THE AGB NEWSLETTER

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

Official publication of the IAU Working Group on Abundances in Red Giants

No. 249 — 5 April 2018

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 249th issue of the AGB Newsletter – apologies for the slight delay but some of us are attending the European Week of Astronomy and Astrophysics, with some very interesting talks and discussions about dust formation in particular. The newsletter also has plenty of interest – symbiotics (R Aqr stealing the show again), end products, masers and grains, and more – plus an announcement for a meeting in Poland.

Please cast your vote on what you think should be on the next, 250th issue's front cover to celebrate the most iconic picture related to the topic of this newsletter. The nominations are:

1 U Ant – https://www.eso.org/public/images/eso1730d/

2 Red Rectangle – https://en.wikipedia.org/wiki/Red_Rectangle_Nebula#/media/File:Redrectangle_hst_full.jpg

3 Mira's tail – http://www.galex.caltech.edu/media/glx2007-04r_img03.html

4 R Scu – http://www.eso.org/public/images/eso1239a/

5 R Scl – https://www.eso.org/public/images/eso1239/

Please e-mail astro.agbnews@keele.ac.uk with your choice before April 30.

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

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

Food for Thought

This month's thought-provoking statement is:

Can we make astrophysical dust in the laboratory under astrophysical conditions?

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

Broad absorption line symbiotic stars: highly ionized species in the fast outflow from MWC 560

Adrian B. Lucy[1], *Christian Knigge*[2] *and J.L. Sokoloski*[1]

[1]Columbia University, Dept. of Astronomy, USA

[2]University of Southampton, School of Physics & Astronomy, UK

In symbiotic binaries, jets and disk winds may be integral to the physics of accretion onto white dwarfs from cool giants. The persistent outflow from symbiotic star MWC 560 (=V 694 Mon) is known to manifest as low-ionization broad absorption lines (BALs), most prominently at the Balmer transitions, and as high-ionization BALs from metastable He I*. We report the detection of higher-ionization BALs from C IV, Si IV, N V, and He II in International Ultraviolet Explorer spectra obtained on 1990 April 29–30, when an optical outburst temporarily erased the obscuring 'iron curtain' of absorption troughs from Fe II and similar ions. The C IV and Si IV BALs reached maximum radial velocities at least 1000 km s^{-1} faster than contemporaneous Mg II and He II BALs; the same behaviors occur in the winds of quasars and cataclysmic variables. An iron curtain lifts to unveil high-ionization BALs during the P Cygni phase observed in some novae, suggesting by analogy a temporary switch in MWC 560 from persistent outflow to discrete mass ejection. At least three more symbiotic stars exhibit broad absorption with blue edges faster than 1500 km s^{-1}; exclusively high-ionization BALs have been reported in AS 304 (= V4018 Sgr), while instead transient Balmer BALs have been reported in Z And and CH Cyg. These BAL-producing fast outflows can have wider opening angles than has been previously supposed. BAL symbiotics are short-timescale laboratories for their giga-scale analogs, broad absorption line quasars (BALQSOs), which display a similarly wide range of ionization states in their winds.

Submitted to MNRAS
Available from https://arxiv.org/abs/1802.07743

Modules for Experiments in Stellar Astrophysics (MESA): convective boundaries, element diffusion, and massive star explosions

Bill Paxton[1], *Josiah Schwab*[2], *Evan B. Bauer*[3], *Lars Bildsten*[1,3], *Sergei Blinnikov*[4,5,6], *Paul Duffell*[7], *R. Farmer*[8,9], *Jared A. Goldberg*[3], *Pablo Marchant*[10], *Elena Sorokina*[4], *Anne Thoul*[11], *Richard H.D. Townsend*[12] *and F.X. Timmes*[9]

[1]Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, USA

[2]Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA 95064, USA

[3]Department of Physics, University of California, Santa Barbara, CA 93106, USA

[4]M.V. Lomonosov Moscow State University, Sternberg Astronomical Institute, Universitetsky pr. 13, Moscow, 119234, Russia

[5]NIC Kurchatov Institute – Institute for Theoretical and Experimental Physics (ITEP), 117218 Moscow, Russia

[6]Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo, Kashiwa, Chiba 277-8583, Japan

[7]Department of Astronomy and Theoretical Astrophysics Center, University of California, Berkeley, CA 94720, USA

[8]Anton Pannekoek Institute for Astronomy, University of Amsterdam, NL-1090 GE Amsterdam, The Netherlands

[9]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA

[10]Department of Physics and Astronomy, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208, USA

[11]Space sciences, Technologies and Astrophysics Research (STAR) Institute, Université de Liège, Allée du 6 Août 19C, Bat. B5C, 4000 Liège, Belgium

[12]Department of Astronomy, University of Wisconsin–Madison, Madison, WI 53706, USA

We update the capabilities of the software instrument Modules for Experiments in Stellar Astrophysics (MESA) and enhance its ease of use and availability. Our new approach to locating convective boundaries is consistent with the physics of convection, and yields reliable values of the convective-core mass during both hydrogen- and helium-burning phases. Stars with $M < 8\ M_\odot$ become white dwarfs and cool to the point where the electrons are degenerate and the ions are strongly coupled, a realm now available to study with MESA due to improved treatments of element diffusion,

latent heat release, and blending of equations of state. Studies of the final fates of massive stars are extended in MESA by our addition of an approximate Riemann solver that captures shocks and conserves energy to high accuracy during dynamic epochs. We also introduce a 1D capability for modeling the effects of Rayleigh–Taylor instabilities that, in combination with the coupling to a public version of the STELLA radiation transfer instrument, creates new avenues for exploring Type II supernova properties. These capabilities are exhibited with exploratory models of pair-instability supernovæ, pulsational pair-instability supernovæ, and the formation of stellar-mass black holes. The applicability of MESA is now widened by the capability to import multidimensional hydrodynamic models into MESA. We close by introducing software modules for handling floating point exceptions and stellar model optimization, as well as four new software tools – MESA-Web, MESA-Docker, pyMESA, and mesastar.org – to enhance MESA's education and research impact.

Published in The Astrophysical Journal Supplement Series, 234, 34 (2018)
Available from https://arxiv.org/abs/1710.08424

Type IIP supernova light curves affected by the acceleration of red supergiant winds

Takashi Moriya[1], *Francisco Forster*[2], *Sung-Chul Yoon*[3], *Götz Gräfener*[4] *and Sergei Blinnikov*[5]

[1]National Astronomical Observatory of Japan, Japan
[2]University of Chile, Chile
[3]Seoul National University, South Korea
[4]University of Bonn, Germany
[5]Institute for Theoretical and Experimental Physics, Russia

We introduce the first synthetic light-curve model set of Type IIP supernovæ exploded within circumstellar media in which the acceleration of the red supergiant winds is taken into account. Because wind acceleration makes the wind velocities near the progenitors low, the density of the immediate vicinity of the red supergiant supernova progenitors can be higher than that extrapolated by using a constant terminal wind velocity. Therefore, even if the mass-loss rate of the progenitor is relatively low, it can have a dense circumstellar medium at the immediate stellar vicinity and the early light curves of Type IIP supernovæ are significantly affected by it. We adopt a simple β velocity law to formulate the wind acceleration. We provide bolometric and multi-color light curves of Type IIP supernovæ exploding within such accelerated winds from the combinations of three progenitors, 12–16 $M_\odot$; five β, 1–5; seven mass-loss rates, 10^{-5}–10^{-2} $M_\odot$ yr^{-1}; and four explosion energies, 0.5×10^{51}–2×10^{51} erg. All the light curve models are available at https://goo.gl/o5phYb. When the circumstellar density is sufficiently high, our models do not show a classical shock breakout as a consequence of the interaction with the dense and optically-thick circumstellar media. Instead, they show a delayed 'wind breakout', substantially affecting early light curves of Type IIP supernovæ. We find that the mass-loss rates of the progenitors need to be 10^{-3}–10^{-2} $M_\odot$ yr^{-1} to explain typical rise times of 5–10 days in Type IIP supernovæ assuming a dense circumstellar radius of 10^{15} cm.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/1802.07752

Asteroseismology of 16000 *Kepler* red giants: global oscillation parameters, masses, and radii

Jie Yu[1,2], *Daniel Huber*[3,1,4,2], *Timothy R. Bedding*[1,2], *Dennis Stello*[5,1,2], *Marc Hon*[5], *Simon J. Murphy*[1,2] *and Shourya Khanna*[1]

[1]Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia
[2]Stellar Astrophysics Centre, Department of Physics and Astronomy, Århus University, Ny Munkegade 120, DK-8000 Århus C, Denmark
[3]Institute for Astronomy, University of Hawai'i, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[4]SETI Institute, 189 Bernardo Avenue, Mountain View, CA 94043, USA
[5]School of Physics, University of New South Wales, NSW 2052, Australia

