white dwarf and a main sequence companion (i.e. WDMS binaries) within 100 pc. We select 112 objects based on their location within the Hertzsprung–Russell diagram, of which 97 are new identifications. We fit their spectral energy distributions (SED) with a two-body fitting algorithm implemented in VOSA (Virtual Observatory SED Analyser) to derive the effective temperatures, luminosities and radii (hence surface gravities and masses) of both components. The stellar parameters are compared to those from the currently largest catalogue of close WDMS binaries, from the Sloan Digital Sky Survey (SDSS). We find important differences between the properties of the Gaia and SDSS samples. In particular, the Gaia sample contains WDMS binaries with considerably cooler white dwarfs and main sequence companions (some expected to be brown dwarfs). The Gaia sample also shows an important population of systems consisting of cool and extremely low-mass white dwarfs, not present in the SDSS sample. Finally, using a Monte Carlo population synthesis code, we find that the volume-limited sample of systems identified here seems to be highly complete ($\simeq 80 \pm 9$ per cent), however it only represents $\simeq 9$ per cent of the total underlying population. The missing $\simeq 91$ per cent includes systems in which the main sequence companions entirely dominate the SEDs. We also estimate an upper limit to the total space density of close WDMS binaries of $\simeq (3.7 \pm 1.9) \times 10^{-4}$ pc^{-3}.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2107.06303

The period–age relation of long-period variables

Michele Trabucchi[1] *and Nami Mowlavi*[1]

[1]Department of Astronomy, University of Geneva, Ch. Pegasi 51, CH-1290 Versoix, Switzerland

Context: Pieces of empirical evidence suggest the existence of a period–age relation for long-period variables (LPVs). Yet, this property has hardly been studied on theoretical grounds thus far.
Aims: We aim to examine the period-age relation using the results from recent nonlinear pulsation calculations.
Methods: We combined isochrone models with theoretical periods to simulate the distribution of fundamental mode LPV pulsators, which include Miras, in the period–age plane, and we compared it with observations of LPVs in Galactic and Magellanic Clouds clusters.
Results: In agreement with observations, models predict that the fundamental mode period decreases with increasing age because of the dominant role of mass in shaping stellar structure and evolution. At a given age, the period distribution shows a non-negligible width and is skewed toward short periods, except for young C-rich stars. As a result, the period–age relations of O-rich and C- rich models are predicted to have different slopes. We derived best-fit relations describing age and initial mass as a function of the fundamental mode period for both O- and C-rich models.
Conclusions: The study confirms the power of the period–age relations to study populations of LPVs of specific types, either O-rich or C-rich, on statistical grounds. In doing so, it is recommended not to limit a study to Miras, which would make it prone to selection biases, but rather to include semi-regular variables that pulsate predominantly in the fundamental mode. The use of the relations to study individual LPVs, on the other hand, requires more care given

the scatter in the period distribution predicted at any given age.

Accepted for publication in Astronomy and Astrophysics Letters
Available from https://arxiv.org/abs/2201.00201

A hot subdwarf–white dwarf super-Chandrasekhar candidate supernova Ia progenitor

Ingrid Pelisoli[1,2], *P. Neunteufel*[3], *S. Geier*[1], *T. Kupfer*[4,5], *U. Heber*[6], *A. Irrgang*[6], *D. Schneider*[6], *A. Bastian*[1], *J. van Roestel*[7], *V. Schaffenroth*[1] *and B.N. Barlow*[8]

[1]Institut für Physik und Astronomie, Universität Potsdam, Germany
[2]Department of Physics, University of Warwick, UK
[3]Max Planck Institut für Astrophysik, Germany
[4]Kavli Institute for Theoretical Physics, University of California, USA
[5]Department of Physics & Astronomy, Texas Tech University, USA
[6]Dr. Karl Remeis-Observatory, Friedrich-Alexander University Erlangen–Nuremberg (FAU), Germany
[7]Division of Physics, Mathematics and Astronomy, California Institute of Technology, USA
[8]Department of Physics and Astronomy, High Point University, USA

Supernovæ Ia are bright explosive events that can be used to estimate cosmological distances, allowing us to study the expansion of the Universe. They are understood to result from a thermonuclear detonation in a white dwarf that formed from the exhausted core of a star more massive than the Sun. However, the possible progenitor channels leading to an explosion are a long-standing debate, limiting the precision and accuracy of supernovæ Ia as distance indicators. Here we present HD 265435, a binary system with an orbital period of less than a hundred minutes, consisting of a white dwarf and a hot subdwarf – a stripped core-helium burning star. The total mass of the system is 1.65 ± 0.25 solar masses, exceeding the Chandrasekhar limit (the maximum mass of a stable white dwarf). The system will merge due to gravitational wave emission in 70 million years, likely triggering a supernova Ia event. We use this detection to place constraints on the contribution of hot subdwarf–white dwarf binaries to supernova Ia progenitors.

