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. 235 — 1 February 2017

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 235$^{\rm th}$ issue of the AGB Newsletter. Not wanting to single out certain works as opposed to others, we would like to highlight the new PARSEC/COLIBRI models from the Padova group (Paola Marigo et al.), the use of Gaia data of Miras to trace the structure of the Magellanic Clouds (Alis Deason et al.) and the review on Kepler's supernova (Jacco Vink).

Do take note of the workshops on the *i* process of nucleosynthesis, during the European week of Astronomy and space Science in Prague; the second conference on the physics of evolved stars – focussing on binarity – in Nice; and the link between observation and theory of AGB stars in Göteborg.

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

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

Food for Thought

This month's thought-provoking statement is:

Kepler's supernova progenitor was once an AGB star

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

(sub)Millimeter emission lines of molecules in born-again stars

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The detection and study of molecular gas in born-again stars would be of great importance to understand their composition and chemical evolution. In addition, the molecular emission would be an invaluable tool to explore the physical conditions, kinematics and formation of asymmetric structures in the circumstellar envelopes of these evolved stars. However, until now, all attempts to detect molecular emission from the cool material around born-again stars have failed. We carried out observations using the APEX and IRAM 30m telescopes to search for molecular emission toward four well studied born-again stars, V4334 Sgr, V605 Aql, A 30 and A 78, that are thought to represent an evolutionary sequence. We detected for the first time emission from HCN and $H^{13}CN$ molecules toward V4334 Sgr, and CO emission in V605 Aql. No molecular emission was detected above the noise level toward A 30 and A 78. A first estimate of the $H^{12}CN/H^{13}CN$ abundance ratio in the circumstellar environment of V4334 Sgr is ≈ 3, which is similar to the value of the $^{12}C/^{13}C$ ratio measured from other observations. We derived a rotational temperature of $T_{\rm rot} = 13 \pm 1$ K, and a total column density of $N_{\rm HCN} = 1.6 \pm 0.1 \times 10^{16}$ cm^{-2} for V4334 Sgr. This result sets a lower limit on the amount of hydrogen that was ejected into the wind during the born-again event of this source. For V605 Aql, we obtained a lower limit for the integrated line intensities $I_{^{12}C}/I_{^{13}C} > 4$.

Accepted for publication in A&A
Available from http://arxiv.org/abs/1612.07037
and from https://www.researchgate.net/publication/
311774998_subMillimeter_Emission_Lines_of_Molecules_in_Born-again_Stars

Constructing stable 3D hydrodynamical models of giant stars

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Hydrodynamical simulations of stellar interactions require stable models of stars as initial conditions. Such initial models, however, are difficult to construct for giant stars because of the wide range in spatial scales of the hydrostatic equilibrium and in dynamical timescales between the core and the envelope of the giant. They are needed for, e.g., modeling the common envelope phase where a giant envelope encompasses both the giant core and a companion star. Here, we present a new method of approximating and reconstructing giant profiles from a stellar evolution code to produce stable models for multi-dimensional hydrodynamical simulations. We determine typical stellar stratification profiles with the one-dimensional stellar evolution code MESA. After an appropriate mapping, hydrodynamical simulations are conducted using the moving-mesh code AREPO. The giant profiles are approximated by replacing the core of the giant with a point mass and by constructing a suitable continuation of the profile to the center. Different

reconstruction methods are tested that can specifically control the convective behaviour of the model. After mapping to a grid, a relaxation procedure that includes damping of spurious velocities yields stable models in three-dimensional hydrodynamical simulations. Initially convectively stable configurations lead to stable hydrodynamical models while for stratifications that are convectively unstable in the stellar evolution code, simulations recover the convective behaviour of the initial model and show large convective plumes with Mach numbers up to 0.8. Examples are shown for a 2 $M_\odot$ red giant and a 0.67 $M_\odot$ asymptotic giant branch star. A detailed analysis shows that the improved method reliably provides stable models of giant envelopes that can be used as initial conditions for subsequent hydrodynamical simulations of stellar interactions involving giant stars.

Accepted for publication in Astronomy and Astrophysics
Available from http://arxiv.org/abs/1612.00008

A new sample of mid-infrared bright, long-period Mira variables from the MACHO Galactic Bulge fields

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Mid-infrared bright objects in the direction of the Galactic Bulge were investigated using time series photometry from the MACHO data archive, which led to the discovery of a large number of long-period variables. Among these, a total of 192 bona-fide Mira variables was identified, which, to the best of our knowledge, are reported here for the first time. Together with the results from our previous investigations, we thereby bring the number of Mira variables found in the MACHO Galactic Bulge fields to a new total of 1286 stars. Light curves, folded light curves and summary data for all new Mira variables are presented and their properties in colour–colour, period–colour and period–magnitude space are investigated. In agreement with our expectations, the present sample of mid-infrared bright objects is composed mostly of luminous, long-period variables.