The *Kepler* mission has provided exquisite data to perform an ensemble asteroseismic analysis on evolved stars. In this work we systematically characterize solar-like oscillations and granulation for 16,094 oscillating red giants, using end-of-mission long-cadence data. We produced a homogeneous catalog of the frequency of maximum power (typical uncertainty $\sigma_{\nu_{\max}} = 1.6\%$), the mean large frequency separation ($\sigma_{\Delta\nu} = 0.6\%$), oscillation amplitude ($\sigma_{\rm A} = 4.7\%$), granulation power ($\sigma_{\rm gran} = 8.6\%$), power excess width ($\sigma_{\rm width} = 8.8\%$), seismically-derived stellar mass ($\sigma_{\rm M} = 7.8\%$), radius ($\sigma_{\rm R} = 2.9\%$), and thus surface gravity ($\sigma_{\log g} = 0.01$ dex). Thanks to the large red giant sample, we confirm that red-giant-branch (RGB) and helium-core-burning (HeB) stars collectively differ in the distribution of oscillation amplitude, granulation power, and width of power excess, which is mainly due to the mass difference. The distribution of oscillation amplitudes shows an extremely sharp upper edge at fixed $\nu_{\max}$, which might hold clues to understand the excitation and damping mechanisms of the oscillation modes. We find both oscillation amplitude and granulation power depend on metallicity, causing a spread of 15% in oscillation amplitudes and a spread of 25% in granulation power from [Fe/H] = −0.7 to 0.5 dex. Our asteroseismic stellar properties can be used as reliable distance indicators and age proxies for mapping and dating Galactic stellar populations observed by *Kepler*. They will also provide an excellent opportunity to test asteroseismology using Gaia parallaxes, and lift degeneracies in deriving atmospheric parameters in large spectroscopic surveys such as APOGEE and LAMOST.

Accepted for publication in The Astrophysical Journal Supplement Series
Available from https://arxiv.org/abs/1802.04455

Polarization as a proof of dusty environments around Type Ia supernovæ: radiative transfer models for SN 2012dn

Takashi Nagao[1], *Kei'ichi Maeda*[1] *and Masayuki Yamanaka*[2]

[1]Department of astronomy, Kyoto University, Japan
[2]Hiroshima Astrophysical Science Center, Hiroshima University, Japan

Geometry of circumstellar (CS) medium around supernovae (SNe) provides important diagnostics to understand the nature of their progenitors. In this paper, properties of CS dust around SN 2012dn, a super-Chandrasekhar candidate Type Ia supernova (SC-SN), have been studied through detailed three dimensional radiation transfer simulations. With the detected near-infrared excess from SN 2012dn, we show that it has a disk-like dusty CS environment whose mass is roughly consistent with a branch of an accreting white dwarf system (the single degenerate scenario). We show that a similar system should produce polarization signals up to $\sim 8\%$ in the B band, depending on the viewing direction if polarimetric observation is performed. We predict that the maximum polarization is reached around ~ 60 days after the B-band maximum. We show that the temporal and wavelength dependence of the polarization signals, together with other unique features, can be easily distinguished from the interstellar polarization and intrinsic SN polarization. Indeed, the small polarization degree observed for normal Type Ia SNe (SNe Ia) can constrain a parameter space in the CS dust mass and distribution. We thus encourage multi-band polarimetric observations for SNe Ia, especially for outliers including SC-SNe for which some arguments for the single degenerate scenario exist but the polarization data are very rare so far.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/1802.08954

The bipolar jet of the symbiotic star R Aquarii: study of its morphology using the high-resolution HST WFC3/UVIS camera

Stanislav Melnikov[1,3], *Matthias Stute*[2] *and Jochen Eislöffel*[1]

[1]Thüringer Landessternwarte Tautenburg, Germany
[2]Simcorp GmbH, Germany
[3]Ulugh Beg Astronomical Institute, Uzbekistan

Context: R Aqr is a symbiotic binary system consisting of a Mira variable with a pulsation period of 387 days and a hot companion which is presumably a white dwarf with an accretion disk. This binary system is the source of a

prominent bipolar gaseous outflow.
Aims: We use high spatial resolution and sensitive images from the *Hubble* Space Telescope (HST) to identify and investigate the different structural components that form the complex morphology of the R Aqr jet.
Methods: We present new high-resolution HST WFC3/UVIS narrow-band images of the R Aqr jet obtained in 2013/14 using the [O III]λ5007, [O I]λ6300, [N II]λ6583, and Hα emission lines. These images also allow us to produce detailed maps of the jet flow in several line ratios such as [O III]λ5007/[O I]λ6300 and [N II]λ6583/[O I]λ6300 which are sensitive to the outflow temperature and its hydrogen ionisation fraction. The new emission maps together with archival HST data are used to derive and analyse the proper motion of prominent emitting features which can be traced over 20 years with the HST observations.
Results: The images reveal the fine gas structure of the jet out to distances of a few tens of arcseconds from the central region, as well as in the innermost region, within a few arcseconds around the stellar source. They reveal for the first time the straight, highly collimated jet component which can be traced to up to $\sim$ 900 au in the NE direction. Images in [O III]λ5007, [O I]λ6300, and [N II]λ6583 clearly show a helical pattern in the jet beams which may derive from the small-scale precession of the jet. The highly collimated jet is accompanied by a wide opening angle outflow which is filled by low excitation gas. The position angles of the jet structures as well as their opening angles are calculated. Our measurements of the proper motions of some prominent emission knots confirm the scenario of gas acceleration during the propagation of the outflow. Finally, we produce several detailed line ratio maps which present a mosaic combined from the large field and the PSF-subtracted inner region.
Conclusions: The high signal-to-noise HST WFC3/UVIS images provide powerful tools for the study of the jet morphology and also bring detailed information about the physical jet gas conditions. The simultaneous observations of [O III], [O I], [N II], and [S II] would allow us to measure basic parameters of the ionised gas in the R Aqr outflow such as electron density, electron temperature and hydrogen ionisation fraction, and compare them with other stellar jets.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1802.00503

An illumination effect and an eccentric orbit for the symbiotic binary PU Vul revealed by 32 years of optical spectroscopy

Virginia A. Cúneo[1,4], Scott J. Kenyon[2], Mercedes N. Gómez[3,4], Drahomir Chochol[5], Sergey Y. Shugarov[5,6] and Eugeni A. Kolotilov[6]

[1]Instituto Argentino de Radioastronomía (CCT La Plata, CONICET), C.C. 5, (1984) Villa Elisa, Buenos Aires, Argentina
[2]Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, USA
[3]Universidad Nacional de Córdoba, Observatorio Astronómico, Laprida 854, X5000BGR, Córdoba, Argentina
[4]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[5]Astronomical Institute, Slovak Academy of Science, 059 60 Tatranská Lomnica, Slovakia
[6]Sternberg Astronomical Institute, University avenue 13, Moscow 119992, Russia

We analyze $\sim$ 32 years of optical spectra and photometry for the symbiotic binary PU Vul. Light curves for the He I λ4471, He II λ4686 and Hβ λ4861 emission lines reveal an illumination effect, where the hot white dwarf ionizes the outflowing wind of the red giant, and evidence for an eccentric orbit with e $\approx$ 0.16. Along with the gradual appearance of high ionization emission from [Fe VII] and O VI, the relative fluxes of these lines suggest an increase in the effective temperature of the hot component, from roughly 10^5 K on JD 2 448 000 (1990) to roughly 2×10^5 K on JD 2 455 000 (2009). During this period, the luminosity of the hot component dropped by a factor of 4–6 to a current value of roughly 1000 $L_\odot$.