Published in Nature Astronomy
Available from https://arxiv.org/abs/2107.09074
and from https://warwick.ac.uk/newsandevents/pressreleases/high-speed_propeller_star

On the role of Type Ia supernovæ in the second-generation star formation in globular clusters

Elena Lacchin[1,2], *Francesco Calura*[1] *and Enrico Vesperini*[3]

[1]INAF–OAS, Osservatorio di Astrofisica e Scienza dello Spazio di Bologna, via Gobetti 93/3, I-40129 Bologna, Italy
[2]Department of Physics and Astronomy, University of Bologna, via Gobetti 93/3, I-40129 Bologna, Italy
[3]Department of Astronomy, Indiana University, Swain West, 727 E. 3rd Street, Bloomington, IN 47405, USA

By means of 3D hydrodynamic simulations, we study how Type Ia supernovae (SNe) explosions affect the star formation history and the chemical properties of second-generation (SG) stars in globular clusters (GC). SG stars are assumed to form once first generation asymptotic giant branch (AGB) stars start releasing their ejecta; during this phase, external gas is accreted by the system and SNe Ia begin exploding, carving hot and tenuous bubbles. Given the large uncertainty on SNe Ia explosion times, we test two different values for the "delay time". We run two different models for the external gas density: in the low-density scenario with short delay time, the explosions start at the beginning of the SG star formation, halting it in its earliest phases. The external gas hardly penetrates the system, therefore most SG stars present extreme helium abundances ($Y > 0.33$). The low-density model with delayed SN explosions has a more extended SG star formation epoch and includes SG stars with modest helium enrichment. On the contrary, the

high-density model is weakly affected by SN explosions, with a final SG mass similar to the one obtained without SNe Ia. Most of the stars form from a mix of AGB ejecta and pristine gas and have a modest helium enrichment. We show that gas from SNe Ia may produce an iron spread of ~ 0.14 dex, consistent with the spread found in about 20 per cent of Galactic GCs, suggesting that SNe Ia might have played a key role in the formation of this sub-sample of GCs.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2107.07962

Spectroscopic and photometric study of the Mira stars SU Camelopardalis and RY Cephei

David Boyd[1]

[1]British Astronomical Association, Variable Star Section, UK

Miras are fascinating stars. A κ-mechanism in their atmosphere drives pulsations which produce changes in their photometric brightness, apparent spectral type and effective temperature. These pulsations also drive the formation of Balmer emission lines in the spectrum. This behaviour can be observed and investigated with small telescopes. We report on a three-year project combining spectroscopy and photometry to analyse the behaviour of Mira stars SU Cam and RY Cep, and describe how their brightness, colour, spectral type, effective temperature and Balmer emission vary over four pulsation cycles.

Published in JAAVSO
Available from https://app.aavso.org/media/jaavso/3762_2vbQXTD.pdf

Probing the progenitors of Type Ia supernovæ using circumstellar material interaction signatures

Peter Clark[1,2], *Kate Maguire*[3], *Mattia Bulla*[4], *Lluís Galbany*[5], *Mark Sullivan*[6], *Joseph P. Anderson*[7,8] *and Stephen J. Smartt*[2]

[1]Institute of Cosmology and Gravitation, University of Portsmouth, Portsmouth PO1 3FX, UK
[2]Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, UK
[3]School of Physics, Trinity College Dublin, Dublin 2, Ireland
[4]The Oskar Klein Centre, Department of Astronomy, Stockholm University, AlbaNova, SE-106 91, Stockholm, Sweden
[5]Institute of Space Sciences (ICE, CSIC), Campus UAB, Carrer de Can Magrans, s/n, E-08193 Barcelona, Spain
[6]School of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, UK
[7]European Southern Observatory, Alonso de Córdova 3107, Casilla 19, Santiago, Chile
[8]Millennium Institute of Astrophysics, Nuncio Monsenor Sotero Sanz 100, Of. 104, Providencia, Santiago, Chile