Published in BAV Journal No. 10, September (2016)
Available from http://arxiv.org/abs/1612.00706
and from https://www.bav-astro.eu/images/Up_Journal/BAVJ010_mid_inf_bright_miras_R2.pdf

ALMA Compact Array observations of the Fried Egg nebula: Evidence for large-scale asymmetric mass-loss from the yellow hypergiant IRAS 17163−3907

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Yellow hypergiants are rare and represent a fast evolutionary stage of massive evolved stars. That evolutionary phase

is characterised by a very intense mass loss, the understanding of which is still very limited. Here we report ALMA Compact Array observations of a 50″-mosaic toward the Fried Egg nebula, around one of the few Galactic yellow hypergiants IRAS 17163−3907. The emission from the ^{12}CO $J = 2$–1 line, H30α recombination line, and continuum is imaged at a resolution of $\sim 8''$, revealing the morphology of the molecular environment around the star. The continuum emission is unresolved and peaks at the position of the star. The radio recombination line H30α shows unresolved emission at the star, with an approximately gaussian spectrum centered on a velocity of 21 ± 3 km s^{-1} with a width of 57 ± 6 km s^{-1}. In contrast, the CO 2–1 emission is complex and decomposes into several components beyond the contamination from interstellar gas in the line of sight. The CO spectrum toward the star is a broad plateau, centered at the systemic velocity of +18 km s^{-1} and with an expansion velocity of 100 ± 10 km s^{-1}. Assuming isotropic and constant mass loss, we estimate a mass-loss rate of $8 \pm 1.5 \times 10^{-5}$ M$_\odot$ yr^{-1}. At a radius of 25″ from the star, we detect CO emission associated with the dust ring previously imaged by *Herschel*. The kinematics of this ring, however, is not consistent with an expanding shell, but show a velocity gradient of $v_{\rm sys} \pm 20$ km s^{-1}. In addition, we find a puzzling bright feature radially connecting the star to the CO ring, at a velocity of +40 km s^{-1} relative to the star. This spur feature may trace a unidirectional ejection event from the star. Our ACA observations reveal the complex morphology around IRAS 17163−3907 and illustrate the breakthroughs that ALMA will bring to the field of massive stellar evolution.

Accepted for publication in Astronomy & Astrophysics
Available from http://arxiv.org/abs/1612.02510
and from http://dx.doi.org/10.1051/0004-6361/201628416

Monitoring observations of H_2O and SiO masers toward post-AGB stars

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We present the results of simultaneous monitoring observations of H_2O 6(1,6)–5(2,3) (22 GHz) and SiO $J = 1$–0, 2–1, 3–2 maser lines (43, 86, 129 GHz) toward five post-AGB (candidate) stars, using the 21-m single-dish telescopes of the Korean VLBI Network. Depending on the target objects, 7–11 epochs of data were obtained. We detected both H_2O and SiO maser lines from four sources: OH 16.1−0.3, OH 38.10−0.13, OH 65.5+1.3, and IRAS 19312+1950. We could not detect H_2O maser emission toward OH 13.1+5.1 between the late OH/IR and post-AGB stage. The detected H_2O masers show typical double-peaked line profiles. The SiO masers from four sources, except IRAS 19312+1950, show the peaks around the stellar velocity as a single peak, whereas the SiO masers from IRAS 19312+1950 occur above the red peak of the H_2O maser. We analyzed the properties of detected maser lines, and investigated their evolutionary state through comparison with the full widths at zero power. The distribution of observed target sources was also investigated in the IRAS two-color diagram in relation with the evolutionary stage of post-AGB stars. From our analyses, the evolutionary sequence of observed sources is suggested as OH 65.5+1.3 → OH 13.1+5.1 → OH 16.1−0.3 → OH 38.10−0.13, except for IRAS 19312+1950. In addition, OH 13.1+5.1 from which the H_2O maser has not been detected is suggested to be on the gateway toward the post-AGB stage. With respect to the enigmatic object, IRAS 19312+1950, we could not clearly figure out its nature. To properly explain the unusual phenomena of SiO and H_2O masers, it is essential to establish the relative locations and spatial distributions of two masers using VLBI technique. We also include the 1.2–160 μm spectral energy distribution using photometric data from the following surveys: 2MASS, WISE, MSX, IRAS, and AKARI (IRC and FIS). In addition, from the IRAS LRS spectra, we found that the depth of silicate absorption features shows significant variations depending on the evolutionary sequence, associated with the termination of AGB phase mass-loss.

Published in Journal of the Korean Astronomical Society
Available from http://jkas.kas.org/journals/2016v49n6/v49n6p261_heon.pdf

Fluorine in the Solar neighborhood: No evidence for the neutrino process

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Asymptotic Giant Branch stars are known to produce 'cosmic' fluorine but it is uncertain whether these stars are the main producers of fluorine in the Solar neighborhood or if any of the other proposed formation sites, type II supernovæ and/or Wolf–Rayet stars, are more important. Recent articles have proposed both Asymptotic Giant Branch stars as well as type II supernovæ as the dominant sources of fluorine in the Solar neighborhood. In this paper we set out to determine the fluorine abundance in a sample of 49 nearby, bright K-giants for which we previously have determined the stellar parameters as well as alpha abundances homogeneously from optical high-resolution spectra. The fluorine abundance is determined from a 2.3 μm HF molecular line observed with the spectrometer Phoenix. We compare the fluorine abundances with those of α elements mainly produced in type II supernovæ and find that fluorine and the α elements do not evolve in lock-step, ruling out type II supernovæ as the dominating producers of fluorine in the Solar neighborhood. Furthermore, we find a secondary behavior of fluorine with respect to oxygen, which is another evidence against the type II supernovæ playing a large role in the production of fluorine in the Solar neighborhood. This secondary behavior of fluorine will put new constraints on stellar models of the other two suggested production sites: Asymptotic Giant Branch stars and Wolf–Rayet stars.