Submitted to MNRAS
Available from https://arxiv.org/abs/1802.10565

Towards an improvement in the spectral description of central stars of planetary nebulæ

W. Weidmann[1,2], R. Gamen[2], D. Mast[1,2], C. Fariña[4], G. Gimeno[5], E.O. Schmidt[2,3], R.P. Ashley[6], L. Peralta de Arriba[7], P. Sowicka[8] and I. Ordonez-Etxeberria[9]

[1]Observatorio Astronómico Córdoba, Argentina

[2]CONICET, Argentina

[3]IATE, Argentina

[4]Isaac Newton Group of Telescopes, E-38700 Santa Cruz de La Palma, La Palma, Spain

[5]Gemini South c/o AURA, Casilla 603, La Serena, Chile

[6]Department of Physics, University of Warwick, Gibbet Hill Road, Coventry, CV4 7AL, UK

[7]Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK

[8]Nicolaus Copernicus Astronomical Center, Bartycka 18, PL-00-716 Warsaw, Poland

[9]Dpto. de Física Aplicada I, Escuela de Ingeniería de Bilbao, Universidad del País Vasco, Bilbao, Spain

Context: There are more than 3000 known Galactic planetary nebulæ (PNe), but only 492 central stars of Galactic planetary nebulæ (CSPN) have known spectral types. It is vital to increase this number in order to have reliable statistics, which will lead to an increase of our understanding of these amazing objects.
Aims: We aim to contribute to the knowledge of central stars of planetary nebulæ and stellar evolution.
Methods: This observational study is based on Gemini Multi-Object Spectrographs (GMOS) and with the Intermediate Dispersion Spectrograph (IDS) at the *Isaac Newton* Telescope (INT) spectra of 78 CSPN. The objects were selected because they did not have any previous classification, or the present classification is ambiguous. These new high quality spectra allowed us to identify the key stellar lines for determining spectral classification in the Morgan–Keenan (MK) system.
Results: We have acquired optical spectra of a large sample of CSPN. From the observed targets, 50 are classified here for the first time while for 28 the existing classifications have been improved. In seven objects we have identified a P-Cygni profile at the He I lines. Six of these CSPN are late O-type. The vast majority of the stars in the sample exhibit an absorption-type spectrum, and in one case we have found wide emission lines typical of [WR] stars. We give a complementary, and preliminary, classification criterion to obtain the sub-type of the O(H)-type CSPN. Finally, we give a more realistic value of the proportion of CSPN that are rich or poor in hydrogen.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1802.02122

High-resolution IR absorption spectroscopy of polycyclic aromatic hydrocarbons in the 3 μm region: role of hydrogenation and alkylation

E. Maltseva[1], C.J. Mackie[2], A. Candian[2], A. Petrignani[1,2], X. Huang[3,4], T.J. Lee[4], A.G.G.M. Tielens[1], J. Oomens[5] and W.J. Buma[1]

[1]University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands

[2]Leiden Observatory, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands

[3]SETI Institute, 189 Bernardo Avenue, Suite 100, Mountain View, CA 94043, USA

[4]NASA Ames Research Center, Moffett Field, California 94035-1000, USA

[5]Radboud University, Toernooiveld 7c, 6525 ED Nijmegen, The Netherlands

Aims: We aim to elucidate the spectral changes in the 3 μm region that result from chemical changes in the molecular periphery of polycyclic aromatic hydrocarbons (PAHs) with extra hydrogens (H-PAHs) and methyl groups (Me-PAHs).
Methods: Advanced laser spectroscopic techniques combined with mass spectrometry were applied on supersonically cooled 1,2,3,4-tetrahydronaphthalene, 9,10-dihydroanthracene, 9,10-dihydrophenathrene, 1,2,3,6,7,8-hexahydropyrene, 9-methylanthracene, and 9,10-dimethylanthracene, allowing us to record mass-selective and conformationally selective absorption spectra of the aromatic, aliphatic, and alkyl CH-stretches in the 3.175–3.636 μm region with laser-limited resolution. We compared the experimental absorption spectra with standard harmonic calculations and with second-order vibrational perturbation theory anharmonic calculations that use the SPECTRO program for treating resonances.
Results: We show that anharmonicity plays an important if not dominant role, affecting not only aromatic, but also

aliphatic and alkyl CH-stretch vibrations. The experimental high-resolution data lead to the conclusion that the variation in Me- and H-PAHs composition might well account for the observed variations in the 3 μm emission spectra of carbon-rich and star-forming regions. Our laboratory studies also suggest that heavily hydrogenated PAHs form a significant fraction of the carriers of IR emission in regions in which an anomalously strong 3 μm plateau is observed.

Published in A&A 610, A65 (2018)
Available from https://arxiv.org/abs/1802.01497
and from https://doi.org/10.1051/0004-6361/201732102

Determining the effects of clumping and porosity on the chemistry in a non-uniform AGB outflow

M. Van de Sande[1], J.O. Sundqvist[1], T.J. Millar[2], D. Keller[1], W. Homan[1], A. de Koter[3], L. Decin[1] and F. De Ceuster[4]

[1]Department of Physics and Astronomy, Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[2]Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast, University Road, Belfast BT7 1NN, UK
[3]Astronomical Institute Anton Pannekoek, University of Amsterdam, Science Park 904, P.O. Box 94249, 1090 GE Amsterdam, The Netherlands
[4]Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK

Context: In the inner regions of AGB outflows, several molecules have been detected with abundances much higher than those predicted from thermodynamic equilibrium chemical models. The presence of the majority of these species can be explained by shock-induced non-equilibrium chemical models, where shocks caused by the pulsating star take the chemistry out of equilibrium in the inner region. Moreover, a non-uniform density structure has been detected in several AGB outflows. Both large-scale structures, such as spirals and disks, and small-scale density inhomogeneities or clumps have been observed. These structures may also have a considerable impact on the circumstellar chemistry. A detailed parameter study on the quantitative effects of a non-homogeneous outflow has so far not been performed.
Aims: We examine the effects of a non-uniform density distribution within an AGB outflow on its chemistry by considering a stochastic, clumpy density structure.
Methods: We implement a "porosity formalism" for treating the increased leakage of light associated with radiation transport through a clumpy, porous medium. We then use this method to examine the effects from the altered UV radiation field penetration on the chemistry, accounting also for the increased reaction rates of two-body processes in the overdense clumps. The specific clumpiness is determined by three parameters: the characteristic length scale of the clumps at the stellar surface, the clump volume filling factor, and the inter-clump density contrast. In this paper, the clumps are assumed to have a spatially constant volume filling factor, which implies that they expand as they move outward in the wind.
Results: We present a parameter study of the effect of clumping and porosity on the chemistry throughout the outflow. Both the higher density within the clumps and the increased UV radiation field penetration have an important impact on the chemistry, as they both alter the chemical pathways throughout the outflow. The increased amount of UV radiation in the inner region leads to photo-dissociation of parent species, releasing the otherwise deficient elements. We find an increased abundance in the inner region of all species not expected to be present assuming thermodynamic equilibrium chemistry, such as HCN in O-rich outflows, H_2O in C-rich outflows, and NH_3 in both.
Conclusions: A non-uniform density distribution directly influences the chemistry throughout the AGB outflow, both through the density structure itself and through its effect on the UV radiation field. Species not expected to be present in the inner region of the outflow assuming thermodynamic equilibrium chemistry are now formed in this region, including species that are not formed in greater abundance by shock-induced non-equilibrium chemistry models. Outflows whose clumps have a large overdensity and that are very porous to the interstellar UV radiation field yield abundances comparable to those observed in O-rich and C-rich outflows for most of the unexpected species investigated. The inner wind abundances of H_2O in C-rich outflows and of NH_3 in O-rich and C-rich outflows are however underpredicted.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1803.01796

Modelling the carbon AGB star R Sculptoris. Constraining the dust properties in the detached shell based on far-infrared and sub-millimeter observations

Magdalena Brunner[1], *Matthias Maercker*[2], *Marko Mecina*[1], *Theo Khouri*[2] *and Franz Kerschbaum*[1]

[1]Department for Astrophysics, University of Vienna, Türkenschanzstraße 17, A-1180 Vienna, Austria

[2]Department of Space, Earth and Environment, Chalmers University of Technology, 43992 Onsala, Sweden

Context: On the asymptotic giant branch (AGB), Sun-like stars lose a large portion of their mass in an intensive wind and enrich the surrounding interstellar medium (ISM) with nuclear processed stellar material in the form of molecular gas and dust. For a number of carbon-rich AGB stars, thin detached shells of gas and dust have been observed. These shells are formed during brief periods of increased mass loss and expansion velocity during a thermal pulse, and open up the possibility to study the mass-loss history of thermally pulsing AGB stars.
Aims: We study the properties of dust grains in the detached shell around the carbon AGB star R Scl and aim to quantify the influence of the dust grain properties on the shape of the spectral energy distribution (SED) and the derived dust shell mass.
Methods: We modelled the SED of the circumstellar dust emission and compared the models to observations, including new observations of *Herschel*/PACS and SPIRE (infrared) and APEX/LABOCA (sub-millimeter). We derived present-day mass-loss rates and detached shell masses for a variation of dust grain properties (opacities, chemical composition, grain size, and grain geometry) to quantify the influence of changing dust properties to the derived shell mass.
Results: The best-fitting mass-loss parameters are a present-day dust mass-loss rate of 2×10^{-10} $M_\odot$ yr^{-1} and a detached shell dust mass of $(2.9 \pm 0.3) \times 10^{-5}$ $M_\odot$. Compared to similar studies, the uncertainty on the dust mass is reduced by a factor of 4. We find that the size of the grains dominates the shape of the SED, while the estimated dust shell mass is most strongly affected by the geometry of the dust grains. Additionally, we find a significant sub-millimeter excess that cannot be reproduced by any of the models, but is most likely not of thermal origin.

