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. 240 — 1 July 2017

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Figure 1: The planetary nebula Kronberger 24 in Hα and [O III]. It is round! Thanks to Sakib Rasool for suggesting. See http://www.cxielo.ch/gallery/f/kn24 for more details.

Editorial

Dear Colleagues,

It is a pleasure to present you the 240$^{\text{th}}$ issue of the AGB Newsletter.

Please consider John Lattanzio's 60$^{\text{th}}$ birthday party – something not to be missed!

Note also the possible opportunity to join a large programme with the James Clerk Maxwell Telescope.

The next issue is planned to be distributed sometime in August – African animals willing.

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

Food for Thought

This month's thought-provoking statement is:

Stars grow when they lose (mass)

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

A SOFIA FORCAST grism study of the mineralogy of dust in the winds of proto-planetary nebulæ: RV Tauri stars and SRd variables

R.A. Arneson[1], *R.D. Gehrz*[1], *C.E. Woodward*[1], *L.A. Helton*[2], *D. Shenoy*[1], *A. Evans*[3], *L.D.Keller*[4], *K.H. Hinkle*[5], *M. Jura*[6], *T. Lebzelter*[7], *C.M. Lisse*[8], *M.T. Rushton*[9] *and J. Mizrachi*[10]

[1]Minnesota Institute for Astrophysics, USA
[2]USRA–SOFIA Science Center, USA
[3]Astrophysics Group, Keele University, UK
[4]Ithaca College, NY, USA
[5]NOAO, USA
[6]University of California, USA
[7]Institute for Astrophysics, University of Vienna, Austria
[8]Solar System Exploration, Johns Hopkins University, USA
[9]Astronomical Institute of the Romanian Academy, Romania
[10]Stony Brook University, NY, USA

We present a SOFIA FORCAST grism spectroscopic survey to examine the mineralogy of the circumstellar dust in a sample of post-asymptotic giant branch yellow supergiants that are believed to be the precursors of planetary nebulæ. Our mineralogical model of each star indicates the presence of both carbon rich and oxygen rich dust species-contrary to simple dredge-up models – with a majority of the dust in the form of amorphous carbon and graphite. The oxygen rich dust is primarily in the form of amorphous silicates. The spectra do not exhibit any prominent crystalline silicate emission features. For most of the systems, our analysis suggests that the grains are relatively large and have undergone significant processing, supporting the hypothesis that the dust is confined to a Keplerian disk and that we are viewing the heavily processed, central regions of the disk from a nearly face-on orientation. These results help to determine the physical properties of the post-AGB circumstellar environment and to constrain models of post-AGB mass loss and planetary nebula formation.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1706.00445

Globular cluster formation with multiple stellar populations: self-enrichment in fractal massive molecular clouds

Kenji Bekki[1]

[1]ICRAR at UWA, Australia

Internal chemical abundance spreads are one of fundamental properties of globular clusters (GCs) in the Galaxy. In order to understand the origin of such abundance spreads, we numerically investigate GC formation from massive molecular clouds (MCs) with fractal structures using our new hydrodynamical simulations with star formation and feedback effects of supernovæ (SNe) and asymptotic giant branch (AGB) stars. We particularly investigate star formation from gas chemically contaminated by SNe and AGB stars within MCs with different initial conditions and environments. The principal results are as follows. GCs with multiple generation of stars can be formed from merging of hierarchical star cluster complexes that are developed from high-density regions of fractal MCs. Feedback effects of SNe and AGB stars can control the formation efficiencies of stars formed from original gas of MCs and from gas ejected from AGB stars. The simulated GCs have radial gradients of helium abundances within the central 3 pc. The original MC masses need to be as large as 10^7 $M_\odot$ for a canonical initial stellar mass function (IMF) so that the final masses of stars formed from AGB ejecta can be 10^5 $M_\odot$. Since star formation from AGB ejecta is rather prolonged (10^8 yr),

their formation can be strongly suppressed by SNe of the stars themselves. This result implies that the so-called mass budget problem is much more severe than ever thought in the self-enrichment scenario of GC formation. and thus that IMF for the second generation of stars should be 'top-light'.

Published in MNRAS
Available from https://arxiv.org/abs/1705.10039

Models of the hydrodynamic histories of post-AGB stars. I. Multiflow shaping of OH 231.8+04.2

Bruce Balick[1], Adam Frank[2], Baowei Liu[2] and Martín Huarte-Espinosa[3]

[1]University of Washington, USA
[2]Department of Physics and Astronomy, University of Rochester, USA
[3]Center for Advanced Comp. & Data Systems, University of Houston, USA

We present a detailed hydrodynamic model that matches the present structure of the well-observed preplanetary nebula OH 231.8+04.2. The purpose of the model is to present a physically justified and coherent picture of its evolutionary history from about 100 years of the start of the formation of its complex outer structures to the present. We have adopted a set of initial conditions that are heavily constrained by high-quality observations of its present structure and kinematics. The shaping of the nebula occurs while the densities of the flows are "light": less than the surrounding AGB-wind environment. The simulations show that pairs of essentially coeval clumps and sprays of the same extent and density but different outflow speeds sculpted both the pair of thin axial flow "or spine" and the bulbs. The total ejected mass and momentum in the best fit model are surprisingly large – 3 $M_\odot$ and 2.2×10^{41} gm cm s^{-1}, respectively – however, these values are reduced by up to a factor of ten in other models that fit the data almost as well. Our ultimate goal is to combine the present model results of masses, momenta, flow speeds, and flow geometries for OH 231 with those of other models to be published in the future in order to find common attributes of their ejection histories.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1706.01516

Rubidium and zirconium abundances in massive Galactic asymptotic giant branch stars revisited

V. Pérez-Mesa[1,2], O. Zamora[1,2], D.A. García-Hernández[1,2], B. Plez[3], A. Manchado[1,2,4], A.I. Karakas[5] and M. Lugaro[5,6]

[1]Instituto de Astrofísica de Canarias (IAC), E-38205 La Laguna, Tenerife, Spain
[2]Departamento de Astrofísica, Universidad de La Laguna (ULL), E-38206 La Laguna, Tenerife, Spain
[3]Laboratoire Univers et Particules de Montpellier, Université de Montpellier2, CNRS, 34095 Montpellier, France
[4]Consejo Superior de Investigaciones Científicas (CSIC), E-28006 Madrid, Spain
[5]Monash Centre for Astrophysics, School of Physics and Astronomy, Monash University, VIC3800, Australia
[6]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, 1121 Budapest, Hungary

Luminous Galactic OH/IR stars have been identified as massive (> 4–5 $M_\odot$) asymptotic giant branch (AGB) stars experiencing hot bottom burning and Li production. Their Rb abundances and [Rb/Zr] ratios, as derived from classical hydrostatic model atmospheres, are significantly higher than predictions from AGB nucleosynthesis models, posing a problem to our understanding of AGB evolution and nucleosynthesis. We report new Rb and Zr abundances in the full sample (21) of massive Galactic AGB stars, previously studied with hydrostatic models, by using more realistic extended model atmospheres. For this, we use a modified version of the spectral synthesis code Turbospectrum

and consider the presence of a circumstellar envelope and radial wind in the modelling of the optical spectra of these massive AGB stars. The Rb and Zr abundances are determined from the 7800 Å Rb I resonant line and the 6474 Å ZrO bandhead, respectively, and we explore the sensitivity of the derived abundances to variations of the stellar ($T_{\rm eff}$) and wind ($\dot{M}$, β and $v_{\rm exp}$) parameters in the pseudo-dynamical models. The Rb and Zr abundances derived from the best spectral fits are compared with the most recent AGB nucleosynthesis theoretical predictions. The Rb abundances derived with the pseudo-dynamical models are much lower (in the most extreme stars even by $\sim$ 1–2 dex) than those derived with the hydrostatic models, while the Zr abundances are similar. The Rb I line profile and Rb abundance are very sensitive to the wind mass-loss rate $\dot{M}$ (especially for $\dot{M} \geq 10^{-8}$ $M_{\odot}$ yr^{-1}) but much less sensitive to variations of the wind velocity-law (β parameter) and the expansion velocity $v_{\rm exp}$(OH). We confirm the earlier preliminary results based on a smaller sample of massive O-rich AGB stars, that the use of extended atmosphere models can solve the discrepancy between the AGB nucleosynthesis theoretical models and the observations of Galactic massive AGB stars. The Rb abundances, however, are still strongly dependent of the wind mass-loss $\dot{M}$, which, unfortunately, is unknown in these AGB stars. Accurate mass-loss rates $\dot{M}$ (e.g., from rotationally excited lines of the CO isotopologues in the radio domain) in these massive Galactic AGB stars are needed in order to break the models degeneracy and get reliable (not model dependent) Rb abundances in these stars.