Accepted for publication in ApJ
Available from http://arxiv.org/abs/1612.04384

$H^{12}CN$ and $H^{13}CN$ excitation analysis in the circumstellar outflow of R Scl

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Context: The $^{12}CO/^{13}CO$ isotopologue ratio in the circumstellar envelope (CSE) of asymptotic giant branch (AGB) stars has been extensively used as the tracer of the photospheric $^{12}C/^{13}C$ ratio. However, spatially-resolved ALMA observations of R Scl, a carbon rich AGB star, have shown that the $^{12}CO/^{13}CO$ ratio is not consistent over the entire CSE. It can hence not necessarily be used as a tracer of the $^{12}C/^{13}C$ ratio. The most likely hypothesis to explain the observed discrepancy between the $^{12}CO/^{13}CO$ and $^{12}C/^{13}C$ ratios is CO isotopologue selective photodissociation by UV radiation. Unlike the CO isotopologue ratio, the HCN isotopologue ratio is not affected by UV radiation. Therefore, HCN isotopologue ratios can be used as the tracer of the atomic C ratio in UV irradiated regions.
Aims: We present ALMA observations of $H^{13}CN$(4–3) and APEX observations of $H^{12}CN$(2–1), $H^{13}CN$(2–1, 3–2) toward R Scl. These new data, combined with previously published observations, are used to determine abundances, the ratio, and the sizes of line-emitting regions of the aforementioned HCN isotopologues.
Methods: We have performed a detailed non-LTE excitation analysis of circumstellar $H^{12}CN$(J = 1–0, 2–1, 3–2, 4–3) and $H^{13}CN$(J = 2–1, 3–2, 4–3) line emission around R Scl using a radiative transfer code based on the accelerated lambda iteration (ALI) method. The spatial extent of the molecular distribution for both isotopologues is constrained based on the spatially resolved $H^{13}CN$(4–3) ALMA observations.
Results: We find fractional abundances of $H^{12}CN/H_2 = (5.0 \pm 2.0) \times 10^{-5}$ and $H^{13}CN/H_2 = (1.9 \pm 0.4) \times 10^{-6}$ in the inner wind ($r < (2.0 \pm 0.25) \times 10^{15}$ cm) of R Scl. The derived circumstellar isotopologue ratio of $H^{12}CN/H^{13}CN = 26.3 \pm 11.9$ is consistent with the photospheric ratio of $^{12}C/^{13}C \sim 19 \pm 6$.
Conclusions: We show that the circumstellar $H^{12}CN/H^{13}CN$ ratio traces the photospheric $^{12}C/^{13}C$ ratio. Hence, contrary to the $^{12}CO/^{13}CO$ ratio, the $H^{12}CN/H^{13}CN$ ratio is not affected by UV radiation. These results support

the previously proposed explanation that CO isotopologue selective-shielding is the main factor responsible for the observed discrepancy between $^{12}C/^{13}C$ and $^{12}CO/^{13}CO$ ratios in the inner CSE of R Scl. This indicates that UV radiation impacts on the CO isotopologue ratio. This study shows how important is to have high-resolution data on molecular line brightness distribution in order to do a proper radiative transfer modelling.

Accepted for publication in Astronomy & Astrophysics
Available from http://arxiv.org/abs/1612.05573

Multiple populations along the asymptotic giant branch of the globular cluster M 4

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Nearly all Galactic globular clusters host stars that display characteristic abundance anti-correlations, like the O-rich/Na-poor pattern typical of field halo stars, together with O-poor/Na-rich additional components. A recent spectroscopic investigation questioned the presence of O-poor/Na-rich stars amongst a sample of asymptotic giant branch stars in the cluster M 4, at variance with the spectroscopic detection of a O-poor/Na-rich component along both the cluster red giant branch and horizontal branch. This is contrary to what is expected from the cluster horizontal branch morphology and horizontal branch stellar evolution models. Here we have investigated this issue by employing the $C_{\rm UBI} = (U - B) - (B - I)$ index, that previous studies have demonstrated to be very effective in separating multiple populations along both the red giant and asymptotic giant branch sequences. We confirm previous results that the RGB is intrinsically broad in the V–$C_{\rm UBI}$ diagram, with the presence of two components which nicely correspond to the two populations identified by high-resolution spectroscopy. We find that AGB stars are distributed over a wide range of $C_{\rm UBI}$ values, in close analogy with what is observed for the RGB, demonstrating that the AGB of M 4 also hosts multiple stellar populations.

Accepted for publication in MNRAS
Available from http://arxiv.org/abs/1612.08929
and from https://academic.oup.com/mnras/article/doi/10.1093/mnras/stw3374/2769502/Multiple-populations-along-the-asymptotic-giant

A second post-AGB nebula that contains gas in rotation and in expansion: ALMA maps of IW Car

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We aim to study the presence of both rotation and expansion in post-AGB nebulae, in particular around IW Car, a binary post-AGB star that was suspected to be surrounded by a Keplerian disk. We obtained high-quality ALMA observations of ^{12}CO and ^{13}CO $J = 3$–2 lines in IW Car. The maps were analyzed by means of a simplified model of

CO emission, based on those used for similar objects. Our observations clearly show the presence of gas components in rotation, in an equatorial disk, and expansion, which shows an hourglass-like structure with a symmetry axis perpendicular to the rotation plane and is probably formed of material extracted from the disk. Our modeling can reproduce the observations and shows moderate uncertainties. The rotation velocity corresponds to a central stellar mass of approximately 1 $M_\odot$. We also derive the total mass of the molecule-rich nebula, found to be of $\sim 4 \times 10^{-3}$ $M_\odot$; the outflow is approximately eight times less massive than the disk. From the kinematical age of the outflow and the mass values derived for both components, we infer a (future) lifetime of the disk of approximately 5 000–10 000 yr.