Accepted for publication in Astronomy & Astrophysics
Available from https://www.aanda.org/component/article?access=doi&doi=10.1051/0004-6361/201732065

Chemical analysis of three barium stars: HD 51959, HD 88035, HD 121447

Drisya Karinkuzhi[1], *Aruna Goswami*[1], *Navin Sridhar*[2], *Thomas Masseron*[3] *and Meenakshi Purandardas*[1]

[1]Indian Institute of Astrophysics, Koramangala, Bangalore 560034, India

[2]Indian Institute of Science Education and Research, Bhopal Bhauri, Bhopal 462066, MP, India

[3]Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK

We present elemental abundance results from high resolution spectral analysis of three nitrogen-enhanced barium stars. The analysis is based on spectra obtained with the FEROS attached to 1.52m telescope at ESO, Chile. The spectral resolution is $R \sim 48\,000$ and the spectral coverage spans from 3500–9000 Å. For the objects HD 51959 and HD 88035, we present the first time abundance analyses results. Although a few studies are available in literature on the object HD 121447, the results are significantly different from each other. We have therefore carried out a detailed chemical composition study for this object based on a high resolution spectrum with high S/N ratio, for a better understanding of the origin of the abundance patterns observed in this star. Stellar atmospheric parameters, the effective temperature, surface gravity, microturbulence and metallicity of the stars are determined from the LTE analysis using model atmospheres. The metallicity of HD 51959 and HD 88035 are found to be near-solar; they exhibit enhanced abundances of neutron-capture elements. HD 121447 is found to be moderately metal-poor with [Fe/H] $= -0.65$. While carbon is near-solar in the other two objects, HD 121447 shows carbon enhancement at a level, [C/Fe] $= 0.82$. Neutron-capture elements are highly enhanced with [X/Fe] > 2 (X: Ba, La, Pr, Nd, Sm) in this object. The α- and iron-peak elements show abundances very similar to field giants with the same metallicity. From kinematic

analysis all the three objects are found to be members of thin disk population with a high probability of 0.99, 0.99 and 0.92 for HD 51959, HD 88035 and HD 121447 respectively.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1802.01343

The planetary nebula luminosity function (PNLF): contamination from supernova remnants

Brian D. Davis[1], *Robin Ciardullo*[1], *John J. Feldmeier*[2] *and George H. Jacoby*[3]

[1]Pennsylvania State University, USA
[2]Youngstown State University, USA
[3]Lowell Observatory, USA

The planetary nebula luminosity function (PNLF) has been used as an extragalactic distance indicator since the 1980s, but there are still unsolved problems associated with its use. One of the most serious involves PNLF distances beyond ~ 10 Mpc, which tend to be slightly smaller than those of other methods. We consider the implications of previous spectroscopic investigations that found that several of the brightest planetary nebula (PN) candidates in M 74 are actually compact supernova remnants (SNRs). Using narrow-band imaging data from the KPNO 4-m telescope, we measure the [O III] $\lambda5007$ and Hα fluxes of all the known SNRs in M 31 and M 33, and test whether those objects could be misidentified as bright PNe at distances beyond ~ 10 Mpc. Our results suggest that compact SNRs are not an important source of contamination in photometric surveys for extragalactic PNe.

Published in Research Notes of the AAS
Available from https://arxiv.org/abs/1802.07185
and from http://iopscience.iop.org/article/10.3847/2515-5172/aab045

The binary dwarf carbon star SDSS J125017.90+252427.6

Bruce Margon[1], *Thomas Kupfer*[2], *Kevin Burdge*[2], *Thomas A. Prince*[2], *Shrinivas R. Kulkarni*[2] *and David L. Shupe*[2]

[1]University of California, Santa Cruz, USA
[2]Caltech and IPAC, USA

Although dwarf carbon (dC) stars are thought universally to be binaries to explain the presence of C_2 in their spectra while still near main sequence luminosity, direct observational evidence for binarity is remarkably scarce. Here we report the detection of a 2.92 d periodicity in both photometry and radial velocity of SDSS J125017.90+252427.6, an $r = 16.4$ mag dC star. This is the first photometric binary dC, and only the second dC spectroscopic binary. The relative phase of the photometric period to the spectroscopic observations suggests that the photometric variations are a reflection effect due to heating from an unseen companion. The observed radial velocity amplitude of the dC component ($K = 98.8 \pm 10.7$ km s^{-1}) is consistent with a white dwarf companion, presumably the evolved star that earlier donated the carbon to the dC, although substantial orbital evolution must have occurred. Large synoptic photometric surveys such as the Palomar Transient Factory, used for this work, may prove useful for identifying binaries among the shorter period dC stars.

Accepted for publication in The Astrophysical Journal Letters
Available from https://arxiv.org/abs/1803.01052

A high-efficiency gas target setup for underground experiments, and redetermination of the branching ratio of the 189.5 keV ^{22}Ne(p,γ)^{23}Na resonance

F. Ferraro[1,2], *M.P. Takács*[3,4], *D. Piatti*[5,6], *V. Mossa*[7,8], *M. Aliotta*[9], *D. Bemmerer*[3], *A. Best*[10], *A. Boeltzig*[11], *C. Broggini*[5], *C.G. Bruno*[9], *A. Caciolli*[5,6], *F. Cavanna*[1,2], *T. Chillery*[9], *G.F. Ciani*[11,12], *P. Corvisiero*[1,2], *L. Csedreki*[12], *T. Davinson*[9], *R. Depalo*[5,6], *G. D'Erasmo*[7,8], *A. Di Leva*[10], *Z. Elekes*[13], *E.M. Fiore*[7,8], *A. Formicola*[12], *Zs. Fülöp*[13], *G. Gervino*[14], *A. Guglielmetti*[15], *C. Gustavino*[16], *Gy. Gyürky*[13], *G. Imbriani*[10], *M. Junker*[12], *I. Kochanek*[12], *M. Lugaro*[17], *L.E. Marcucci*[18], *P. Marigo*[5,6], *R. Menegazzo*[5], *F.R. Pantaleo*[7,8], *V. Paticchio*[8], *R. Perrino*[8], *P. Prati*[1,2], *L. Schiavulli*[7,8], *K. Stöckel*[3,4], *O. Straniero*[19], *T. Szücs*[13], *D. Trezzi*[15] *and S. Zavatarelli*[2]

[1]Dipartimento di Fisica, Università degli Studi di Genova, Genova, Italy
[2]INFN, Sezione di Genova, Genova, Italy
[3]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany
[4]Technische Universität Dresden, Dresden, Germany
[5]INFN, Sezione di Padova, Padova, Italy
[6]Dipartimento di Fisica e Astronomia, Università di Padova, Padova, Italy
[7]Dipartimento Interateneo di Fisica "Michelangelo Merlin", Università degli Studi di Bari, Bari, Italy
[8]INFN, Sezione di Bari, Bari, Italy
[9]SUPA, School of Physics and Astronomy, University of Edinburgh, Edinburgh, UK
[10]Dipartimento di Fisica "E. Pancini", Università di Napoli Federico II and INFN, Sezione di Napoli, Strada Comunale Cinthia, 80126 Napoli, Italy
[11]Gran Sasso Science Institute, L'Aquila, Italy
[12]INFN, Laboratori Nazionali del Gran Sasso, Assergi, Italy
[13]Institute of Nuclear Research (MTA Atomki), Debrecen, Hungary
[14]Dipartimento di Fisica, Università di Torino, and INFN Sezione di Torino, Torino, Italy
[15]Università degli Studi di Milano and INFN, Sezione di Milano, Milano, Italy
[16]INFN, Sezione di Roma "La Sapienza", Roma, Italy
[17]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, 1121 Budapest, Hungary
[18]Dipartimento di Fisica "E. Fermi", Università di Pisa, and INFN, Sezione di Pisa, Pisa, Italy
[19]INAF Osservatorio Astronomico di Teramo, Via Mentore Maggini, 64100 Teramo, Italy

The experimental study of nuclear reactions of astrophysical interest is greatly facilitated by a low-background, high-luminosity setup. The Laboratory for Underground Nuclear Astrophysics (LUNA) 400 kV accelerator offers ultra-low cosmic-ray induced background due to its location deep underground in the Gran Sasso National Laboratory (INFN–LNGS), Italy, and high intensity, 250–500 μA, proton and α ion beams. In order to fully exploit these features, a high-purity, recirculating gas target system for isotopically enriched gases is coupled to a high-efficiency, six-fold optically segmented bismuth germanate (BGO) γ-ray detector. The beam intensity is measured with a beam calorimeter with constant temperature gradient. Pressure and temperature measurements have been carried out at several positions along the beam path, and the resultant gas density profile has been determined. Calibrated γ-intensity standards and the well-known E_p = 278 keV ^{14}N(p,γ)^{15}O resonance were used to determine the γ-ray detection efficiency and to validate the simulation of the target and detector setup. As an example, the recently measured resonance at E_p = 189.5 keV in the ^{22}Ne(p,γ)^{23}Na reaction has been investigated with high statistics, and the γ-decay branching ratios of the resonance have been determined.