This work aims to study different probes of Type Ia supernova progenitors that have been suggested to be linked to the presence of circumstellar material (CSM). In particular, we have investigated, for the first time, the link between narrow blueshifted Na I D absorption profiles and the presence and strength of the broad high-velocity Ca II near infrared triplet absorption features seen in Type Ia supernovæ around maximum light. With the probes exploring different distances from the supernova; Na I D $> 10^{17}$ cm, high-velocity Ca II features $< 10^{15}$ cm. For this, we have used a new intermediate-resolution X-Shooter spectral sample of 15 Type Ia supernovæ. We do not identify a link between these two probes, implying either that, one (or both) is not physically related to the presence of CSM or that the occurrence of CSM at the distance explored by one probe is not linked to its presence at the distance probed by the other. However, the previously identified statistical excess in the presence of blueshifted (over redshifted) Na I D absorption is confirmed in this sample at high significance and is found to be stronger in Type Ia supernovæ hosted by late-type galaxies. This excess is difficult to explain as being from an interstellar-medium origin as has been suggested by some recent modelling, as such an origin is not expected to show a bias for blue-shifted absorption. However,

a circumstellar origin for these features also appears unsatisfactory based on our new results given the lack of link between the two probes of CSM investigated.

Published in Monthly Notices of the Royal Astronomical Society, 507, 4367 (2021)
Available from https://arxiv.org/abs/2107.09034
and from https://academic.oup.com/mnras/article/507/3/4367/6322847

Spectroscopic and photometric analysis of symbiotic candidates – I. Ten candidates on classical symbiotic stars

J. Merc[1,2], *R. Gális*[2], *M. Wolf*[1], *P. Velez*[3], *C. Buil*[3], *F. Sims*[3], *T. Bohlsen*[3], *M. Vrašťák*[4], *C. Boussin*[3], *H. Boussier*[3], *P. Cazzato*[3], *I. Diarrasouba*[3] *and F. Teyssier*[3]

[1]Astronomical Institute, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague, Czechia
[2]Institute of Physics, Faculty of Science, P.J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovakia
[3]Astronomical Ring for Amateur Spectroscopy Group
[4]Private observatory Liptovská Štiavnica, Kľučiny 457/74, Slovakia

Symbiotic stars belong to a group of interacting binaries that display a wide variety of phenomena, including prominent outbursts connected with mass transfer, as well as stellar winds, jets, eclipses, or intrinsic variability of the components. Dozens of new symbiotic stars and candidates have been discovered in recent years. However, there are many objects which are still poorly studied. Some symbiotic candidates suspected in the literature have never been studied spectroscopically. In this contribution, we present the first results of the ongoing campaign focused on symbiotic candidates. In the first paper in the series, we study the nature of ten candidate classical symbiotic stars suspected based on their photometric behaviour, colours or abundance pattern. To confirm or reject the symbiotic nature of the studied candidates, we obtained new spectra and analysed them in detail together with available multi-frequency photometric and spectroscopic observations of the objects. Hen 3-860 and V2204 Oph are genuine symbiotic systems showing typical spectral features of burning symbiotic stars and outbursts in the last 100 years. The first object belongs to the uncommon group of eclipsing symbiotic stars. V1988 Sgr cannot be classified as a genuine burning symbiotic star, but the scenario of an accreting-only symbiotic system cannot be ruled out. Hen 4-204 might be a bona-fide symbiotic star due to its similarity with the known symbiotic binary BD Cam. Six other symbiotic candidates (V562 Lyr, IRAS 19050+0001, EC 19249−7343, V1017 Cyg, PN K1-6, V379 Peg) are either single dwarf or giant stars or non-symbiotic binaries.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2107.05953

Hen 3-860: new southern eclipsing symbiotic star observed in the outburst

J. Merc[1,2], *R. Gális*[2], *M. Wolf*[1], *P. Velez*[3], *T. Bohlsen*[3] *and B.N. Barlow*[4]

[1]Astronomical Institute, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague, Czech Republic
[2]Institute of Physics, Faculty of Science, P.J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic
[3]Astronomical Ring for Amateur Spectroscopy Group
[4]Department of Physics, High Point University, One University Parkway, High Point, NC 27268, USA