Published in Astronomy & Astrophysics, 597, L5 (2017)
Available from http://arxiv.org/abs/1612.03568

Photometric and spectroscopic observations of the outburst of the symbiotic star AG Draconis between March and June 2016

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The symbiotic star AG Dra experienced a double-peaked outburst of 0.6 magnitudes in April and May 2016. Photometry and spectroscopy through the outburst showed the $B - V$ colour index varying linearly with the V magnitude and enabled the temperature variation of the hot star to be calculated from the changing flux in the Hβ and He II 4686Å emission lines.

Published in Journal of the British Astronomical Association, 126, 271 (2016)
Available from http://arxiv.org/abs/1612.07352

ALMA observations of the water fountain pre-planetary nebula IRAS 16342−3814: High-velocity bipolar jets and an expanding torus

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We have mapped ^{12}CO $J = 3$–2 and other molecular lines from the "water-fountain" bipolar pre-planetary nebula (PPN) IRAS 16342−3814 with $\sim 0\farcs35$ resolution using ALMA. We find (i) two very high-speed knotty, jet-like molecular outflows, (ii) a central high-density (> few $\times 10^6$ cm^{-3}), expanding torus of diameter 1300 au, and (iii) the circumstellar envelope of the progenitor AGB, generated by a sudden, very large increase in the mass-loss rate to $> 3.5 \times 10^{-4}$ $M_\odot$ yr^{-1} in the past ~ 455 yr. Strong continuum emission at 0.89 mm from a central source (690 mJy), if due to thermally-emitting dust, implies a substantial mass (0.017 $M_\odot$) of very large (∼mm-sized) grains. The measured expansion ages of the above structural components imply that the torus (age ~ 160 yr) and the younger high-velocity outflow (age ~ 110 yr) were formed soon after the sharp increase in the AGB mass-loss rate. Assuming a binary model for the jets in IRAS 16342−3814, the high momentum rate for the dominant jet-outflow in IRAS 16342−3814 implies a high minimum accretion rate, ruling out standard Bondi–Hoyle–Lyttleton wind accretion and wind Roche lobe overflow (RLOF) models with white-dwarf or main-sequence companions. Most likely, enhanced RLOF from the primary or accretion modes operating within common envelope evolution are needed.

Accepted for publication in Astrophysical Journal Letters
Available from http://arxiv.org/abs/1612.05616

The adventure of carbon stars – Observations and modelling of a set of C-rich AGB stars

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Context: Modelling stellar atmospheres is a complex, intriguing task in modern astronomy. A systematic comparison of models with multi-technique observations is the only efficient way to constrain the models.
Aims: We intend to perform self-consistent modelling of the atmospheres of six carbon-rich AGB stars: R Lep, R Vol, Y Pav, AQ Sgr, U Hya and X TrA, with the aim of enlarging the knowledge of the dynamic processes occurring in their atmospheres.
Methods: We used VLTI/MIDI interferometric observations, in combination with spectro-photometric data, and compared them with self-consistent dynamic models atmospheres.
Results: We found that the models can reproduce SED data well at wavelengths longward of 1 μm, and the interferometric observations between 8 μm and 10 μm. Discrepancies observed at wavelengths shorter than 1 μm in the SED, and longwards of 10 μm in the visibilities, could be due to a combination of data- and model-related effects. The models best fitting the Miras are significantly extended, and have a prominent shell-like structure. On the contrary, the models best fitting the non-Miras are more compact, showing lower average mass-loss. The mass loss is of episodic or multi-periodic nature but causes the visual amplitudes to be notably larger than the observed ones. A number of stellar parameters were derived from the model fitting: $T_{\rm eff}$, $L_{\rm bol}$, M, C/O, $\dot{M}$. Our findings agree well with literature values within the uncertainties. $T_{\rm eff}$ and $L_{\rm bol}$ are also in good agreement with the temperature derived from the angular diameter $\theta_{(V-K)}$ and the bolometric luminosity from the SED fitting $L_{\rm bol}$, except for AQ Sgr. The possible reasons are discussed in the text. Finally, $\theta_{\rm Ross}$ and $\theta_{(V-K)}$ agree with each other better for the Miras targets than for the non-Miras, which is probably connected to the episodic nature of the latter models. We also located the stars in the H–R diagram, comparing them with evolutionary tracks. We found that the main derived properties (L, $T_{\rm eff}$, C/O ratios and stellar masses) from the model fitting are in good agreement with TP-AGB evolutionary calculations for carbon stars carried out with the COLIBRI code.

Accepted for publication in Astronomy & Astrophysics
Available from http://arxiv.org/abs/1701.04331

A circumbinary debris disk in a polluted white dwarf system

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Planetary systems commonly survive the evolution of single stars, as evidenced by terrestrial-like planetesimal debris observed orbiting and polluting the surfaces of white dwarfs. This letter reports the identification of a circumbinary dust disk surrounding a white dwarf with a substellar companion in a 2.27 hr orbit. The system bears the dual hallmarks of atmospheric metal pollution and infrared excess, however the standard (flat and opaque) disk configuration is dynamically precluded by the binary. Instead, the detected reservoir of debris must lie well beyond the Roche limit in an optically thin configuration, where erosion by stellar irradiation is relatively rapid. This finding demonstrates that rocky planetesimal formation is robust around close binaries, even those with low mass ratios.