Accepted for publication in Eur. Phys. J. A, 54, 44 (2018)
Available from https://arxiv.org/abs/1802.04164

High-resolution observations of IRAS 08544−4431. Detection of a disk orbiting a post-AGB star and of a slow disk wind

V. Bujarrabal[1], *A. Castro-Carrizo*[2], *H. Van Winckel*[3], *J. Alcolea*[4], *C. Sánchez Contreras*[5], *M. Santander-García*[4] *and M. Hillen*[3]

[1]Observatorio Astronómico Nacional (OAN–IGN), Alcalá de Henares, Spain; v.bujarrabal@oan.es

[2]IRAM, Grenoble, France

[3]Instituut voor Sterrenkunde, K.U. Leuven, Leuven, Belgium

[4]Observatorio Astronómico Nacional (OAN–IGN), Madrid, Spain

[5]Centro de Astrobiología (CSIC–INTA), Torrejón de Ardoz, Spain

We are studying a class of binary post-AGB stars that seem to be systematically surrounded by equatorial disks and slow outflows. Although the rotating dynamics had only been well identified in three cases, the study of such structures is thought to be fundamental to the understanding of the formation of disks in various phases of the late evolution of binary stars and the ejection of planetary nebulæ from evolved stars.
We present ALMA maps of ^{12C}O and ^{13}CO $J = 3$–2 lines in the source IRAS 08544−4431, which belongs to the above mentioned class of objects. We analyzed the data by means of nebula models, which account for the expectedly composite source and can reproduce the data. From our modeling, we estimated the main nebula parameters, including the structure and dynamics and the density and temperature distributions. We discuss the uncertainties of the derived values and, in particular, their dependence on the distance.
Our observations reveal the presence of an equatorial disk in rotation; a low-velocity outflow is also found, probably formed of gas expelled from the disk. The main characteristics of our observations and modeling of IRAS 08544−4431 are similar to those of better studied objects, confirming our interpretation. The disk rotation indicates a total central mass of about 1.8 $M_\odot$, for a distance of 1100 pc. The disk is found to be relatively extended and has a typical diameter of $\sim 4 \times 10^{16}$ cm. The total nebular mass is $\sim 2 \times 10^{-2}$ $M_\odot$, of which $\sim$ 90% corresponds to the disk. Assuming that the outflow is due to mass loss from the disk, we derive a disk lifetime of $\sim$ 10 000 yr. The disk angular momentum is found to be comparable to that of the binary system at present. Assuming that the disk angular momentum was transferred from the binary system, as expected, the high values of the disk angular momentum in this and other similar disks suggest that the size of the stellar orbits has significantly decreased as a consequence of disk formation.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1802.04019

Formation and evolution of hybrid He–CO white dwarfs and their properties

Yossef Zenati [1], *Silvia Toonen* [2] *and Hagai B. Perets* [1]

[1]Physics Department, Technion – Israel Institute of Technology, Haifa 3200004, Israel

[2]Anton Pannekoek Institute for Astronomy, University of Amsterdam, 1090 GE, Amsterdam, The Netherlands

White dwarfs (WDs) are the stellar core remnants of low mass ($\sim$ 8 $M_\odot$) stars. They are typically divided into three main composition groups: Oxygen–Neon (ONe), Carbon–Oxygen (CO) and Helium (He) WDs. The evolution of binary systems can significantly change the evolution of the binary stellar components. In particular, striping the envelope of an evolved star can give rise to a core remnant, which can later evolve into a WD with significantly different composition. Here we focus on the formation and evolution of hybrid HeCO WDs. We follow the formation and stellar evolution of such WDs for a range of initial conditions and provide their detailed structure, mass-radius relation and luminousity–temperature evolution. We find that both low-mass WDs (< 0.45 $M_\odot$, typically thought to be He–WDs) and intermediate-mass WDs ($0.45 < M_{\rm WD}/M_\odot \leq 0.7$, typically thought to be CO–WDs) could in fact be hybrid HeCO WDs, with 5–25(75–95)% of their mass in He (CO). We use population synthesis calculations to infer the birth rate and properties of such WDs. We find that hybrid HeCO–WD comprise the majority of young (< 2 Gyr) WDs in binaries, but are more rare among older WDs in binaries. The high frequency and large He content of such WDs could have an important role in WD–WD mergers, and may give rise to sub-Chandrasekhar thermonuclear supernova explosions.

Submitted to MNRAS
Available from https://arxiv.org/abs/1803.04444

Widespread HCN maser emission in carbon-rich evolved stars

K.M. Menten[1], *F. Wyrowski*[1], *D. Keller*[1,2] *and T. Kamiński*[3]

[1]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[2]Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[3]Harvard–Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

Context: HCN is a major constituent of the circumstellar envelopes of carbon-rich evolved stars, and rotational lines from within its vibrationally excited states probe parts of these regions closest to the stellar surface. A number of such lines are known to show maser action. Historically, in one of them, the 177 GHz $J = 2 \rightarrow 1$ line in the l-doubled bending mode has been found to show relatively strong maser action, with results only published for a single object, the archetypical high-mass loss asymptotic giant branch (AGB) star IRC +10°216.
Aims: To examine how common 177 GHz HCN maser emission is, we conducted an exploratory survey for this line toward a select sample of carbon-rich asymptotic giant branch stars that are observable from the southern hemisphere.
Methods: We used the Atacama Pathfinder Experiment 12 meter submillimeter Telescope (APEX) equipped with a new receiver to simultaneously observe three $J = 2 \rightarrow 1$ HCN rotational transitions, the $(0, 1^{1^c}, 0)$ and $(0, 1^{1^d}, 0)$ l-doublet components, and the line from the (0,0,0) ground state.
Results: The $(0, 1^{1^c}, 0)$ maser line is detected toward 11 of 13 observed sources, which all show emission in the (0,0,0) transition. In most of the sources, the peak intensity of the $(0, 1^{1^c}, 0)$ line rivals that of the (0,0,0) line; in two sources, it is even stronger. Except for the object with the highest mass-loss rate, IRC +10°216, the $(0, 1^{1^c}, 0)$ line covers a smaller velocity range than the (0,0,0) line.
Conclusions: Maser emission in the 177 GHz $J = 2 \rightarrow 1$ $(0, 1^{1^c}, 0)$ line of HCN appears to be common in carbon-rich AGB stars. (Abbreviated)

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1803.00943

ALMA detection of a tentative nearly edge-on rotating disk around the nearby AGB star R Doradus

Ward Homan[1], *Taissa Danilovich*[1], *Leen Decin*[1], *Alex de Koter*[1,2], *Joseph Nuth*[3] *and Marie Van de Sande*[1]

[1]Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D B2401, 3001 Leuven, Belgium
[2]Sterrenkundig Instituut 'Anton Pannekoek', Science Park 904, 1098 XH Amsterdam, The Netherlands
[3]NASA Goddard Space Flight Center, Code 690, Greenbelt MD 20771, USA

A spectral scan of the circumstellar environment of the asymptotic giant branch (AGB) star R Doradus was taken with ALMA in cycle 2 at frequencies between 335 and 362 GHz and with a spatial resolution of $\sim$ 150 milliarcseconds. Many molecular lines show a spatial offset between the blue and red shifted emission in the innermost regions of the wind. The position–velocity diagrams of this feature, in combination with previous SPHERE data and theoretical work point towards the presence of a compact differentially rotating disk, orientated nearly edge-on. We model the ^{28}SiO ($v = 1$, $J = 8 \rightarrow 7$) emission with a disk model. We estimate the disk mass and angular momentum to be 3×10^{-6} M$_\odot$ and 5×10^{40} m^2 kg s^{-1}. The latter presents an 'angular momentum problem' that may be solved by assuming that the disk is the result of wind-companion interactions with a companion of at least 2.5 Earth masses, located at 6 au, the tentatively determined location of the disk's inner rim. An isolated clump of emission is detected to the south-east with a velocity that is high compared to the previously determined terminal velocity of the wind. Its position and mean velocity suggest that it may be associated with a companion planet, located at the disk's inner rim.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/1803.06207

Turbulence closure for mixing length theories

Adam S. Jermyn[1], *Pierre Lesaffre*[2], *Christopher A. Tout*[1] *and Shashikumar M. Chitre*[1,3]

[1]Institute of Astronomy, University of Cambridge, Madingley Rd., Cambridge CB3 0HA, UK

[2]École Normale Supérieure 24 rue Lhomond, 75231 Paris, France

[3]Centre for Basic Sciences, University of Mumbai, India

We present an approach to turbulence closure based on mixing length theory with three-dimensional fluctuations against a two-dimensional background. This model is intended to be rapidly computable for implementation in stellar evolution software and to capture a wide range of relevant phenomena with just a single free parameter, namely the mixing length. We incorporate magnetic, rotational, baroclinic and buoyancy effects exactly within the formalism of linear growth theories with nonlinear decay. We treat differential rotation effects perturbatively in the co-rotating frame using a novel controlled approximation which matches the time evolution of the reference frame to arbitrary order. We then implement this model in an efficient open source code and discuss the resulting turbulent stresses and transport coefficients. We demonstrate that this model exhibits convective, baroclinic and shear instabilities as well as the magneto-rotational instability (MRI). It also exhibits non-linear saturation behaviour, and we use this to extract the asymptotic scaling of various transport coefficients in physically interesting limits.