Available from https://arxiv.org/abs/1706.02268

SiS in the circumstellar envelope of IRC +10°216: maser and quasi-thermal emission

Y. Gong[1,2], C. Henkel[2,3], J. Ott[4], K.M. Menten[2], M.R. Morris[5], D. Keller[2,6], M.J. Claussen[4], M. Grasshoff[7] and R.Q. Mao[1]

[1]Purple Mountain Observatory & Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, 2 West Beijing Road, 210008 Nanjing, PR China

[2]Max-Planck Institut für Radioastronomie, Auf Dem Hügel 69, 53121 Bonn, Germany

[3]Astronomy Department, King Abdulaziz University, P.O. Box 80203, 21589 Jeddah, Saudi Arabia

[4]National Radio Astronomy Observatory, P.O. Box O, 1003 Lopezville Road, Socorro, NM 87801, USA

[5]Department of Physics and Astronomy, University of California, Los Angeles, California 90095-1547, USA

[6]Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

[7]Visiting the Max-Planck Institut für Radioastronomie, Auf Dem Hügel 69, 53121 Bonn, Germany

We present new Effelsberg-100 m, ATCA, and VLA observations of rotational SiS transitions in the circumstellar envelope (CSE) of IRC +10°216. Thanks to the high angular resolution achieved by the ATCA observations, we unambiguously confirm that the molecule's $J = 1 \rightarrow 0$ transition exhibits maser action in this CSE, as first suggested more than thirty years ago. The maser emission's radial velocity peaking at a local standard of rest velocity of -39.862 ± 0.065 km s^{-1} indicates that it arises from an almost fully accelerated shell. Monitoring observations show time variability of the SiS (1 → 0) maser. The two lowest-J SiS quasi-thermal emission lines trace a much more extended emitting region than previous high-J SiS observations. Their distributions show that the SiS quasi-thermal emission consists of two components: one is very compact (radius $< 1\farcs5$, corresponding to $< 3 \times 10^{15}$ cm), and the other extends out to a radius $> 11''$. An incomplete shell-like structure is found in the north–east, which is indicative of existing SiS shells. Clumpy structures are also revealed in this CSE. The gain of the SiS (1 → 0) maser (optical depths of about -5 at the blue-shifted side and, assuming inversion throughout the entire line's velocity range, about -2 at the red-shifted side) suggests that it is unsaturated. The SiS (1 → 0) maser can be explained in terms of ro-vibrational excitation caused by infrared pumping, and we propose that infrared continuum emission is the main pumping source.

Accepted for publication in ApJ

Available from https://arxiv.org/abs/1706.02446

An updated 2017 astrometric solution for Betelgeuse

G.M. Harper[1], A. Brown[1], E.F. Guinan[2], E. O'Gorman[3], A.M.S. Richards[4], P. Kervella[5,6] and L. Decin[7]

[1]Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309, USA

[2]Villanova University, PA 19085, USA

[3]Dublin Institute for Advanced Studies, Dublin 2, Ireland

[4]Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, UK

[5]Unidad Mixta Internacional Franco–Chilena de Astronomía (UMI 3386), Departamento de Astronomía, Universidad de Chile, Santiago, Chile

[6]Observatoire de Paris, PSL Research University, CNRS, UPMC, Univ. Paris-Diderot, France

[7]Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

We provide an update for the astrometric solution for the Type II supernova progenitor Betelgeuse using the revised *Hipparcos* Intermediate Astrometric Data (HIAD) of van Leeuwen, combined with existing VLA and new e-MERLIN and ALMA positions. The 2007 *Hipparcos* refined abscissa measurements required the addition of so called Cosmic Noise of 2.4 mas to find an acceptable 5-parameter stochastic solution. We find that a measure of radio Cosmic Noise should also be included for the radio positions because surface inhomogeneities exist at a level significant enough to introduce additional intensity centroid uncertainty. Combining the 2007 HIAD with the proper motions based solely on the radio positions leads to a parallax of $\pi = 5.27 \pm 0.78$ mas (190^{+33}_{-25} pc), smaller than the *Hipparcos* 2007 value of 6.56 ± 0.83 mas (152^{+22}_{-17} pc). Furthermore, combining the VLA and new e-MERLIN and ALMA radio positions with the 2007 HIAD, and including radio Cosmic Noise of 2.4 mas, leads to a nominal parallax solution of 4.51 ± 0.80 mas (222^{+48}_{-34} pc), which, while only 0.7σ different from the 2008 solution of Harper et al., is 2.6σ different from the solution of van Leeuwen. An accurate and precise parallax for Betelgeuse is always going to be difficult to obtain because it is small compared to the stellar angular diameter ($\theta = 44$ mas). We outline an observing strategy utilizing future mm and sub-mm high-spatial resolution interferometry that must be used if substantial improvements in the precision and accuracy of the parallax and distance are to be achieved.

Accepted for publication in AJ

The inhomogeneous sub-millimeter atmosphere of Betelgeuse

Eamon O'Gorman[1], P. Kervella[2,3], G.M. Harper[4], A.M.S. Richards[5], L. Decin[6], M. Montargès[7] and I. McDonald[5]

[1]Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, Dublin 2, Ireland

[2]Unidad Mixta Internacional Franco–Chilena de Astronomía (CNRS UMI 3386), Departamento de Astronomía, Universidad de Chile, Camino El Observatorio 1515, Las Condes, Santiago, Chile

[3]LESIA (UMR 8109), Observatoire de Paris, PSL Research University, CNRS, UPMC, Univ. Paris-Diderot, 5 place Jules Janssen, 92195 Meudon, France

[4]Center for Astrophysics and Space Astronomy, University of Colorado, 389 UCB, Boulder, CO 80309, USA

[5]JBCA, Department Physics and Astronomy, University of Manchester, Manchester M13 9PL, UK

[6]Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D B2401, 3001 Leuven, Belgium

[7]Institut de Radioastronomie Millimètrique, 300 rue de la Piscine, 38406 Saint-Martin d'Hères, France

The mechanisms responsible for heating the extended atmospheres of early-M spectral-type supergiants are poorly understood. So too is the subsequent role these mechanisms play in driving the large mass-loss rates of these stars. Here we present ALMA long (i.e., $\sim$ 16 km) baseline 338 GHz (0.89 mm) continuum observations of the free–free emission in the extended atmosphere of the M2 spectral-type supergiant Betelgeuse. The spatial resolution of 14 mas exquisitely resolves the atmosphere, revealing it to have a mean temperature of 2760 K at ~ 1.3 R$_\star$, which is below both the photospheric effective temperature ($T_{\rm eff} = 3690$ K) and the temperatures at ~ 2 R$_\star$. This is unambiguous proof for the existence of an inversion of the mean temperature in the atmosphere of a red supergiant. The emission is clearly not spherically symmetric with two notable deviations from a uniform disk detected in both the images and visibilities. The most prominent asymmetry is located in the north-east quadrant of the disk and is spatially resolved showing it to be highly elongated with an axis-ratio of 2.4 and occupying $\sim 5\%$ of the disk projected area. Its temperature is approximately 1000 K above the measured mean temperature at 1.3 R$_\star$. The other main asymmetry is located on the disk limb almost due east of the disk center and occupies $\sim 3\%$ of the disk projected area. Both emission asymmetries are clear evidence for localized heating taking place in the atmosphere of Betelgeuse. We suggest that the detected localized heating is related to magnetic activity generated by large-scale photospheric convection.