Accepted for publication in Nature Astronomy
Available from http://arxiv.org/abs/1612.05259

Chemical abundance analysis of 13 southern symbiotic giants from high-resolution spectra at ~ 1.56 μm

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Symbiotic stars (SySt) are binaries composed of a star in the later stages of evolution and a stellar remnant. The enhanced mass-loss from the giant drives interacting mass exchange and makes these systems laboratories for understanding binary evolution. Studies of the chemical compositions are particularly useful since this parameter has strong impact on the evolutionary path. The previous paper in this series presented photospheric abundances for 24 giants in S-type SySt enabling a first statistical analysis. Here we present results for an additional sample of 13 giants. The aims are to improve statistics of chemical composition involved in the evolution of SySt, to study evolutionary status, mass transfer and to interpret this in terms of Galactic populations. High-resolution, near-IR spectra are used, employing the spectrum synthesis method in a classical approach, to obtain abundances of CNO and elements around the iron peak (Fe, Ti, Ni). Low-resolution spectra in the region around the Ca II triplet were used for spectral classification. The metallicities obtained cover a wide range with a maximum around ~ -0.2 dex. The enrichment in the ^{14}N isotope indicates that these giants have experienced the first dredge-up. Relative O and Fe abundances indicate that most SySt belong to the Galactic disc; however, in a few cases, the extended thick-disc/halo is suggested. Difficult to explain, relatively high Ti abundances can indicate that adopted microturbulent velocities were too small by ~ 0.2–0.3 km s^{-1}. The revised spectral types for V2905 Sgr, and WRAY 17-89 are M3 and M6.5, respectively.

Accepted for publication in MNRAS
Available from http://arxiv.org/abs/1612.04632

New R Coronæ Borealis and DY Persei candidates in the SMC

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We report 3 new R Coronæ Borealis and 63 new DY Persei candidates in the Small Magellanic Cloud. Our analysis, based on data published by the OGLE team, consisted in a search for the characteristic drops in brightness that define these classes. All candidates had been previously classified as semi-regular or Mira variables. We briefly remark upon the possible existence of a "borderline" DY Per-like star and a "transitional" DY Per/RCB star. Follow-up observations are needed to conclusively establish the nature of our candidates.

Published in Information Bulletin on Variable Stars
Available from http://arxiv.org/abs/1612.05546
and from http://ibvs.konkoly.hu/cgi-bin/IBVS?6190

Astrometry of OH/IR stars using 1612 MHz hydroxyl masers. I. Annual parallaxes of WX Psc and OH 138.0+7.2

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We report on the measurement of the trigonometric parallaxes of 1612 MHz hydroxyl masers around two asymptotic giant branch stars, WX Psc and OH 138.0+7.2, using the NRAO Very Long Baseline Array with in-beam phase referencing calibration. We obtained a 3σ upper limit of ≤ 5.3 mas on the parallax of WX Psc, corresponding to a lower limit distance estimate of $\gtrsim$190 pc. The obtained parallax of OH 138.0+7.2 is 0.52 ± 0.09 mas ($\pm$18%), corresponding to a distance of $1.9^{+0.4}_{-0.3}$ kpc, making this the first hydroxyl maser parallax below one milliarcsecond. We also introduce a new method of error analysis for detecting systematic errors in the astrometry. Finally, we compare our trigonometric distances to published phase-lag distances toward these stars and find a good agreement between the two methods.

Accepted for publication in The Astronomical Journal
Available from http://arxiv.org/abs/1701.05101

Multi-band polarimetry of post-asymptotic giant branch stars stars – I. Optical measurements

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We present new optical broad-band ($UBVRI$) aperture polarimetric observations of 53 post-asymptotic giant branch (AGB) stars selected to exhibit a large near-infrared excess. 24 out of the 53 stars (45% of our sample) are presented for the first time. A statistical analysis shows four distinctive groups of po larized post-AGB stars: unpolarized or very lowly polarized (degree of polarization or $DoP < 1\%$), lowly polarized ($1\% < DoP < 4\%$), moderately polarized ($4\% < DoP < 8\%$) and highly polarized ($DoP > 8\%$). 23 out of the 53 (66%) belong to the first group, 10 (19%) to the second, five (9%) to the third and only three (6%) to the last group. Approximately, 34% of our sample was found to be unpolarized objects, which is close to the percentage of round planetary nebulæ. On average, the low and moderate groups show a wavelength-dependent polarization that increases towards shorter wavelength, implying an intrinsic origin of the polarization, which signifies a Rayleigh-like scattering spectrum typical for non-symmetrical envelopes composed principally of small dust grains. The moderately polarized stars exhibit higher $K-W3$ and $W1-W3$ colour

indices compared with the group of lowly polarized stars suggesting a possible relation between DoP and mass-loss rate. Moreover, they are found to be systematically colder (redder in $B-V$), which may be associated with the condensation process close to these stars that results in higher degree of polarization. We also provide evidence that multiple scattering in optically thin polar outflows is the mechanism that gives high DoP in post-AGB stars with a bipolar or multi-polar envelopes.