Published in Monthly Notices of the Royal Astronomical Society, 476, 646 (2018)
Available from https://arxiv.org/abs/1803.00579
and from https://github.com/adamjermyn/Mixer

Flickering in AGB stars: probing the nature of accreting companions

S. Snaid [1,2], *A.A. Zijlstra*[1], *I. McDonald*[1], *Helen Barker*[1], *T.R. Marsh*[3] *and V.S. Dhillon*[4,5]

[1]Jodrell Bank Centre for Astrophysics, School of Physics & Astronomy, University of Manchester Oxford Road, Manchester M13 9PL, UK

[2]Astronomy Department, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia

[3]Department of Physics, University of Warwick, Gibbet Hill Road, Coventry, CV4 7AL, UK

[4]Department of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, UK

[5]Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain

Binary companions to asymptotic giant branch (AGB) stars are an important aspect of their evolution. Few AGB companions have been detected, and in most cases it is difficult to distinguish between main-sequence and white dwarf companions. Detection of photometric flickering, a tracer of compact accretion disks around white dwarfs, can help identify the nature of these companions. In this work, we searched for flickering in four AGB stars suggested to have likely accreting companions. We found no signs for flickering in two targets: R Aqr and V1016 Cyg. Flickering was detected in the other two stars: Mira and Y Gem.We investigated the true nature of Mira's companion using three different approaches. Our results for Mira strongly suggest that its companion is a white dwarf.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1803.04338

Extremely ^{54}Cr- and ^{50}Ti-rich presolar oxide grains in a primitive meteorite: Formation in rare types of supernovæ and implications for the astrophysical context of solar system birth

Larry R. Nittler[1], *Conel M.O'D. Alexander*[1], *Nan Liu*[1] *and Jianhua Wang*[1]

[1]Carnegie Institution of Washington, USA

We report the identification of 19 presolar oxide grains from the Orgueil CI meteorite with substantial enrichments in ^{54}Cr, with ^{54}Cr/^{52}Cr ratios ranging from 1.2 to 56 times the solar value. The most enriched grains also exhibit enrichments at mass 50, most likely due in part to ^{50}Ti, but close-to-normal or depleted ^{53}Cr/^{52}Cr ratios. There is a strong inverse relationship between ^{54}Cr enrichment and grain size; the most extreme grains are all < 80 nm in diameter. Comparison of the isotopic data with predictions of nucleosynthesis calculations indicate that these grains most likely originated in either rare, high-density Type Ia supernovæ (SNIa), or in electron-capture supernovæ (ECSN) which may occur as the end stage of evolution for stars of mass 8–10 $M_{\odot}$. This is the first evidence for preserved presolar grains from either type of supernova. An ECSN origin is attractive since these likely occur much more frequently than high-density SNIa, and their evolutionary timescales ($\sim$ 20 Myr) are comparable to those of molecular clouds. Self-pollution of the Sun's parent cloud from an ECSN may explain the heterogeneous distribution of n-rich isotopic anomalies in planetary materials, including a recently reported dichotomy in Mo isotopes in the solar system. The stellar origins of three grains with solar ^{54}Cr/^{52}Cr, but anomalies in ^{50}Cr or ^{53}Cr, as well as of a grain enriched in ^{57}Fe, are unclear.

Accepted for publication in Astrophysical Journal Letters
Available from https://arxiv.org/abs/1803.04286

Why are peculiar Type Ia supernovæ more likely to show the signature of a single-degenerate model?

Xiangcun Meng[1] *and Zhanwen Han*[1]

[1]Yunnan Observatories, CAS, China

Although type Ia supernovæ (SNe Ia) are very useful in many astrophysical fields, their exact progenitor nature is still unclear. A basic method to distinguish the different progenitor models is to search the signal from the single-degenerate (SD) model, e.g., the signal for the existence of a non-degenerate companion before or after supernova explosion. Observationally, some SNe Ia show such signals, while the others do not. Here, we propose a universal model to explain these observations based on the spin-up/spin-down model, in which a white dwarf (WD) will experience a spin-down phase before supernova explosion, and the spin-down timescale is determined by its initial mass, i.e., the more massive the initial WD, the shorter the spin-down timescale and then the more likely the SN Ia is to show the SD signature. Therefore, our model predicts that the SNe Ia from hybrid carbon–oxygen–neon WDs are more likely to show the SD signature observationally, as some peculiar SNe Ia showed.

Published in ApJ, 855, L18 (2018)
Available from https://arxiv.org/abs/1802.10231

Evolving ONe WD+He star systems to intermediate-mass binary pulsars

Dongdong Liu[1,2,3]*, Bo Wang*[1,2,3]*, Wencong Chen*[4]*, Zhaoyu Zuo*[5] *and Zhanwen Han*[1,2,3]

[1]Key Laboratory for the Structure and Evolution of Celestial Objects, Yunnan Observatories, Chinese Academy of Sciences, Kunming 650216, China

[2]University of Chinese Academy of Sciences, Beijing 100049, China

[3]Center for Astronomical Mega-Science, Chinese Academy of Sciences, Beijing 100012, China

[4]School of Physics and Electrical Information, Shangqiu Normal University, Shangqiu 476000, China

[5]School of Science, Xi'an Jiaotong University, Xi'an 710049, China

It has been suggested that accretion-induced collapse (AIC) is a non-negligible path for the formation of the observed neutron stars (NSs). An ONe white dwarf (WD) that accretes material from a He star may experience AIC process and eventually produce intermediate-mass binary pulsars (IMBPs), named as the ONe WD+He star scenario. Note that previous studies can only account for part of the observed IMBPs with short orbital periods. In this work, we investigate the evolution of about 900 ONe WD+He star binaries to explore the distribution of IMBPs. We found that

the ONe WD+He star scenario could form IMBPs including pulsars with 5–340 ms spin periods and 0.75–1.38 $M_\odot$ WD companions, in which the orbital periods range from 0.04 to 900 d. Compared with the 20 observed IMBPs, this scenario can cover the parameters of 13 sources in the final orbital period–WD mass plane and the Corbet diagram, most of which has short orbital periods. We found that the ONe WD+He star scenario can explain almost all the observed IMBPs with short orbital periods. This work can well match the observed parameters of PSR J1802−2124 (one of the two precisely observed IMBPs), providing a possible evolutional path for its formation. We also speculate that the compact companion of HD 49798 (a hydrogen depleted sdO6 star) may be not a NS based on the present work.

Published in MNRAS
Available from https://arxiv.org/abs/1802.09804
and from https://doi.org/10.1093/mnras/sty561

Case A and B evolution towards electron capture supernova

L. Siess[1,2] *and U. Lebreuilly*[1]

[1]Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles (ULB), CP 226, B-1050 Brussels, Belgium
[2]Max-Planck-Institut für Astrophysik, Karl Schwarzschild Str. 1, 85741 Garching bei München, Germany

Context: Most super AGB stars are expected to end their life as oxygen–neon white dwarfs rather than electron capture supernovæ (ECSN). The reason is ascribed to the ability of the second dredge-up to significantly reduce the mass of the He core and of the efficient AGB winds to remove the stellar envelope before the degenerate core reaches the critical mass for the activation of electron capture reactions.
Aims: In this study, we investigate the formation of ECSN through case A and case B mass transfer. In these scenarios, when Roche lobe overflow stops, the primary has become a helium star. With a small envelope left, the second dredge-up is prevented, potentially opening new paths to ECSN.
Methods: We compute binary models using our stellar evolution code BINSTAR. We consider three different secondary masses of 8, 9, and 10 $M_\odot$ and explore the parameter space, varying the companion mass, orbital period, and input physics.
Results: Assuming conservative mass transfer, with our choice of secondary masses all case A systems enter contact either during the main sequence or as a consequence of reversed mass transfer when the secondary overtakes its companion during core helium burning. Case B systems are able to produce ECSN progenitors in a relatively small range of periods ($3 \lesssim P(\mathrm{d}) \lesssim 30$) and primary masses ($10.9 \leq M/M_\odot \leq 11.5$). Changing the companion mass has little impact on the primary's fate as long as the mass ratio M_1/M_2 remains less than 1.4–1.5, above which evolution to contact becomes unavoidable. We also find that allowing for systemic mass loss substantially increases the period interval over which ECSN can occur. This change in the binary physics does not however affect the primary mass range. We finally stress that the formation of ECSN progenitors through case A and B mass transfer is very sensitive to adopted binary and stellar physics.
Conclusions: Close binaries provide additional channels for ECSN but the parameter space is rather constrained likely making ECSN a rare event.