Brightening of Hen 3-860, previously classified as an Hα emitter, was detected by the ASAS-SN survey at the end of the year 2016. We have obtained the first spectroscopic observations of the transient and supplemented them with photometric data from the DASCH archive of astronomical plates, ASAS and ASAS-SN surveys. Based on the results of our analysis, we can classify the object as a classical symbiotic star of the infrared type S, consisting of an M2–3 giant with $T_{\rm g} \sim 3\,550$ K, a radius $R_{\rm g} \sim 60$–75 $\rm R_{\odot}$, and a luminosity $L_{\rm g} \sim 540$–760 $\rm L_{\odot}$, and a hot and luminous

component ($T_{\rm h} \sim 1$–2×10^5 K and $L_{\rm h} \sim 10^3$ L$_\odot$). The system experienced at least four outbursts in the last 120 years. In addition to the outbursts, its light curves revealed the presence of eclipses of the hot component and its surrounding (relatively cool) shell, which developed during the outburst and redistributed a fraction of the radiation of the hot component into the optical, by the giant, classifying the object as a representative of a group of eclipsing symbiotic stars. The eclipses allowed us to reveal the orbital period of the system to be 602 days.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2111.14975

A low-energy explosion yields the underluminous Type IIP SN 2020cxd

S. Yang[1], *J. Sollerman*[1], *N.L. Strotjohann*[2], *S. Schulze*[3], *R. Lunnan*[1], *E. Kool*[1], *C. Fremling*[4], *D. Perley*[5], *E. Ofek*[2], *T. Schweyer*[1], *E.C. Bellm*[6], *M.M. Kasliwal*[5], *F.J. Masci*[7], *M. Rigault*[8] *and Y. Yang*[2,9]

[1]Department of Astronomy, The Oskar Klein Center, Stockholm University, AlbaNova, 10691 Stockholm, Sweden
[2]Department of Particle Physics and Astrophysics, Weizmann Institute of Science, 234 Herzl St., 76100 Rehovot, Israel
[3]Department of Physics, The Oskar Klein Center, Stockholm University, AlbaNova, 10691 Stockholm, Sweden
[4]Division of Physics, Mathematics, and Astronomy, California Institute of Technology, Pasadena, CA 91125, USA
[5]Astrophysics Research Institute, Liverpool John Moores University, IC2, Liverpool Science Park, 146 Brownlow Hill, Liverpool L3 5RF, UK
[6]DIRAC Institute, Department of Astronomy, University of Washington, 3910 15$^{\rm th}$ Avenue NE, Seattle, WA 98195, USA
[7]IPAC, California Institute of Technology, 1200 E. California, Blvd., Pasadena, CA 91125, USA
[8]Univ. Lyon, Univ. Claude Bernard Lyon 1, CNRS, IP2I Lyon / IN2P3, IMR 5822, F-69622, Villeurbanne, France
[9]Department of Astronomy, University of California, Berkeley, CA 94720-3411, USA

We present our observations and analysis of SN 2020cxd, a low-luminosity (LL), long-lived Type IIP supernova (SN). This object is a clear outlier in the magnitude-limited SN sample recently presented by the *Zwicky* Transient Facility's (ZTF) Bright Transient Survey. We demonstrate that SN 2020cxd is an additional member of the group of LL SNe and we discuss the rarity of LL SNe in the context of the ZTF survey. We consider how further studies of these faintest members of the core-collapse (CC) SN family might help improve the general understanding of the underlying initial mass function for stars that explode. We used optical light curves (LCs) from the ZTF in the *gri* bands and several epochs of ultraviolet data from the *Neil Gehrels* Swift Observatory as well as a sequence of optical spectra. We constructed the colour curves and a bolometric LC. Then we compared the evolution of the ejecta velocity and black-body temperature for LL SNe as well as for typical Type II SNe. Furthermore, we adopted a Monte Carlo code that fits semi-analytic models to the LC of SN 2020cxd, which allows for the estimation of the physical parameters. Using our late-time nebular spectra, we also make a comparison against SN II spectral synthesis models from the literature to constrain the progenitor properties of SN 2020cxd. The LCs of SN 2020cxd show a great similarity with those of LL SNe IIP in terms of luminosity, timescale, and colours. Also, the spectral evolution of SN 2020cxd is that of a Type IIP SN. The spectra show prominent and narrow P-Cygni lines, indicating low expansion velocities. This is one of the faintest LL SNe observed, with an absolute plateau magnitude of $M_r = -14.5$ mag and also one with the longest plateau lengths, with a duration of 118 days. Finally, the velocities measured from the nebular emission lines are among the lowest ever seen in a SN, with an intrinsic full width at half maximum value of 478 km s^{-1}. The underluminous late-time exponential LC tail indicates that the mass of ^{56}Ni ejected during the explosion is much smaller than the average of normal SNe IIP, we estimate $M_{^{56}\rm Ni} = 0.003$ M$_\odot$. The Monte Carlo fitting of the bolometric LC suggests that the progenitor of SN 2020cxd had a radius of $R_0 = 1.3 \times 10^{13}$ cm, kinetic energy of $E_{\rm kin} = 4.3 \times 10^{50}$ erg, and ejecta mass of $M_{\rm ej} = 9.5$ M$_\odot$. From the bolometric LC, we estimated the total radiated energy $E_{\rm rad} = 1.52 \times 10^{48}$ erg. Using our late-time nebular spectra, we compared these results against SN II spectral synthesis models to constrain the progenitor zero-age main sequence mass and found that it is likely to be $\lesssim 15$ M$_\odot$. SN 2020cxd is a LL Type IIP SN. The inferred progenitor parameters and the features observed in the nebular spectrum favour a low-energy, Ni-poor, iron CC SN from a low-mass (~ 12 M$_\odot$) red supergiant.