Accepted for publication in A&A Letters

Tidal dissipation in rotating low-mass stars and implications for the orbital evolution of close-in planets. I. From the PMS to the RGB at solar metallicity

F. Gallet[1], *E. Bolmont*[2,3], *S. Mathis*[2], *C. Charbonnel*[1,4] *and L. Amard*[1,5]

[1]Department of Astronomy, University of Geneva, Chemin des Maillet tes 51, 1290 Versoix, Switzerland

[2]Laboratoire AIM Paris-Saclay, CEA / DRF – CNRS – Univ. Paris Diderot – IRFU / SAp, Centre de Saclay, F-91191 13 Gif-sur-Yvette Cedex, France

[3]NaXys, Department of Mathematics, University of Namur, 8 Rempa rt de la Vierge, 5000 Namur, Belgium

[4]IRAP, UMR 5277, CNRS and Université de Toulouse, 14, av. E. Belin, F-31400 Toulouse, France

[5]LUPM UMR 5299 CNRS / UM, Université de Montpellier, CC 72, F-34095 Montpellier Cedex 05, France

Star–planet interactions must be taken into account in stellar models to understand the dynamical evolution of close-in planets. The dependence of the tidal interactions on the structural and rotational evolution of the star is of peculiar importance and should be correctly treated. We quantify how tidal dissipation in the convective envelope of rotating low-mass stars evolves from the pre-main sequence up to the red-giant branch depending on the initial stellar mass. We investigate the consequences of this evolution on planetary orbital evolution. We couple the tidal dissipation formalism described in Mathis (2015) to the stellar evolution code STAREVOL and apply it to rotating stars with masses between 0.3 and 1.4 $M_\odot$. As a first step, this formalism assumes a simplified bi-layer stellar structure with corresponding averaged densities for the radiative core and the convective envelope. We use a frequency-averaged treatment of the dissipation of tidal inertial waves in the convection zone (we neglect the dissipation of tidal gravity waves in the radiation zone). In addition, we generalize the work of Bolmont & Mathis (2016) by following the orbital evolution of close-in planets using the new tidal dissipation predictions for advanced phases of stellar evolution. On the pre-main sequence the evolution of tidal dissipation is controlled by the evolution of the internal structure of the contracting star. On the main-sequence it is strongly driven by the variation of surface rotation that is impacted by magnetized stellar winds braking. The main effect of taking into account the rotational evolution of the stars is to lower the tidal dissipation strength by about four orders of magnitude on the main-sequence, compared to a normalized dissipation rate that only takes into account structural changes. The evolution of the dissipation strongly depends on the evolution of the internal structure and rotation of the star. From the pre-main sequence up to the tip of the red-giant branch, it varies by several orders of magnitude, with strong consequences for the orbital evolution of close-in massive planets. These effects are the strongest during the pre-main sequence, implying that the planets are mainly sensitive to the star's early history.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1705.10164

Near-degeneracy effects on the frequencies of rotationally-split mixed modes in red giants

S. Deheuvels[1,2], *R.M. Ouazzani*[3,4,5] *and S. Basu*[6]

[1]Université de Toulouse; UPS–OMP; IRAP; Toulouse, France

[2]CNRS; IRAP; 14, avenue Edouard Belin, F-31400 Toulouse, France

[3]Institut d'Astrophysique et de Géophysique de l'Université de Liège, Allée du 6 Août 17, 4000 Liège, Belgium

[4]Stellar Astrophysics Centre, Department of Physics and Astronomy, Århus University, Ny Munkegade 120, DK-8000 Århus C, Denmark

[5]Observatoire de Paris, LESIA, CNRS UMR 8109, 92195 Meudon, France

[6]Department of Astronomy, Yale University, P.O. Box 208101, New Haven, CT 06520-8101, USA

The *Kepler* space mission has made it possible to measure the rotational splittings of mixed modes in red giants, thereby providing an unprecedented opportunity to probe the internal rotation of these stars. Asymmetries have been detected in the rotational multiplets of several red giants. This is unexpected since all the red giants whose rotation profiles have been measured thus far are found to rotate slowly, and low rotation, in principle, produces symmetrical multiplets. Our aim here is to explain these asymmetries and find a way of exploiting them to probe the internal rotation of red giants. We show that in the cases where asymmetrical multiplets were detected, near-degeneracy effects are expected to occur, because of the combined effects of rotation and mode mixing. Such effects have not been taken into account so far. By using both perturbative and non-perturbative approaches, we show that near-degeneracy effects produce multiplet asymmetries that are very similar to the observations. We then propose and validate a method based on the perturbative approach to probe the internal rotation of red giants using multiplet asymmetries. We successfully apply our method to the asymmetrical $l = 2$ multiplets of the *Kepler* young red giant KIC 7341231 and obtain precise estimates of its mean rotation in the core and the envelope. The observed asymmetries are reproduced with a good statistical agreement, which confirms that near-degeneracy effects are very likely the cause of the detected multiplet asymmetries. We expect near-degeneracy effects to be important for $l = 2$ mixed modes all along the red giant branch (RGB). For $l = 1$ modes, these effects can be neglected only at the base of the RGB. They must therefore be taken into account when interpreting rotational splittings and as shown here, they can bring valuable information about the internal rotation of red giants.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1705.10326

The 2017 release of CLOUDY

G.J. Ferland[1], *M. Chatzikos*[2], *F. Guzmán*[2], *M.L. Lykins*[2], *P.A.M. van Hoof*[2], *R.J.R. Williams*[2], *N.P. Abel*[2], *N.R. Badnell*[2], *F.P. Keenan*[2], *R.L. Porter*[2] *and P.C. Stancil*[2]

[1]University of Kentucky, USA
[2]several institutions and countries

We describe the 2017 release of the spectral synthesis code CLOUDY. A major development since the previous release has been exporting the atomic data into external data files. This greatly simplifies updates and maintenance of the data. Many large datasets have been incorporated with the result that we can now predict well over an order of magnitude more emission lines when all databases are fully used. The use of such large datasets is not realistic for most calculations due to the time and memory needs, and we describe the limited subset of data we use by default. Despite the fact that we now predict significantly more lines than the previous CLOUDY release, this version is faster because of optimization of memory access patterns and other tuning. The size and use of the databases can easily be adjusted in the command-line interface. We give examples of the accuracy limits using small models, and the performance requirements of large complete models. We summarize several advances in the H- and He-like iso-electronic sequences. We use our complete collisional-radiative models of the ionization of these one and two electron ions to establish the highest density for which the coronal or interstellar medium (ISM) approximation works, and the lowest density where Saha or local thermodynamic equilibrium can be assumed. The coronal approximation fails at surprisingly low densities for collisional ionization equilibrium but is valid to higher densities for photoionized gas clouds. Many other improvements to the physics have been made and are described. These include the treatment of isotropic continuum sources such as the cosmic microwave background (CMB) in the reported output, and the ability to follow the evolution of cooling non-equilibrium clouds.