Accepted for publication in MNRAS
Available from http://arxiv.org/abs/1701.03809

A new generation of PARSEC–COLIBRI stellar isochrones including the TP-AGB phase

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We introduce a new generation of PARSEC–COLIBRI stellar isochrones that include a detailed treatment of the thermally-pulsing asymptotic giant branch (TP-AGB) phase, and covering a wide range of initial metallicities ($0.0001 < Z_{\rm i} < 0.06$). Compared to previous releases, the main novelties and improvements are: use of new TP-AGB tracks and related atmosphere models and spectra for M and C-type stars; inclusion of the surface H+He+CNO abundances in the isochrone tables, accounting for the effects of diffusion, dredge-up episodes and hot-bottom burning; inclusion of complete thermal pulse cycles, with a complete description of the in-cycle changes in the stellar parameters; new pulsation models to describe the long-period variability in the fundamental and first overtone modes; new dust models that follow the growth of the grains during the AGB evolution, in combination with radiative transfer calculations for the reprocessing of the photospheric emission. Overall, these improvements are expected to lead to a more consistent and detailed description of properties of TP-AGB stars expected in resolved stellar populations, especially in regard to their mean photometric properties from optical to mid-infrared wavelengths. We illustrate the expected numbers of TP-AGB stars of different types in stellar populations covering a wide range of ages and initial metallicities, providing further details on the C-star island that appears at intermediate values of age and metallicity, and about the AGB-boosting effect that occurs at ages close to 1.6 Gyr for populations of all metallicities. The isochrones are available through a new dedicated web server.

Published in The Astrophysical Journal, 835, 77 (2017)

The origin of the near-infrared excess in SN Ia 2012dn: Circumstellar dust around the super-Chandrasekhar supernova candidate

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The nature of progenitors of the so-called super-Chandrasekhar candidate Type Ia supernovæ (SC-SNe Ia) has been

actively debated. Recently, Yamanaka et al. (2016) reported a near-infrared (NIR) excess for SN 2012dn, and proposed that the excess originates from an echo by circumstellar (CS) dust. In this paper, we examine a detailed distribution of the CS dust around SN 2012dn, and investigate implications of the CS dust echo scenario for general cases of SC-SNe Ia. We find that a disk/bipolar CS medium configuration reproduces the NIR excess fairly well, where the radial density distribution is given by a stationary mass loss. The inner radius of the CS dust is 0.04 pc. The mass-loss rate of the progenitor system is estimated to be 1.2×10^{-5} and 3.2×10^{-6} $M_\odot$ yr^{-1} for the disk and bipolar CS medium configurations, respectively, which adds another support for the single degenerate scenario. Our models limit SN 2009dc, another SC-SN Ia, to have a dust mass less than 0.16 times that of SN 2012dn. While this may merely indicate some variation on the CS environment among SC-SNe Ia, this could raise another interesting possibility. There could be two classes among SC-SNe Ia; the brighter SC-SNe Ia in a clean environment (SN 2009dc) and the fainter SC-SNe Ia in a dusty environment (SN 2012dn).

Accepted for publication in The Astrophysical Journal
Available from http://arxiv.org/abs/1612.06632

The Clouds are breaking: tracing the Magellanic system with Gaia DR1 Mira variables

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We exploit the first data release from the Gaia mission to identify candidate Mira variables in the outskirts of the Magellanic Clouds. The repeated observations of sources during the initial phase of the Gaia mission is used to identify stars that show signs of variability. This variability information, combined with infrared photometry from 2MASS and WISE, allows us to select a clean sample of giants in the periphery of the LMC. We find evidence for Miras surrounding the LMC out to $\sim 20^\circ$ in all directions, apart from the North–West quadrant. Our sample does not generally follow the gas distribution of the Magellanic system; Miras are notably absent in the gaseous bridge between the LMC and SMC, but they are likely related to the stellar RR Lyræ bridge reported by Belokurov et al. (2016). The stellar stream discovered by Mackey et al. (2016) to the North of the LMC is almost perfectly delineated by our Mira variables, and likely extends further East toward the Galactic plane. The presence of an intermediate-age population in this stream advocates an LMC disc origin. We also find a significant excess of Miras to the East of the LMC; these more diffusely distributed stars are likely stripped SMC stars due to interactions with the LMC. Miras are also identified in regions of the sky away from the Clouds; we locate stars likely associated with known massive substructures, and also find potential associations with stripped SMC debris above the Galactic plane.

Accepted for publication in MNRAS
Available from http://arxiv.org/abs/1611.04600

Conference Papers

Measuring the core rotation of red giant stars

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Red giant stars present mixed modes, which behave as pressure modes in the convective envelope and as gravity modes in the radiative interior. This mixed character allows to probe the physical conditions in their core. With the advent

of long-duration time series from space-borne missions such as CoRoT and *Kepler*, it becomes possible to study the red giant core rotation. As more than 15 000 red giant light curves have been recorded, it is crucial to develop a robust and efficient method to measure this rotation. Such measurements of thousands of mean core rotation would open the way to a deeper understanding of the physical mechanisms that are able to transport angular momentum from the core to the envelope in red giants. In this work, we detail the principle of the method we developed to obtain automatic measurements of the red giant mean core rotation. This method is based on the stretching of the oscillation spectra and on the use of the so-called Hough transform. We finally validate this method for stars on the red giant branch, where overlapping rotational splittings and mixed-mode spacings produce complicated frequency spectra.

Oral contribution, published in "Astro Fluid 2016" conference, EAS publication series, EDP sciences
Available from http://arxiv.org/abs/1612.05414

^{3}He abundances in planetary nebulæ

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The ^{3}He isotope is important to many fields of astrophysics, including stellar evolution, chemical evolution, and cosmology. The isotope is produced in stars which evolve through the planetary nebula phase. Planetary nebulæ are the final evolutionary phase of low- and intermediate-mass stars, where the extensive mass lost by the star on the asymptotic giant branch is ionised by the emerging white dwarf. This ejecta quickly disperses and merges with the surrounding ISM.