Published in Astronomy & Astrophysics, 655, A90 (2021)
Available from https://arxiv.org/abs/2107.13439

Direct measurements of giant star effective temperatures and linear radii: calibration against spectral types and V–K color

Gerard T. van Belle[1], Kaspar von Braun[1], David R. Ciardi[2], Genady Pilyavsky[3], Ryan S. Buckingham[1], Andrew F. Boden[4], Catherine A. Clark[1,5], Zachary Hartman[1,6], Gerald van Belle[7], William Bucknew[1] and Gary Cole[8]

[1]Lowell Observatory, USA
[2]NASA NExScI, Caltech, USA
[3]Systems & Technology Research, USA
[4]Caltech, USA
[5]Northern Arizona University, USA
[6]Georgia State University, USA
[7]University of Washington, USA
[8]Starphysics Observatory, USA

We calculate directly determined values for effective temperature ($T_{\rm eff}$) and radius (R) for 191 giant stars based upon high resolution angular size measurements from optical interferometry at the Palomar Testbed Interferometer. Narrow- to wide-band photometry data for the giants are used to establish bolometric fluxes and luminosities through spectral energy distribution fitting, which allow for homogeneously establishing an assessment of spectral type and dereddened $V_0 - K_0$ color; these two parameters are used as calibration indices for establishing trends in $T_{\rm eff}$ and R. Spectral types range from G0 III to M7.75 III, $V_0 - K_0$ from 1.9 to 8.5. For the $V_0 - K_0 = \{1.9, 6.5\}$ range, median $T_{\rm eff}$ uncertainties in the fit of effective temperature versus color are found to be less than 50 K; over this range, $T_{\rm eff}$ drops from 5050 K to 3225 K. Linear sizes are found to be largely constant at 11 $R_\odot$ from G0 III to K0 III, increasing linearly with subtype to 50 $R_\odot$ at K5 III, and then further increasing linearly to 150 $R_\odot$ by M8 III. Three examples of the utility of this data set are presented: first, a fully empirical Hertzsprung–Russell Diagram is constructed and examined against stellar evolution models; second, values for stellar mass are inferred based on measures of R and literature values for $\log g$. Finally, an improved calibration of an angular size prediction tool, based upon V and K values for a star, is presented.

Published in The Astrophysical Journal
Available from https://arxiv.org/abs/2107.09205
and from https://iopscience.iop.org/article/10.3847/1538-4357/ac1687

PUSHing core-collapse supernovæ to explosions in spherical symmetry – V. Equation of state dependency of explosion properties, nucleosynthesis yields, and compact remnants

Somdutta Ghosh[1], Noah Wolfe[1] and Carla Fröhlich[1]