Submitted to Revista Mexicana (comments welcome)
Available from https://arxiv.org/abs/1705.10877
and from nublado.org

A grid of MARCS model atmospheres for late-type stars. II. S stars and their properties

S. Van Eck[1], *P. Neyskens*[1], *A. Jorissen*[1], *B. Plez*[2], *B. Edvardsson*[3], *K. Eriksson*[3], *B. Gustafsson*[3], *U.G. Jørgensen*[4] *and Å. Nordlund*[4]

[1]Institut d'Astronomie et d'Astrophysique, Université libre de Bruxelles, Belgium

[2]Laboratoire Univers et Particules de Montpellier, Université de Montpellier, France

[3]Department of Physics and Astronomy, Uppsala University, Sweden

[4]Niels Bohr Institute, Copenhagen, Denmark

S-type stars are late-type giants whose atmospheres are enriched in carbon and s-process elements because of either extrinsic pollution by a binary companion or intrinsic nucleosynthesis and dredge-up on the thermally-pulsing asymptotic giant branch. A grid of MARCS model atmospheres has been computed for S stars, covering the range $2700 \leq T_{\rm eff}(\rm K) \leq 4000$, $0.50 \leq \rm C/O \leq 0.99$, $0 \leq \log g \leq 5$, [Fe/H] $= 0$, -0.5 dex, and [s/Fe] $= 0$, 1, and 2 dex (where the latter quantity refers to the global overabundance of s-process elements). The MARCS models make use of a new ZrO line list. Synthetic spectra computed from these models are used to derive photometric indices in the Johnson and Geneva systems, as well as TiO and ZrO band strengths. A method is proposed to select the model best matching any given S star, a non-trivial operation since the grid contains more than 3500 models covering a five-dimensional parameter space. The method is based on the comparison between observed and synthetic photometric indices and spectral band strengths, and has been applied on a vast subsample of the Henize sample of S stars. Our results confirm the old claim by Piccirillo (1980, MNRAS, 190, 441) that ZrO bands in warm S stars ($T_{\rm eff} > 3200$ K) are not caused by the C/O ratio being close to unity, as traditionally believed, but rather by some Zr overabundance. The TiO and ZrO band strengths, combined with V–K and J–K photometric indices, are used to select $T_{\rm eff}$, C/O, [Fe/H] and [s/Fe]. The Geneva U–B1 and B2–V1 indices (or any equivalent) are good at selecting the gravity. The defining spectral features of dwarf S stars are outlined, but none is found among the Henize S stars. More generally, it is found that, at $T_{\rm eff} = 3200$ K, a change of C/O from 0.5 to 0.99 has a strong impact on V–K (2 mag). Conversely, a range of 2 mag in V–K corresponds to a 200 K shift along the ($T_{\rm eff}$, V–K) relationship (for a fixed C/O value). Hence, the use of a ($T_{\rm eff}$, V–K) calibration established for M stars will yield large errors for S stars, so that a specific calibration must be used, as provided in the present paper. Using the atmospheric parameters derived by our method for the sample of Henize S stars, we show that the extrinsic–intrinsic dichotomy among S stars reveals itself very clearly as a bimodal distribution in the effective temperatures. Moreover, the increase of s-process element abundances with increasing C/O ratios and decreasing temperatures is apparent among intrinsic stars, confirming theoretical expectations.

Published in Astronomy & Astrophysics, 601, A10 (2017)

Partial mixing and the formation of ^{13}C pockets in AGB stars: effects on the s-process elements

J. Buntain[1], *C. Doherty*[2,1], *M. Lugaro*[2,1], *J.C. Lattanzio*[1], *R.J. Stancliffe*[3] *and A.I. Karakas*[1,4]

[1]Monash Centre for Astrophysics (MoCA), School of Physics and Astronomy, Monash University, Victoria 3800, Australia

[2]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, H-1121 Budapest, Hungary

[3]Argelander Institute for Astronomy, University of Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany

[4]Research School of Astronomy and Astrophysics, Australian National University, Canberra, ACT 2611, Australia

The production of the elements heavier than iron via slow neutron captures (the s process) is a main feature of the contribution of asymptotic giant branch (AGB) stars of low mass (< 5 M$_\odot$) to the chemistry of the cosmos. However, our understanding of the main neutron source, the ^{13}C(α,n)^{16}O reaction, is still incomplete. It is commonly assumed that in AGB stars mixing beyond convective borders drives the formation of ^{13}C pockets. However, there is no agreement on the nature of such mixing and free parameters are present. By means of a parametric model we investigate the impact of different mixing functions on the final s-process abundances in low-mass AGB models. Typically, changing the shape of the mixing function or the mass extent of the region affected by the mixing produce the same results. Variations in the relative abundance distribution of the three s-process peaks (Sr, Ba, and Pb) are generally within $\pm$0.2 dex, similar to the observational error bars. We conclude that other stellar uncertainties – the

effect of rotation and of overshoot into the C-O core – play a more important role than the details of the mixing function. The exception is at low metallicity, where the Pb abundance is significantly affected. In relation to the composition observed in stardust SiC grains from AGB stars, the models are relatively close to the data only when assuming the most extreme variation in the mixing profile.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.05802

Three-dimensional hydrodynamical CO[5]BOLD model atmospheres of red giant stars. VI. First chromosphere model of a late-type giant

S. Wedemeyer[1], A. Kučinskas[2], J. Klevas[2] and H.-G. Ludwig[3]

[1]Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, N-0315 Oslo, Norway
[2]Institute of Theoretical Physics and Astronomy, Vilnius University, Saulėtekio al. 5, Vilnius LT-10221, Lithuania
[3]ZAH, Landessternwarte Königstuhl, D-69117 Heidelberg, Germany

Although observational data unequivocally point to the presence of chromospheres in red giant stars, no attempts have been made so far to model them using 3D hydrodynamical model atmospheres. We therefore compute an exploratory 3D hydrodynamical model atmosphere for a cool red giant in order to study the dynamical and thermodynamic properties of its chromosphere, as well as the influence of the chromosphere on its observable properties. Three-dimensional radiation hydrodynamics simulations are carried out with the CO[5]BOLD model atmosphere code for a star with the atmospheric parameters ($T_{\rm eff} \approx 4010$ K, $\log g = 1.5$, [M/H] = 0.0), which are similar to those of the K-type giant star Aldebaran (α Tau). The computational domain extends from the upper convection zone into the chromosphere ($7.4 \geq \log \tau_{\rm Ross} \geq -12.8$) and covers several granules in each horizontal direction. Using this model atmosphere, we compute the emergent continuum intensity maps at different wavelengths, spectral line profiles of Ca II K, the Ca II infrared triplet line at 854.2 nm, and Hα, as well as the spectral energy distribution (SED) of the emergent radiative flux. The initial model quickly develops a dynamical chromosphere that is characterised by propagating and interacting shock waves. The peak temperatures in the chromospheric shock fronts reach values of up to 5000 K, although the shock fronts remain quite narrow. Similar to the Sun, the gas temperature distribution in the upper layers of red giant stars is composed of a cool component due to adiabatic cooling in the expanding post-shock regions and a hot component due to shock waves. For this red giant model, the hot component is a rather flat high-temperature tail, which nevertheless affects the resulting average temperatures significantly. The simulations show that the atmospheres of red giant stars are dynamic and intermittent. Consequently, many observable properties cannot be reproduced with static 1D models, but require advanced 3D hydrodynamical modelling. Furthermore, including a chromosphere in the models might produce significant contributions to the emergent UV flux.

Accepted for publication in A&A
Available from https://arxiv.org/abs/1705.09641
and from https://www.aanda.org/component/article?access=doi&doi=10.1051/0004-6361/201730405

A new titanium oxide index in visual band

Bahar Bidaran[1], Mohammad Taghi Mirtorabi[1] and Fatemeh Azizi[2]

[1]Department of Physics, Alzahra University, P.O. Box 1993893973, Tehran, Iran
[2]Department of Physics, Payame Noor University (PNU), P.O. Box 19395-3697, Tehran, Iran

We introduce a new color index consisting of two spectral band width to measure TiO absorption band strength centered at 567 nm. Based on the most up-to-date line list for TiO we regenerate a grid of synthesized spectra and investigate the temperature sensitivity of the index. The new index behave similar to older Wing TiO-index where it decrease monotonically from coolest atmosphere with $T_{\rm eff}$ = 2800 up to $T_{\rm eff}$ = 4000 where the TiO molecules

disassociate. To further examine the feasibility of the new index we reproduce the calibration using a list of observed high resolution spectra and found similar results. This index extend TiO absorption band capability to measure effective temperature of late K to M stars to visual spectrum where it is more accessible to small telescopes for long term dedicated observation.