Accepted for publication in A&A
Available from http://www.astro.ulb.ac.be/∼siess/News

A new 3D maser code applied to flaring events

M.D. Gray[1], *L. Mason*[1,2] *and S. Etoka*[1]

[1]Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, M13 9PL, UK
[2]Pendleton Sixth Form Centre, Salford City College, M6 7FR, UK

We set out the theory and discretization scheme for a new finite-element computer code, written specifically for the

simulation of maser sources. The code was used to compute fractional inversions at each node of a 3-D domain for a range of optical thicknesses. Saturation behaviour of the nodes with regard to location and optical depth were broadly as expected. We have demonstrated via formal solutions of the radiative transfer equation that the apparent size of the model maser cloud decreases as expected with optical depth as viewed by a distant observer. Simulations of rotation of the cloud allowed the construction of light-curves for a number of observable quantities. Rotation of the model cloud may be a reasonable model for quasi-periodic variability, but cannot explain periodic flaring.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1803.01625

Chemical abundances of main-sequence, turnoff, subgiant, and red giant stars from APOGEE spectra I: signatures of diffusion in the open cluster M 67

Diogo Souto[1], Katia Cunha[1,2], Verne V. Smith[3], C. Allende Prieto[3,4], D.A. García-Hernández[3,4], Marc Pinsonneault[6], Parker Holzer[7], Peter Frinchaboy[8], Jon Holtzman[9], J.A. Johnson[6], Henrik Jönsson[10], Steven R. Majewski[11], Matthew Shetrone[12], Jennifer Sobeck[11], Guy Stringfellow[13], Johanna Teske[14], Olga Zamora[4,3], Gail Zasowski[7], Ricardo Carrera[15], Keivan Stassun[16], J.G. Fernandez-Trincado[17,18], Sandro Villanova[17], Dante Minniti[19] and Felipe Santana[20]

[1]Observatório Nacional, Rua General José Cristino, 77, 20921-400 São Cristóvão, Rio de Janeiro, RJ, Brazil
[2]Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721-0065, USA
[3]National Optical Astronomy Observatory, 950 North Cherry Avenue, Tucson, AZ 85719, USA
[4]Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain
[5]Departamento de Astrofísica, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain
[6]Department of Astronomy, The Ohio State University, Columbus, OH 43210, USA
[7]Department of Physics and Astronomy, The University of Utah, Salt Lake City, UT 84112, USA
[8]Department of Physics & Astronomy, Texas Christian University, Fort Worth, TX 76129, USA
[9]New Mexico State University, Las Cruces, NM 88003, USA
[10]Lund Observatory, Department of Astronomy and Theoretical Physics, Lund University, Box 43, SE-221 00 Lund, Sweden
[11]Department of Astronomy, University of Virginia, Charlottesville, VA 22904-4325, USA
[12]University of Texas at Austin, McDonald Observatory, USA
[13]Center for Astrophysics and Space Astronomy, Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, CO 80309, USA
[14]Department of Terrestrial Magnetism, Carnegie Institution for Science, Washington, DC 20015, USA
[15]INAF–Osservatorio Astronomico di Padova, Padova, Italy
[16]Department of Physics and Astronomy, Vanderbilt University, VU Station 1807, Nashville, TN 37235, USA
[17]Departamento de Astronomía, Universidad de Concepción, Casilla 160-C, Concepción, Chile
[18]Institut Utinam, CNRS UMR6213, Univ. Bourgogne Franche-Comté, OSU THETA, Observatoire de Besançon, BP 1615, F-25010 Besançon Cedex, France
[19]Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, 782-0436 Macul, Santiago, Chile
[20]Universidad de Chile, Av. Libertador Bernardo O'Higgins 1058, Santiago de Chile, Chile

Detailed chemical abundance distributions for fourteen elements are derived for eight high-probability stellar members of the solar metallicity old open cluster M 67 with an age of $\sim$ 4 Gyr. The eight stars consist of four pairs, with each pair occupying a distinct phase of stellar evolution: two G-dwarfs, two turnoff stars, two G-subgiants, and two red clump K-giants. The abundance analysis uses near-IR high-resolution spectra (λ1.5–1.7 μm) from the APOGEE survey and derives abundances for C, N, O, Na, Mg, Al, Si, K, Ca, Ti, V, Cr, Mn, and Fe. Our derived stellar parameters and metallicity for 2M08510076+113115 suggest that this star is a solar-twin, exhibiting abundance differences relative to the Sun of $\leq$ 0.04 dex for all elements. Chemical homogeneity is found within each class of stars ($\sim$ 0.02 dex), while significant abundance variations ($\sim$ 0.05–0.20 dex) are found across the different evolutionary phases; the turnoff stars typically have the lowest abundances, while the red clump tend to have the largest. Non-LTE corrections to the LTE-derived abundances are unlikely to explain the differences. A detailed comparison of the derived Fe, Mg, Si, and Ca abundances with recently published surface abundances from stellar models that include chemical diffusion, provides a good match between the observed and predicted abundances as a function of stellar mass. Such agreement would indicate the detection of chemical diffusion processes in the stellar members of M 67.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1803.04461

Further insight on the hypervelocity white dwarf, LP 40−365 (GD 492): a nearby emissary from a single-degenerate Type Ia supernova

R. Raddi[1], *M.A. Hollands*[1], *D. Koester*[2], *B.T. Gänsicke*[1], *N.P. Gentile Fusillo*[1], *J.J. Hermes*[3] *and D.M. Townsley*[4]

[1]University of Warwick, UK
[2]University of Kiel, Germany
[3]University of North Carolina – Chapel Hill, USA
[4]University of Alabama, USA

The recently discovered hypervelocity white dwarf LP 40−65 (aka GD 492) has been suggested as the outcome of the failed disruption of a white dwarf in a sub-luminous Type Ia supernova (SN Ia). We present new observations confirming GD 492 as a single star with unique spectral features. Our spectroscopic analysis suggests that a helium-dominated atmosphere, with ~ 33 percent neon and 2 percent oxygen by mass, can reproduce most of the observed properties of this highly unusual star. Although our atmospheric model contrasts with the previous analysis in terms of dominant atmospheric species, we confirm that the atmosphere of GD 492 is strongly hydrogen deficient, $\log(\mathrm{H/He}) < -5$, and displays traces of eleven other α- and iron-group elements (with sulfur, chromium, manganese, and titanium as new detections), indicating nuclear processing of carbon and silicon. We measure a manganese-to-iron ratio seven times larger than Solar. While the observed abundances of GD 492 do not fully match any predicted nuclear yields of a partially-burned supernova remnant, the manganese excess strongly favors a link with a single-degenerate SN Ia event over alternative scenarios.