The abundance of ^{3}He can only be derived from the hyperfine transition of the ionised ^{3}He, which is represented as ^{3}He$^+$, these transition can be observed in the radio at the rest frequency of 8.665 GHz. ^{3}He abundances in PNe can help test models of the chemical evolution of the Galaxy.

Many hours have been put into trying to detect this line, using telescopes like Effelsberg a 100m dish from the Max Planck Institute for Radio Astronomy, the National Radio Astronomy Observatory (NRAO) 140-foot telescope, the NRAO Very Large Array, the Arecibo antenna, the Green Bank Telescope, and only just recently, the Deep Space Station 63 antenna from the Madrid Deep Space Communications Complex.

Oral contribution, published in IAU Symposium No. 323, 2017, eds. X. Liu, L. Stanghellini & A. Karakas
Available from http://arxiv.org/abs/1612.02599

Chemical abundances in Galactic planetary nebulæ from faint emission lines

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Deep spectrophotometry has proved to be a fundamental tool to improve our knowledge on the chemical content of planetary nebulae. With the arrival of very efficient spectrographs installed in the largest ground-based telescopes, outstanding spectra have been obtained. These data are essential to constrain state-of-the-art nucleosynthesis models in asymptotic giant branch stars and, in general, to understand the chemical evolution of our Galaxy. In this paper we review the last advances on the chemical composition of the ionized gas in planetary nebulae based on faint emission lines observed through very deep spectrophotometric data.

Oral contribution, published in "Chemical abundances in ionized nebulæ" held in Campos do Jordão, Brazil between 3–5 November 2016. To be published in BAAA. eds. G. Hägele, M. Cardaci & E. Pérez-Montero (invited review)
Available from http://arxiv.org/abs/1612.02568

Analysis of the X-ray spectrum of the hot bubble of B +30°3639

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We developed a model for wind-blown bubbles with temperature and density profiles based on self-similar solutions including thermal conduction. We constructed also heat-conduction bubbles with chemical discontinuities. The X-ray emission is computed using the well-documented CHIANTI code (v6.0.1). These bubble models are used to (re)analyse the high-resolution X-ray spectrum of the hot bubble of BD +30°3639, and they appeared to be much superior to constant temperature approaches.

We found for the X-ray emission of BD +30°3639 that temperature-sensitive and abundance-sensitive line ratios computed on the basis of heat-conducting wind-blown bubbles and with abundances as found in the stellar photosphere/wind can only be reconciled with the observations if the hot bubble of BD +30°3639 is chemically stratified, i.e. if it contains also a small mass fraction ($\sim 3\%$) of hydrogen-rich matter immediately behind the conduction front. Neon appears to be strongly enriched, with a mass fraction of at least about 0.06.

Oral contribution, published in IAU Symposium No. 323, 2016
Available from http://arxiv.org/abs/1612.01389

Investigating spatial variation of the physical and chemical conditions of NGC 6778

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A number of planetary nebulae show binary central stars and significant abundance discrepancies between values estimated from collisionally excited lines when compared to the same abundances estimated from recombination lines. One approach to investigate this yet unsolved problem is using spatially resolved images of emission lines in an attempt to detect a possibly distinct metal rich component in the nebula. In this work we present results of spatially resolved abundance analysis of NGC 6778 based on data gathered from VLT VIMOS-IFU. We discuss the spatial variations found as well as possible limitations of the method in answering questions about abundance variations.

Poster contribution, published in "Chemical abundances in ionized nebulæ" held in Campos do Jordão, Brazil, 3–5 November 2016
Available from http://arxiv.org/abs/1612.07381

Atomic data and neutron-capture element abundances in planetary nebulæ

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Neutron(n)-capture elements are produced by s-process nucleosynthesis in low- and intermediate-mass AGB stars, and therefore can be enriched in planetary nebulæ (PNe). In the last ten years, n-capture elements have been detected in more than 100 PNe in the Milky Way and nearby galaxies. In some objects, several different n-capture elements have been detected, providing valuable constraints to models of AGB nucleosynthesis and evolution. These detections have motivated theoretical and experimental investigations of the atomic data needed to derive accurate n-capture element

abundances. In this review, I discuss the methods and results of these atomic data studies, and their application to abundance determinations in PNe.

Oral contribution, published in IAU Symp. 323: "Planetary Nebulæ: Multi-wavelength probes of stellar and galactic evolution"
Available from http://arxiv.org/abs/1612.08210

Towards an experimental determination of the transition strength between the ground states of ^{20}F and ^{20}Ne

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Electron capture on ^{20}Ne is thought to play a crucial rôle in the final evolution of electron-degenerate ONe stellar cores. Recent calculations suggest that the capture process is dominated by the second-forbidden transition between the ground states of ^{20}Ne and ^{20}F, making an experimental determination of this transition strength highly desirable. To accomplish this task we are refurbishing an intermediate-image magnetic spectrometer capable of focusing 7 MeV electrons, and designing a scintillator detector surrounded by an active cosmic-ray veto shield, which will serve as an energy-dispersive device at the focal plane.