Published in MNRAS
Available from https://arxiv.org/abs/1612.08298

Spectroscopy and photometry of multiple populations along the asymptotic giant branch of NGC 2808 and NGC 6121 (M 4)

Anna F. Marino[1], Antonino P. Milone[1], David Yong[1], Gary Da Costa[1], Martin Asplund[1], Luigi R. Bedin[2], Helmut Jerjen[1], Domenico Nardiello[3], Giampaolo Piotto[3], Alvio Renzini[2] and Matthew Shetrone[4]

[1]Research School of Astronomy & Astrophysics, Australia

[2]Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Padova, Italy

[3]Dipartimento di Fisica e Astronomia "Galileo Galilei" – Università di Padova, Italy

[4]McDonald Observatory, University of Texas at Austin, USA

We present a photometric and spectroscopic study of multiple populations along the asymptotic giant branch (AGB) of the intermediate-metallicity globular clusters (GCs) NGC 2808 and NGC 6121 (M 4). Chemical abundances of O, Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Fe, Co, Ni, Zn, Y, and Ce in AGB stars from high-resolution FLAMES+UVES@VLT spectra are reported for both clusters. Our spectroscopic results have been combined with multiwavelength photometry from the *Hubble* Space Telescope UV survey of Galactic GCs and ground-based photometry, as well as proper motions derived by combining stellar positions from ground-based images and Gaia DR1. Our analysis reveals that the AGBs of both clusters host multiple populations with different chemical compositions. In M 4, we have identified two main populations of stars with different Na/O content lying on distinct AGBs in the mF438W versus CF275W, F336W, F438W and the V versus CU,B,I pseudo-color–magnitude diagrams. In the more massive and complex GC NGC 2808, three groups of stars with different chemical abundances occupy different locations on the so-called "chromosome map" photometric diagram. The spectroscopic + photometric comparison of stellar populations along the AGB and the red giants of this GC suggests that the AGB hosts stellar populations with a range in helium abundances from primordial to high contents of $Y \sim 0.32$. By contrast, from our data set, there is no evidence for stars with extreme helium abundance ($Y \sim 0.38$) on the AGB, suggesting that the most He-rich stars of NGC 2808 do not reach this phase.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1706.02278

Testing the white dwarf mass–radius relationship with eclipsing binaries

S.G. Parsons[1], B.T. Gänsicke[2], T.R. Marsh[2], R.P. Ashley[2], M.C.P. Bours[3], E. Breedt[2], M.R. Burleigh[4], C.M. Copperwheat[5], V.S. Dhillon[1], M. Green[2], L.K. Hardy[1], J.J. Hermes[6], P. Irawati[7], P. Kerry[1], S.P. Littlefair[1], M.J. McAllister[1], S. Rattanasoon[1,7], A. Rebassa-Mansergas[8], D.I. Sahman[1] and M.R. Schreiber[3]

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

[2]Department of Physics, University of Warwick, Coventry CV4 7AL, UK

[3]Instituto de Física y Astronomía, Universidad de Valparaíso, Avenida Gran Bretaña 1111, Valparaíso, 2360102, Chile

[4]Department of Physics and Astronomy, University of Leicester, Leicester LE1 7RH, UK

[5]Astrophysics Research Institute, Liverpool John Moores University, IC2, Liverpool Science Park, L3 5RF, UK

[6]Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599-3255, USA

[7]National Astronomical Research Institute of Thailand, 191 Siriphanich Bldg., Huay Kaew Road, Chiang Mai 50200, Thailand

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

We present high precision, model independent, mass and radius measurements for 16 white dwarfs in detached eclipsing binaries and combine these with previously published data to test the theoretical white dwarf mass–radius relationship. We reach a mean precision of 2.4 per cent in mass and 2.7 per cent in radius, with our best measurements reaching a precision of 0.3 per cent in mass and 0.5 per cent in radius. We find excellent agreement between the measured and predicted radii across a wide range of masses and temperatures. We also find the radii of all white dwarfs with masses less than 0.48 $M_\odot$ to be fully consistent with helium core models, but they are on average 9 per cent larger than those of carbon–oxygen core models. In contrast, white dwarfs with masses larger than 0.52 $M_\odot$ all have radii consistent with carbon–oxygen core models. Moreover, we find that all but one of the white dwarfs in our sample have radii consistent with possessing thick surface hydrogen envelopes ($10^{-5} \geq M_{\rm H}/M_{\rm WD} \geq 10^{-4}$), implying that the surface hydrogen layers of these white dwarfs are not obviously affected by common envelope evolution.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.05016

Fundamental parameters and infrared excesses of *Tycho*–Gaia stars

Iain McDonald[1], *Albert Zijlstra*[1,2] *and Robert Watson*[1]

[1]Jodrell Bank Centre for Astrophysics, Alan Turing Building, Manchester, M13 9PL, UK
[2]Department of Physics, The University of Hong Kong, Pokfulam Road, Hong Kong, China

Effective temperatures and luminosities are calculated for 1,475,921 *Tycho*-2 and 107,145 *Hipparcos* stars, based on distances from Gaia Data Release 1. Parameters are derived by comparing multi-wavelength archival photometry to BT–Settl model atmospheres. The 1-σ uncertainties for the *Tycho*-2 and *Hipparcos* stars are ±137 K and ±125 K in temperature and ±35 per cent and ±19 per cent in luminosity. The luminosity uncertainty is dominated by that of the Gaia parallax. Evidence for infrared excess between 4.6 and 25 μm is found for 4256 stars, of which 1883 are strong candidates. These include asymptotic giant branch (AGB) stars, Cepheids, Herbig Ae/Be stars, young stellar objects, and other sources. We briefly demonstrate the capabilities of this dataset by exploring local interstellar extinction, the onset of dust production in AGB stars, the age and metallicity gradients of the solar neighbourhood and structure within the Gould Belt. We close by discussing the potential impact of future Gaia data releases.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.02208

Near-infrared variability study of the central $2'.3 \times 2'.3$ of the Galactic Centre I. Catalog of variable sources

Hui Dong[1], *Rainer Schödel*[1], *Benjamin F. Williams*[2], *Francisco Nogueras-Lara*[1], *Eulalia Gallego-Cano*[1], *Teresa Gallego-Calvente*[1], *Q. Daniel Wang*[3], *Mark R. Morris*[4], *Tuan Do*[4] *and Andrea Ghez*[4]

[1]IAA–CSIC, Spain
[2]University of Washington, Seattle, USA
[3]University of Massachusetts, Amherst, USA
[4]University of California, Los Angeles, USA

We used four-year baseline HST/WFC3 IR observations of the Galactic Centre in the F153M band (1.53 μm) to identify variable stars in the central $\sim 2'.3 \times 2'.3$ field. We classified 3845 long-term (periods from months to years) and 76 short-term (periods of a few days or less) variables among a total sample of 33 070 stars. For 36 of the latter ones, we also derived their periods (< 3 days). Our catalog not only confirms bright long period variables and massive eclipsing binaries identified in previous works, but also contains many newly recognized dim variable stars. For example, we found δ Scuti and RR Lyræ stars towards the Galactic Centre for the first time, as well as one BL Her star (period < 1.3 d). We cross-correlated our catalog with previous spectroscopic studies and found that 319 variables have well-defined stellar types, such as Wolf–Rayet, OB main sequence, supergiants and asymptotic giant branch stars.