Accepted for publication in The Astrophysical Journal
Available from https://arxiv.org/abs/1803.07564

Ion implantation in nanodiamonds: size effect and energy dependence

A.A. Shiryaev[1,2], *J.A. Hinks*[3], *N.A. Marks*[4], *G. Greaves*[3], *F.J. Valencia*[5,6,7], *S.E. Donnely*[3], *R.I. González*[7,8], *M. Kiwi*[6,7], *A.L. Trigub*[9], *E.M. Bringa*[10,11], *J.L. Fogg*[4] *and I.I. Vlasov*[12,13]

[1]Frumkin Institute of Physical Chemistry and Electrochemistry RAS, Leninsky pr. 31 korp. 4, Moscow 119071, Russia. Tel. +7 495 9554664
[2]Chemistry Dept., Lomonosov Moscow State University, Moscow, Russia
[3]University of Huddersfield, Queensgate, Huddersfield, HD1 3DH, United Kingdom
[4]Dept. of Physics and Astronomy, Curtin University, Perth, Australia
[5]Núcleo de Matemáticas, Física y Estadística, Facultad de Ciencias, Universidad Mayor, Chile
[6]Departamento de Física, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile
[7]Centro para el Desarrollo de la Nanociencia y la Nanotecnología, CEDENNA, Avda. Ecuador 3493, Santiago, Chile 9170124
[8]Centro de Nanotecnología Aplicada, Facultad de Ciencias, Universidad Mayor, Camino La Pirámide 5750, Huechuraba, Santiago
[9]National Research Center Kurchatov Institute, Moscow, Russia
[10]Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, Mendoza 5500, Argentina
[11]CONICET, Argentina
[12]General Physics Institute RAS, Vavilova St. 38, Moscow, Russia
[13]National Research Nuclear University MEPhI, Moscow, 115409, Russia

Nanoparticles are ubiquitous in nature and are increasingly important for technology. They are subject to bombardment by ionizing radiation in a diverse range of environments. In particular, nanodiamonds represent a variety of nanoparticles of significant fundamental and applied interest. Here we present a combined experimental and computational study of the behaviour of nanodiamonds under irradiation by xenon ions. Unexpectedly, we observed a pronounced size effect on the radiation resistance of the nanodiamonds: particles larger than 8 nm behave similarly to macroscopic diamond (i.e. characterized by high radiation resistance) whereas smaller particles can be completely destroyed by a single impact from an ion in a defined energy range. This latter observation is explained by extreme heating of the nanodiamonds by the penetrating ion. The obtained results are not limited to nanodiamonds, making them of interest for several fields, putting constraints on processes for the controlled modification of nanodiamonds, on the survival of dust in astrophysical environments, and on the behaviour of actinides released from nuclear waste into the environment.

Published in Scientific reports
Available from https://arxiv.org/abs/1803.09081
and from DOI: 10.1038/s41598-018-23434-y

Conference Papers

Impacts of nuclear-physics uncertainties in the *s*-process determined by Monte-Carlo variations

N. Nishimura[1], *G. Cescutti*[2], *R. Hirschi*[3,4], *T. Rauscher*[5,6], *J. den Hartogh*[3] *and A.St.J. Murphy*[7]

[1]YITP, Kyoto University, Japan
[2]INAF, Osservatorio Astronomico di Trieste, Italy
[3]Astrophysics Group, Keele University, UK
[4]Kavli IPMU (WPI), University of Tokyo, Japan
[5]Department of Physics, University of Basel, Switzerland
[6]Centre for Astrophysical Research, University of Hertfordshire, UK
[7]School of Physics and Astronomy, University of Edinburgh, UK

The *s*-process, a production mechanism based on slow-neutron capture during stellar evolution, is the origin of about half the elements heavier than iron. Abundance predictions for *s*-process nucleosynthesis depend strongly on the relevant neutron-capture and β-decay rates, as well as on the details of the stellar model being considered. Here, we have used a Monte-Carlo approach to evaluate the nuclear uncertainty in *s*-process nucleosynthesis. We considered the helium burning of massive stars for the weak *s*-process and low-mass asymptotic-giant-branch stars for the main *s*-process. Our calculations include a realistic and general prescription for the temperature dependent uncertainty for the reaction cross sections. We find that the adopted uncertainty for (n,γ) rates, tens of per cent on average, effects the production of *s*-process nuclei along the line of β-stability, and that the uncertainties in β-decay from excited state contributions, has the strongest impact on branching points.

Oral contribution, published in the 2017 Symposium on Nuclear Data
Available from https://arxiv.org/abs/1802.05836

Stellar evolution research in the far-IR in the AKARI era and beyond

Toshiya Ueta[1]

[1]University of Denver, USA

At the turn of the 21st century, we enjoyed a renaissance of far-IR astronomy because of the coming of the next generation of far-IR satellites, *Spitzer*, AKARI, and *Herschel*. Here, we quickly summarize outcomes of the stellar evolution research done using far-IR data taken these space telescopes, especially those that are based on imaging

of the evolved star circumstellar shells. Also, we briefly outline what to be done using the next generation of far-IR telescopes.

Oral contribution, published in "The Cosmic Wheel and the Legacy of the AKARI archive: from galaxies and stars to planets and life", a conference held at the University of Tokyo, Tokyo Japan October 17–20, 2017
Available from https://repository.exst.jaxa.jp/dspace/handle/a-is/874005

Flux calibration of point and extended sources in the AKARI far-IR all-sky survey maps

Toshiya Ueta[1], Ryszard Szczerba[2], Andrew Fullard[1] and Satoshi Takita[3]

[1]University of Denver, USA

[2]Nicolaus Copernicus Astronomical Centre, PAS, Poland

[3]ISAS/JAXA, Japan

The AKARI Infrared Astronomical Satellite produced the far-IR all-sky survey (AFASS) maps at roughly arc-minute spatial resolution with its Far-IR Surveyor (FIS) instrument. The AFASS maps enable us to probe the whole sky for sources having far-IR surface brightnesses higher than a few to a couple of dozen MJy sr^{-1}. While the AFASS maps are absolutely calibrated against large-scale diffuse background emission, it is uncertain whether or not an additional flux correction is necessary for small-scale compact and point sources. Here, we verify that point-source photometry reproduces fluxes in the AKARI-FIS bright source catalogue (BSC) as long as the aperture correction based on the empirical point-spread-function profiles of the AFASS maps is applied. This means that far-IR photometry of any source can be done from the AFASS maps by summing surface brightness pixel values within an appropriately-defined perimeter of the target source.

Poster contribution, published in "The Cosmic Wheel and the Legacy of the AKARI archive: from galaxies and stars to planets and life", a conference held at the University of Tokyo, Tokyo Japan October 17–20, 2017
Available from https://repository.exst.jaxa.jp/dspace/handle/a-is/874005

Announcement

ESO Workshop: A revolution in stellar physics with Gaia and large surveys

Third Announcement:
September 3–7, 2018, Warsaw, Poland
contact: revolution@camk.edu.pl

The workshop will focus on discussions about the advances in our understanding of stellar physical processes made possible by combining the exquisite astrometry and photometry of Gaia with data of other large photometric, spectroscopic, and asteroseismic stellar surveys. These combined data will permit detailed studies of stellar physics to a level that is unprecedented in the history of stellar astrophysics.

REGISTRATION and ABSTRACT SUBMISSION:

The deadline for registration and abstract submission (for contributed talks & posters) is **April 15, 2018**. Please, notice that these are two separated processes. Do not forget to do both of them.

Registration fee is 1050 PLN ($\sim$ 250 EUR) for payment before June 1, 2018. Notification of talk selection is expected by mid-May.

As the space available in the venue is limited, payment of the registration fee in advance is the only form of guaranteeing your attendance.

FINANCIAL SUPPORT:

We can offer partial financial support for a small number of early-career researchers (PhD students and young post-docs). A justification for the financial request has to be sent together with the registration by the same deadline of April 15, 2018.

Abstract submission is mandatory if you are applying for support. Only those presenting work will be considered for support. Notification of financial support is expected by mid-May.

TOPICS:

- Accuracy of stellar models
- Binaries and multiple stars
- Gaia and stellar physics
- Low- and high-mass stars
- Mixing processes
- Observational tests of stellar evolution
- Ongoing and future stellar surveys
- Stars in all evolutionary stages (pre-main sequence to white dwarf regime)
- Stellar ages
- Stellar clusters
- Stellar variability

INVITED SPEAKERS:

- Carine Babusiaux (Université Grenoble Alpes, France);
- Maria Bergemann (Max-Planck Institute for Astronomy, Germany);
- Corinne Charbonnel (Geneva Observatory, Switzerland);
- Kevin Covey (Western Washington University, USA);
- Laurent Eyer (University of Geneva, Switzerland);
- Gregory Feiden (University of North Georgia, USA);
- Boris Gänsicke (University of Warwick, UK);
- Léo Girardi (Padova Observatory, Italy);
- Lynne Hillenbrand (Caltech, USA);
- Daniel Huber (University of Hawai'i, USA);
- Amanda Karakas (Monash University, Australia);

- Andreas Korn (Uppsala University, Sweden);
- Marco Limongi (Rome Observatory, Italy);
- Tim Naylor (University of Exeter, UK);
- Igor Soszyński (University of Warsaw, Poland);
- Silvia Toonen (University of Amsterdam, The Netherlands).

SOC: Sylvia Ekström (Geneva Observatory, Switzerland); Gerald Handler (CAMK, Poland); Gaitee Hussain (ESO Garching); Scilla Degl'Innocenti (University of Pisa, Italy); Rob Jeffries (Keele University, UK); Danny Lennon (ESA); Andrea Miglio (University of Birmingham, UK); Luca Pasquini (ESO Garching); Sofia Randich (INAF/Arcetri, Italy); Rodolfo Smiljanic (CAMK, Poland); Andrzej Udalski (University of Warsaw, Poland).

See also https://indico.camk.edu.pl/e/revolution