[1]Department of Physics, North Carolina State University, Raleigh NC 27695, USA

In this fifth paper of the series, we use the parametrized, spherically symmetric explosion method PUSH to investigate the impact of eight different nuclear equations of state (EOS). We present and discuss the explosion properties and the detailed nucleosynthesis yields, and predict the remnant (neutron star or black hole) for all our simulations. For this, we perform two sets of simulations. One, a complete study of non-rotating stars from 11 to 40 $M_\odot$ at three different metallicities using the SFHo EOS. And two, a suite of simulations for four progenitors (16 $M_\odot$ at three metallicities and 25 $M_\odot$ at solar metallicity) for eight different nuclear EOS. We compare our predicted explosion energies and yields to observed supernovæ and to the metal-poor star HD 84937. We find EOS-dependent differences in the explosion properties and the nucleosynthesis yields. However, when comparing to observations, these differences are not large enough to rule out any EOS considered in this work.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/2107.13016

The initial–final mass relation for hydrogen-deficient white dwarfs

Joseph W. Barnett[1], Kurtis A. Williams[1], A. Bedard[2] and M. Bolte[3]

[1]Texas A&M University–Commerce, Commerce, TX, USA
[2]University of Montréal, Montréal, Quebec, Canada
[3]UCO/Lick Observatory, Santa Cruz, CA, USA

he initial–final mass relation (IFMR) represents the total mass lost by a star during the entirety of its evolution from the zero age main sequence to the white dwarf cooling track. The semi-empirical IFMR is largely based on observations of DA white dwarfs, the most common spectral type of white dwarf and the simplest atmosphere to model. We present a first derivation of the semi-empirical IFMR for hydrogen deficient white dwarfs (non-DA) in open star clusters. We identify a possible discrepancy between the DA and non-DA IFMRs, with non-DA white dwarfs ≈ 0.07 $M_\odot$ less massive at a given initial mass. Such a discrepancy is unexpected based on theoretical models of non-DA formation and observations of field white dwarf mass distributions. If real, the discrepancy is likely due to enhanced mass loss during the final thermal pulse and renewed post-AGB evolution of the star. However, we are dubious that the mass discrepancy is physical and instead is due to the small sample size, to systematic issues in model atmospheres of non-DAs, and to the uncertain evolutionary history of Procyon B (spectral type DQZ). A significantly larger sample size is needed to test these assertions. In addition, we also present Monte Carlo models of the correlated errors for DA and non-DA white dwarfs in the initial–final mass plane. We find the uncertainties in initial–final mass determinations for individual white dwarfs can be significantly asymmetric, but the recovered functional form of the IFMR is grossly unaffected by the correlated errors.

Published in The Astronomical Journal, 162, 162 (2021)
Available from https://arxiv.org/abs/2107.06373

Chemistry and physical properties of the born-again planetary nebula HuBi 1

B. Montoro-Molina[1], M.A. Guerrero[1], B. Pérez-Díaz[1], J.A. Toalá[2], S. Cazzoli[1], M.M. Miller Bertolamí[3,4] and C. Morisset[5]

[1]Instituto de Astrofísica de Andalucía, IAA–CSIC, Glorieta de la Astronomía S/N, Granada 18008, Spain
[2]Instituto de Radioastronomía y Astrofísica, UNAM Campus Morelia, Apartado Postal 3-72, 58090 Morelia, Michoacán, México
[3]Instituto de Astrofísica de La Plata, UNLP–CONICET, La Plata, Argentina
[4]Facultad de Ciencias Astronómicas y Geofísicas, UNLP, La Plata, Argentina
[5]Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, B.C., México

The central star of the planetary nebula (PN) HuBi 1 has been recently proposed to have experienced a very late thermal pulse (VLTP), but the dilution of the emission of the recent ejecta by that of the surrounding H-rich old outer shell has so far hindered confirming its suspected H-poor nature. We present here an analysis of the optical properties of the ejecta in the innermost regions of HuBi 1 using MEGARA high-dispersion integral field and OSIRIS intermediate-dispersion long-slit spectroscopic observations obtained with the 10.4m Gran Telescopio de Canarias. The unprecedented tomographic capability of MEGARA to resolve structures in velocity space allowed us to disentangle for the first time the Hα and Hβ emission of the recent ejecta from that of the outer shell. The recent ejecta is found to have much higher extinction than the outer shell, implying the presence of large amounts of dust. The spatial distribution of the emission from the ejecta and the locus of key line ratios in diagnostic diagrams probe the shock excitation of the inner ejecta in HuBi 1, in stark contrast with the photoionization nature of the H-rich outer shell. The abundances of the recent ejecta have been computed using the MAPPINGS V code under a shock scenario. They are found to be consistent with a born-again ejection scenario experienced by the progenitor star, which is thus firmly confirmed as a new "born-again" star.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2202.00353