We used colours and magnitudes to infer the probable variable types for those stars without accurately measured periods or spectroscopic information. We conclude that the majority of unclassified variables could potentially be eclipsing/ellipsoidal binaries and Type II Cepheids. Our source catalog will be valuable for future studies aimed at constraining the distance, star formation history and massive binary fraction of the Milky Way nuclear star cluster.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.03243

Evidence for orbital motion of CW Leonis from ground-based astrometry

Alessandro Sozzetti[1], *Richard L. Smart*[1], *Ronald Drimmel*[1], *Palo Giacobbe*[1] *and Mario G. Lattanzi*[1]

[1]INAF – Osservatorio Astrofisico di Torino, Italy

Recent ALMA observations indicate that CW Leo, the closest carbon-rich AGB star to the Sun, might have a low-mass stellar companion. We present archival ground-based astrometric measurements of CW Leo obtained within the context of the Torino Parallax Program and with > 6 yr (1995–2001) of time baseline. The residuals to a single-star solution show significant curvature, and they are strongly correlated with the well-known I -band photometric variations due to stellar pulsations. We describe successfully the astrometry of CW Leo with a variability-induced motion (VIM) + acceleration model. We obtain proper motion and parallax of the center-of-mass of the binary, the former in fair agreement with recent estimates, the latter at the near end of the range of inferred distances based on indirect methods. The VIM + acceleration model results allow us to derive a companion mass in agreement with that inferred by ALMA, they point towards a somewhat longer period than implied by ALMA, but are not compatible with much longer period estimates. These data will constitute a fundamental contribution towards the full understanding of the orbital architecture of the system when combined with Gaia astrometry, providing a ~ 25 yr time baseline.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.04391

On the observational characteristics of lithium-enhanced giant stars in comparison with normal red giants

Yoichi Takeda[1] *and Akito Tajitsu*[2]

[1]National Astronomical Observatory, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[2]Subaru Telescope, 650 N. A'ohoku Place, Hilo, HI 96720, U.S.A.

While lithium is generally deficient in the atmosphere of evolved giant stars because of the efficient mixing-induced dilution, a small fraction of red giants show unusually strong Li lines indicative of conspicuous abundance excess. With an aim to shed light on the origin of these peculiar stars, we carried out a spectroscopic study on the observational characteristics of selected 20 bright giants already known to be Li-rich from past studies, in comparison with the reference sample of a large number of normal late-G – early-K giants. Our special attention was paid to clarifying any difference between the two samples from a comprehensive point of view (i.e., with respect to stellar parameters, rotation, activity, kinematic properties, ^{6}Li/^{7}Li ratio, and the abundances of Li, Be, C, O, Na, S, and Zn). Our sample stars are roughly divided into "bump/clump group" and "luminous group" according to the positions on the HR diagram. Regarding the former group ($1.5 \lesssim \log(L/\mathrm{L}_{\odot}) \lesssim 2$ and $M \sim 1.5$–$3\ \mathrm{M}_{\odot}$), Li-enriched giants and normal giants appear practically similar in almost all respect except for Li, suggesting that surface Li enhancement in this group may be a transient episode which normal giants undergo at certain evolutionary stages in their lifetime. Meanwhile, those Li-rich giants belonging to the latter group ($\log(L/\mathrm{L}_{\odot}) \sim 3$ and $M \sim 3$–$5\ \mathrm{M}_{\odot}$) appear more anomalous in the sense that they tend to show higher rotation as well as higher activity, and that their elemental abundances (especially those derived from high-excitation lines) are apt to show apparent overabundances, though this might be due to a

spurious effect reflecting the difficulty of abundance derivation in stars of higher rotation and activity. Our analysis confirmed considerable Be deficiency as well as absence of ^{6}Li as the general characteristics of Li-rich giants under study, which implies that engulfment of planets is rather unlikely for the origin of Li-enrichment.

Accepted for publication in Publ. Astron. Soc. Japan
Available from https://arxiv.org/abs/1706.02273

First detection of methanol towards a post-AGB object, HD 101584

H. Olofsson[1], W.H.T. Vlemmings[1], P. Bergman[1], E.M.L. Humphreys[2], M. Lindqvist[1], M. Maercker[1], L. Nyman[3], S. Ramstedt[4] and D. Tafoya[1]

[1]Dept. of Space, Earth and Environment, Chalmers Univ. of Technology, Onsala Space Observatory, SE-43992 Onsala, Sweden
[2]ESO. Karl-Schwarzschild-Str. 2, D-85748 Garching bei München, Germany
[3]Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura, Santiago de Chile, Chile
[4]Dept. of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden

The circumstellar environments of objects on the asymptotic giant branch and beyond are rich in molecular species. Nevertheless, methanol has never been detected in such an object, and is therefore often taken as a clear signpost for a young stellar object. However, we report the first detection of CH_3OH in a post-AGB object, HD 101584, using ALMA. Its emission, together with emissions from CO, SiO, SO, CS, and H_2CO, comes from two extreme velocity spots on either side of the object where a high-velocity outflow appears to interact with the surrounding medium. We have derived molecular abundances, and propose that the detected molecular species are the effect of a post-shock chemistry where circumstellar grains play a role. We further provide evidence that HD 101584 was a low-mass, M-type AGB star.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1706.08254

UCLCHEM: A gas–grain chemical code for clouds, cores and C-shocks

Jonathan Holdship[1], Serena Viti[1], Izaskun Jiménez-Serra[2], Felix Priestley[1] and Antonios Makrymallis[1]

[1]University College London, UK
[2]Queen Mary University of London, UK

We present a publicly available, open source version of the time dependent gas–grain chemical code UCLCHEM. UCLCHEM propagates the abundances of chemical species through a large network of chemical reactions in a variety of physical conditions. The model is described in detail along with its applications. As an example of possible uses, UCLCHEM is used to explore the effect of protostellar collapse on commonly observed molecules and to study the behaviour of molecules in C-type shocks. We find the collapse of a simple Bonnor–Ebert sphere successfully reproduces most of the behaviour of CO,CS and NH_3 from cores observed by Tafalla et al. (2004) but cannot predict the behaviour of N_2H^+. In the C-shock application, we find that molecules can be categorized so that they can be useful observational tracers of shocks and their physical properties. Whilst many molecules are enhanced in shocked gas, we identify two groups of molecules in particular. A small number of molecules are enhanced by the sputtering of the ices as the shock propagates and then remain high in abundance throughout the shock. A second, larger set are also enhanced by sputtering but then are destroyed as the gas temperature rises. Through these applications the general applicability of UCLCHEM is demonstrated.

Accepted for publication in The Astronomical Journal
Available from https://arxiv.org/abs/1705.10677
and from uclchem.github.io

The impact of red giant/AGB winds on AGN jet propagation

Manel Perucho[1,2], *Valentí Bosch-Ramon*[3] *and Maxim V. Barkov*[4,5,6]

[1]Dept. d'Astronomia i Astrofísica, Universitat de València, C/ Dr. Moliner 50, 46100, Burjassot (València), Spain

[2]Observatori Astronòmic, Universitat de València, C/ Catedràtic José Beltrán 2, 46980, Paterna (València), Spain

[3]Departament de Física Quàntica i Astrofísica, Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona, IEEC-UB, Martí i Franquès 1, E08028 Barcelona, Spain

[4]Astrophysical Big Bang Laboratory, RIKEN, Saitama 351-0198, Japan

[5]DESY, Platanenallee 6, 15738 Zeuthen, Germany

[6]Department of Physics and Astronomy, Purdue University, 525 Northwestern Avenue, West Lafayette, IN 47907-2036, USA

Context: Dense stellar winds may mass-load the jets of active galactic nuclei, although it is unclear what are the time and spatial scales in which the mixing takes place. Aims. Our aim is to study the first steps of the interaction between jets and stellar winds, and also the scales at which the stellar wind may mix with the jet and mass-load it.
Methods: We present a detailed two-dimensional simulation, including thermal cooling, of a bubble formed by the wind of a star, designed to study the initial stages of jet–star interaction. We also study the first interaction of the wind bubble with the jet using a three-dimensional simulation in which the star enters the jet. Stability analysis is carried out for the shocked wind structure, to evaluate the distances over which the jet-dragged wind, which forms a tail, can propagate without mixing with the jet flow.
Results: The two-dimensional simulations point at quick wind bubble expansion and fragmentation after about one bubble shock crossing time. Three-dimensional simulations and stability analysis point at local mixing in the case of strong perturbations and relatively small density ratios between the jet and the jet dragged-wind, and to a possibly more stable shocked wind structure at the phase of maximum tail mass flux. Analytical estimates also indicate that very early stages of the star jet-penetration time may be also relevant for mass loading. The combination of these and previous results from the literature suggests highly unstable interaction structures and efficient wind-jet flow mixing on the scale of the jet interaction height.
Conclusions: The winds of stars with strong mass-loss can efficiently mix with jets from active galactic nuclei. In addition, the initial wind bubble shocked by the jet leads to a transient, large interaction surface. The interaction between jets and stars can produce strong inhomogeneities within the jet. As mixing is expected to be effective on large scales, even individual AGB stars can significantly contribute to the mass-load of the jet and thus affect its dynamics. Shear layer mass-entrainment could be important. The interaction structure can be a source of significant non-thermal emission.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/1706.06301

Do meteoritic silicon carbide grains originate from asymptotic giant branch stars of super-solar metallicity?

M. Lugaro[1,2], *A.I. Karakas*[2,3], *M. Pető*[1] *and E. Plachy*[1]

[1]Konkoly Observatory of the Hungarian Academy of Sciences (MTA CSFK), Hungary

[2]Monash Centre for Astrophysics, Monash University, Australia

[3]Research School for Astronomy and Astrophysics, Australian National University, Australia

We compare literature data for the isotopic ratios of Zr, Sr, and Ba from analysis of single meteoritic stardust silicon carbide (SiC) grains to new predictions for the slow neutron-capture process (the *s* process) in metal-rich asymptotic giant branch (AGB) stars. The models have initial metallicities $Z = 0.014$ (solar) and $Z = 0.03$ (twice-solar) and initial masses 2–4.5 $M_\odot$, selected such as the condition C/O > 1 for the formation of SiC is achieved. Because of the higher Fe abundance, the twice-solar metallicity models result in a lower number of total free neutrons released by the $^{13}C(\alpha,n)^{16}O$ neutron source. Furthermore, the highest-mass (4–4.5 $M_\odot$) AGB stars of twice-solar metallicity present a milder activation of the $^{22}Ne(\alpha,n)^{25}Mg$ neutron source than their solar metallicity counterparts, due to cooler temperatures resulting from the effect of higher opacities. They also have a lower amount of the ^{13}C neutron source than the lower-mass models, following their smaller He-rich region. The combination of these different effects allows our AGB models of twice-solar metallicity to provide a match to the SiC data without the need to consider large

variations in the features of the ^{13}C neutron source nor neutron-capture processes different from the s process. This raises the question if the AGB parent stars of meteoritic SiC grains were in fact on average of twice-solar metallicity. The heavier-than-solar Si and Ti isotopic ratios in the same grains are in qualitative agreement with an origin in stars of super-solar metallicity because of the chemical evolution of the Galaxy. Further, the SiC dust mass ejected from C-rich AGB stars is predicted to significantly increase with increasing the metallicity.

Published in Geochimica Cosmochimica Acta
Available from http://www.sciencedirect.com/science/article/pii/S001670371730354X

Formation of globular clusters with internal abundance spreads in r-process elements: strong evidence for prolonged star formation

Kenji Bekki[1]

[1]ICRAR at UWA, Australia

Several globular clusters (GCs) in the Galaxy are observed to show internal abundance spreads in r-process elements (e.g., Eu). We here propose a new scenario which explains the origin of these GCs (e.g., M 5 and M 15). In this scenario, stars with no/little abundance variations first form from a massive molecular cloud (MC). After all of the remaining gas of the MC is expelled by numerous supernovæ, gas ejected from asymptotic giant branch stars can be accumulated in the central region of the GC to form a high-density intra-cluster medium (ICM). Merging of neutron stars then occurs to eject r-process elements, which can be efficiently trapped in and subsequently mixed with the ICM. New stars formed from the ICM can have r-process abundances quite different from those of earlier generations of stars within the GC. This scenario can explain both (i) why r-process elements can be trapped within GCs and (ii) why GCs with internal abundance spreads in r-process elements do not show [Fe/H] spreads. Our model shows that (i) a large fraction of Eu-rich stars can be seen in Na-enhanced stellar populations of GCs, as observed in M 15, and (ii) why most of the Galactic GCs do not exhibit such internal abundance spreads. Our model demonstrates that the observed internal spreads of r-process elements in GCs provide strong evidence for prolonged star formation ($\sim 10^8$ yr).

Accepted for publication in ApJ
Available from https://arxiv.org/abs/1706.01194

The origin of discrete multiple stellar populations in globular clusters

Kenji Bekki[1]

[1]ICRAR at UWA, Australia

Recent observations have revealed that at least several old globular clusters (GCs) in the Galaxy have discrete distributions of stars along the Mg–Al anti-correlation. In order to discuss this recent observation, we construct a new one-zone GC formation model in which the maximum stellar mass ($m_{\rm max}$) in the initial mass function (IMF) of stars in a forming GC depends on the star formation rate (SFR), as deduced from independent observations. We investigate the star formation histories of forming GCs. The principal results are as follows. About 30 Myr after the formation of the first generation (1G) of stars within a particular GC, new stars can be formed from ejecta from asymptotic giant branch (AGB) stars of 1G. However, the formation of this second generation (2G) of stars can last only for 10–20 Myr, because the most massive SNe of 2G expel all of the remaining gas. The third generation (3G) of stars are then formed from AGB ejecta $\sim$ 30 Myr after the truncation of 2G star formation. This cycle of star formation followed by its truncation by SNe can continue until all AGB ejecta is removed from the GC by some physical process. Thus, it is inevitable that GCs have discrete multiple stellar populations in the [Mg/Fe]–[Al/Fe] diagram. Our model predicts that low-mass GCs are unlikely to have discrete multiple stellar populations, and young massive clusters may not have massive OB stars owing to low $m_{\rm max}$ (20–30 $M_\odot$) during the secondary star formation.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/1706.06787

Conference Papers

San Pedro meeting on Wide Field Variability Surveys: Some concluding comments

Michael Feast[1,2]

[1]South African Astronomical Observatory, South Africa

[2]Astronomy Dept. University of Cape Town, South Africa

This is a written version of the closing talk at the 22$^{\rm nd}$ Los Alamos Stellar pulsation conference on wide field variability surveys. It comments on some of the issues which arise from the meeting. These include the need for attention to photometric standardization (especially in the infrared) and the somewhat controversial problem of statistical bias in the use of parallaxes (and other methods of distance determination). Some major advances in the use of pulsating variables to study Galactic structure are mentioned. The paper includes a clarification of apparently conflicting results from classical Cepheids and RR Lyræ stars in the inner Galaxy and bulge. The importance of understanding non-periodic phenomena in variable stars,particularly AGB variables and RCB stars is stressed, especially for its relevance to mass-loss, in which pulsation may only play a minor role.