Conference Paper

VLTI images of circumbinary disks around evolved stars

J. Kluska[1], *R. Claes*[1], *A. Corporaal*[1], *H. Van Winckel*[1], *J. Alcolea*[2], *N. Anugu*[3], *J.-P. Berger*[4], *D. Bollen*[1], *V. Bujarrabal*[2], *R. Izzard*[5], *D. Kamath*[6], *S. Kraus*[7], *J.-B. Le Bouquin*[4], *M. Min*[8], *J.D. Monnier*[9] *and H. Olofsson*[10]

[1]K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[2]Observatorio Astronómico Nacional, Spain
[3]University of Arizona, USA
[4]Institut de Planétologie et d'Astrophysique de Grenoble, France
[5]University of Surrey, UK
[6]Macquarie University, Australia
[7]University of Exeter, UK
[8]SRON Netherlands Institute for Space Research, The Netherlands
[9]Univ. of Michigan, USA
[10]Chalmers University of Technology, Sweden

The new generation of VLTI instruments (GRAVITY, MATISSE) aims to produce routinely interferometric images to uncover the morphological complexity of different objects at high angular resolution. Image reconstruction is, however, not a fully automated process. Here we focus on a specific science case, namely the complex circumbinary environments of a subset of evolved binaries, for which interferometric imaging provides the spatial resolution required to resolve the immediate circumbinary environment. Indeed, many binaries where the main star is in the post-asymptotic giant branch (post-AGB) phase are surrounded by circumbinary disks. Those disks were first inferred from the infrared excess produced by dust. Snapshot interferometric observations in the infrared confirmed disk-like morphology and revealed high spatial complexity of the emission that the use of geometrical models could not recover without being strongly biased. Arguably, the most convincing proof of the disk-like shape of the circumbinary environment came from the first interferometric image of such a system (IRAS 08544−4431) using the PIONIER instrument at the VLTI. This image was obtained using the SPARCO image reconstruction approach that enables to subtract a model of a component of the image and reconstruct an image of its environment only. In the case of IRAS 08544−4431, the model involved a binary and the image of the remaining signal revealed several unexpected features. Then, a second image revealed a different but also complex circumstellar morphology around HD 101584 that was well studied by ALMA. To exploit the VLTI imaging capability to understand these targets, we started a large program at the VLTI to image post-AGB binary systems using both PIONIER and GRAVITY instruments.

Oral contribution, published in Proceedings of the SPIE, Volume 11446, id. 114460D (2020)
Available from https://arxiv.org/abs/2012.07448
and from https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11446/2561480/VLTI-images-of-circumbinary-disks-around-evolved-stars/10.1117/12.2561480.short?SSO=1

Job Advert

Vacancy Staff Astronomer / Instrument Scientist

Dear colleagues,

The ESO observatory is looking for a new Staff Astronomer, duty station is ESO Chile. The deadline for the application is 13 March 2022. Please forward this information to any potential candidate.

https://recruitment.eso.org/jobs/2022_0001

Do not hesitate to drop me a line if you would like some information about the job.

Best Regards
Claudia Paladini

See also https://recruitment.eso.org/jobs/2022_0001

Announcement

Our Galactic Ecosystem: Opportunities and Diagnostics in the Infrared and Beyond Conference (In person, Lake Arrowhead, CA, USA)

The far infrared contains critical information about Galactic ecosystem; The circle of life of stars and planets. How does interstellar material cycle between atomic and molecular clouds, and how does its chemical composition (and particularly the abundance of hydride molecules) reflect the environment in which it is found? What is the role of feedback (from young and old stars) on the interstellar medium (ISM)? What is the role of magnetic fields in the evolution of the ISM and star formation?

SOFIA provides a flexible, and our currently only, general access to the far infrared (30–300 μm) and its tracers of atomic and molecular lines and FIR polarization. This conference will allow in-person discussions of the results and future opportunities in studying galactic ecosystem using FIR methods, from SOFIA and other platforms. A goal will be to explore synergy with other observatories, including JWST and ALMA, and with theory.

We will require proof of vaccination against COVID-19 from all attendees of the conference. We will also have strict COVID vaccination, testing and masking protocols during the duration of the event to make sure our attendees are safe.

Late registration: February 14$^{\text{th}}$

See also https://arrowhead-2022.constantcontactsites.com/