Oral contribution, published in the San Pedro meeting
Available from https://arxiv.org/abs/1702.07147

Spectroscopic surveys of massive AGB and super-AGB stars

D.A. García-Hernández[1,2]

[1]Instituto de Astrofísica de Canarias, Tenerife, Spain

[2]Departamento de Astrofísica, Universidad de La Laguna (ULL), Tenerife, Spain

It is now about 30 years ago that photometric and spectroscopic surveys of asymptotic giant branch (AGB) stars in the Magellanic Clouds (MCs) uncovered the first examples of truly massive (> 3–$4\ M_\odot$) O-rich AGB stars experiencing hot bottom burning (HBB). Massive (Li-rich) HBB AGB stars were later identified in our own Galaxy and they pertain to the Galactic population of obscured OH/IR stars. High-resolution optical spectroscopic surveys have revealed the massive Galactic AGB stars to be strongly enriched in Rb compared to other nearby *s*-process elements like Zr, confirming that ^{22}Ne is the dominant neutron source in these stars. Similar surveys of OH/IR stars in the MCs disclosed their Rb-rich low-metallicity counterparts, showing that these stars are usually brighter (because of HBB flux excess) than the standard adopted luminosity limit for AGB stars ($M_{\rm bol} \sim -7.1$ mag) and that they might have stellar masses of at least ~ 6–$7\ M_\odot$. The chemical composition and photometric variability are efficient separating the massive AGB stars from massive red supergiants (RSG) but the main difficulty is to distinguish between massive AGB and super-AGB stars because the present theoretical nucleosynthesis models predict both stars to be chemically identical. Here I review the available multiwavelength (from the optical to the far-IR) observations on massive AGB and super-AGB stars as well as the current caveats and limitations in our undestanding of these stars. Finally, I underline the expected observations on massive AGB and super-AGB stars from on-going massive surveys like Gaia and SDSS-IV/APOGEE-2 and future facilities such as the *James Webb* Space Telescope.

Oral contribution, published in "The AGB–Supernovæ Mass Transition", MemSAI (Invited Review)
Available from https://arxiv.org/abs/1706.02107

Observed properties of red supergiant and massive AGB star populations

Jacco Th. van Loon[1]

[1]Lennard Jones Laboratories, Keele University, ST5 5BG, UK

This brief review describes some of the observed properties of the populations of massive asymptotic giant branch (AGB) stars and red supergiants (RSGs) found in nearby galaxies, with a focus on their luminosity functions, mass-loss rates and dust production. I do this within the context of their role as potential supernova (SN) progenitors, and the evolution of SNe and their remnants. The paper ends with an outlook to the near future, in which new facilities such as the *James Webb* Space Telescope offer a step change in our understanding of the evolution and fate of the coolest massive stars in the Universe.

Oral contribution, published in "The AGB–Supernovæ Mass transition" held in Rome in March 2017, Memorie della Società Astronomica Italiana, eds. Amanda Karakas, Paolo Ventura, Flavia Dell'Agli and Marcella Di Criscienzo (Invited Review)
Available from https://arxiv.org/abs/1706.01729

Overshoot Inwards from the bottom of the intershell convective zone in (S)AGB stars

J.C. Lattanzio[1]*, C.A. Tout*[2]*, E.V. Neumerzhitckii*[1]*, A.I. Karakas*[1] *and P. Lesaffre*[3]

[1]Monash Centre for Astrophysics, School of Physics and Astronomy, Monash University, 3800, Australia

[2]Institute of Astronomy, The Observatories, Madingley Road, Cambridge, CB3 0HA, UK

[3]Laboratoire de radioastronomie, LERMA, Observatoire de Paris, École Normale Supérieure (UMR 8112 CNRS), 75231 Paris Cedex 05, France

We estimate the extent of overshooting inwards from the bottom of the intershell convective zone in thermal pulses in (S)AGB stars. We find that the buoyancy is so strong that any overshooting should be negligible. The temperature inversion at the bottom of the convective zone adds to the stability of the region. Any mixing that occurs in this region is highly unlikely to be due to convective overshooting, and so must be due to another process.

Oral contribution, published in "The AGB–Supernovæ Mass Transition", Rome, March 27–31, 2017
Available from https://arxiv.org/abs/1706.07615

Announcements

One Hand Waving Free
A Workshop to Celebrate the first 60 years of John Lattanzio

One Hand Waving Free
A Workshop to Celebrate the first 60 years of John Lattanzio
Port Douglas, Queensland
29$^{\text{th}}$ October to 4$^{\text{th}}$ November 2017.

This meeting celebrates the life and achievements of Prof. John C. Lattanzio. John has made a succession of important contributions to the theory of stellar evolution over a sustained career that has seen him move to Canada, the USA and the United Kingdom before returning to his Australian roots. He remains instantly recognisable on the international stage where he is a speaker of choice on many aspects of stellar evolution and nucleosynthesis. Lattanzio's contributions to research training at all levels are numerous. His undergraduate lectures are delivered with an enthusiasm that has ignited many a career in astrophysics and he has trained a number of excellent graduate students and post-doctoral researchers who have gone on to hold positions worldwide. John is the active president of the International

Astronomical Union's Division G3 on stellar evolution.

The workshop will cover the topics on which John has had such an impact through his varied and distinguished career. Scientific sessions will focus on topics on which John has worked and will include stellar evolution of low- and intermediate- mass stars, SAGB stars, nucleosynthesis, grains, galactic archæology and hydrodynamics of star formation and evolution as well as outreach sessions for the public and for undergraduates.

Please address any questions to lattanzio60th@gmail.com

We look forward to hearing from you soon and indeed seeing you in Port Douglas.

Spaces are limited but there is plenty of room for now. Registration is open with a deadline of 28$^{\mathrm{th}}$ July.

Many thanks and best wishes,
Christopher Tout, John Lattanzio, Richard Stancliffe, Amanda Karakas and Ghina Halabi

See also http://www.ast.cam.ac.uk/~gmh/JL60th/

Open Enrollment for the JCMT Large Program NESS: The Nearby Evolved Stars Survey

We are pleased to announce the JCMT large program "The Nearby Evolved Stars Survey: the gas and dust return to the Galactic interstellar medium" (NESS). As all JCMT large programs, there is a period during which enrollment is open to any astronomer associated with an EAO region (China, Japan, South Korea or Taiwan) or JCMT partner (Canada or certain institutes in the UK); to confirm whether you are eligible please visit
http://www.eaobservatory.org/jcmt/proposals/eao_eligibility/.
You may join NESS at http://www.surveygizmo.com/s3/3584497/JCMT-OpenEnrollment2017.

NESS targets a volume-limited sample of $\sim$ 300 mass-losing AGB stars within 2 kpc to derive the dust and gas return rates in the Solar Neighborhood, and constrain the physics underlying these processes. The sample covers 6 orders of magnitude in dust-production rate, and will reveal the interplay between different physical processes.

We will observe our sample with SCUBA2, thus extending the infrared spectral energy distribution to the submm, allowing us to detect the coldest dust tracing historical mass loss. Second, we will target our sample with HARP and RxA3 in the CO(3–2) and CO(2–1) transition, to determine the gas mass loss rate, where, again for nearby sources it is possible to construct maps that allow us to spatially resolve the gas mass-loss history. Nearby targets will be spatially resolved in both continuum and CO lines, making it possible to resolve variations in the dust mass-loss history and gas-to-dust ratio. Finally, we will observe the sample in the ^{13}CO(2–1) and (3–2) lines to measure the ^{13}C/^{12}C ratio, providing strong constraints on models of stellar evolution and AGB nucleosynthesis.

For further information, please contact me (peterscicluna@asiaa.sinica.edu.tw) or your regional coordinator (see http://www.eaobservatory.org/jcmt/science/large-programs/ness/). Please forward this announcement to others who may be interested in the project. Once again, you may join the project by visiting
http://www.surveygizmo.com/s3/3584497/JCMT-OpenEnrollment2017; we hope to hear from many of you soon.

Kind regards,

Peter Scicluna, on behalf of the NESS team.

See also http://www.eaobservatory.org/jcmt/science/large-programs/
and http://www.eaobservatory.org/jcmt/science/large-programs/ness/