Oral contribution, published in NIC-XIV

Review Paper

Supernova 1604, Kepler's supernova, and its remnant

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Supernova 1604 is the last Galactic supernova for which historical records exist. Johannes Kepler's name is attached to it, as he published a detailed account of the observations made by himself and European colleagues. Supernova 1604 was very likely a Type Ia supernova, which exploded 350 pc to 750 pc above the Galactic plane. Its supernova remnant, known as Kepler's supernova remnant, shows clear evidence for interaction with nitrogen-rich material in the north/northwest part of the remnant, which, given the height above the Galactic plane, must find its origin in mass loss from the supernova progenitor system. The combination of a Type Ia supernova and the presence of circumstellar material makes Kepler's supernova remnant a unique object to study the origin of Type Ia supernovæ. The evidence suggests that the progenitor binary system of supernova 1604 consisted of a carbon–oxygen white dwarf and an evolved companion star, which most likely was in the (post) asymptotic giant branch of its evolution. A problem with this scenario is that the companion star must have survived the explosion, but no trace of its existence has yet been found, despite a deep search.

Published in Handbook of Supernovæ, edited by Athem W. Alsabti and Paul Murdin, Spinger
Available from http://arxiv.org/abs/1612.06905
and from
https://arxiv.org/ct?url=http%3A%2F%2Fdx.doi.org%2F10%252E1007%2F978-3-319-20794-0_49-1&v=6addf286

Announcements

The Physics of Evolved Stars: the impact of binarity
Nice, 10–13$^{\text{th}}$ of July 2017

Dear colleagues,

We are organizing the second conference on the physics of evolved stars in Nice between 10–13$^{\text{th}}$ of July 2017 (the first one occurred in 2015: poe2015.sciencesconf.org). We aim at focusing it on the role of binarity, be it for low-mass evolved stars (AGB, post-AGB, novæ, cataclysmic variables...), or for high-mass stars (RSG, WR, LBV, sgB[e] stars, post-interaction products...). The goal of the conference is to gather observer and theoreticians from both the low mass stars and massive stars communities. Ample discussion time is a key feature of this conference alongside breakout discussion session to trigger ideas/collaborations to tackle the main questions in the study of evolved stars.

We invite you to save the date, submit an abstract and come to the French riviera to share your work with specialists of stellar physics during this conference. We foresee to link all the talks to the ADS instead of publishing proceedings.

Please visit our website – poe2017.sciencesconf.org, where we will post all the relevant information (registration, program, etc.). So please stay tuned!

Important dates to keep in mind are the following:

- Abstract submissions are now accepted
- 15 Feb: registration starts
- 30 Mar: deadline for abstract submission
- 15 Apr: talk/poster selection announcement
- 1 Jun: end of normal registration / beginning of late registration
- 15 Jun: no more registration accepted
- 10 Jul: start of the conference

See also poe2017.sciencesconf.org

Connecting observational and theoretical studies of AGB stars – COASTARS 2017

For the first time we can observationally resolve the surfaces of, and wind formation around, nearby giant stars. This fits very timely with the recent development of 3D models of surface convection in giant stars, and detailed models aimed at studying the wind-driving mechanisms.

The Swedish AGB research community is deeply involved in both theoretical and observational aspects, and can provide an ideal setting for discussions on the recent dramatic progress. We will organize an international conference where a selected set of current topics will be discussed in detail. The recent progress in each topic will be covered by two invited keynote speakers followed by contributed talks, and extended afternoon discussion sessions.

The conference is open to any astronomer, will take place during the 12–16$^{\text{th}}$ of June 2017, in Göteborg and is limited to about 70 participants. The conference is called COASTARS – Connecting Observational and theoretical studies of AGB STARS, since the aim of the meeting is to create fruitful discussions between theoretical and observational researchers. Registration will open on the 15$^{\text{th}}$ of February.

Topics:

Day 1: Dust in M-type AGB stars – theory and wind

Day 2: Dust in M-type AGB stars – observations

Day 3: High-energy emission – Chromospheres or companions?

Day 4: Detached shells – Only for carbon stars?

Day 5: Stellar surface imaging – What will it tell us?

Keynote speakers:

Day 1: Anja Andersen, Sara Bladh

Day 2: Markus Wittkowski, Tomasz Kamiński

Day 3: Raghvendra Sahai, Rodolfo Montez

Day 4: Paola Marigo, Franz Kerschbaum

Day 5: Claudia Paladini, Keiichi Ohnaka

SOC:

- Sofia Ramstedt
- Susanne Höfner
- Bernd Freytag
- Hans Olofsson
- Wouter Vlemmings
- Kay Justtanont
- Matthias Maercker
- Elvire De Beck
- Theo Khouri

See also http://www.astro.uu.se/∼coastars17/

EWASS 2017 Special Session 8
Uncovering the i-process. A new mode of heavy element production throughout the Galaxy

Dear Colleagues,

As part of the European Week of Astronomy and Space Science (EWASS) 2017 meeting in Prague, Czech Republic from 26–30$^{\text{th}}$ June 2017, there is to be a one day Special Session (Friday 30$^{\text{th}}$ June) on the i-(intermediate) neutron capture process.

Understanding the origins of the elements is one of the most important questions of modern astrophysics. The cosmic production of elements heavier than iron occurs predominately via neutron capture processes. Depending on the competition between the neutron capture and beta decay time scales, the neutron captures are either slow or rapid with respect to the β decay; with the slow (s-process) characterised by low neutron densities ($n \sim 10^{8-11}$ cm^{-3}) whilst the rapid (r-process) is characterized by very high neutron densities ($n > 10^{20}$ cm^{-3}). These two processes produce quite distinct abundance patterns. However, recent observations of heavy element distributions in some of the oldest stars in the Universe demonstrate the limits of this simplified picture: some stars appear to require a process with neutron densities in between that of the s- and r-processes, with $n \sim 10^{15}$ cm^{-3}, dubbed the intermediate (i) process. Furthermore, this newly uncovered process now seems necessary to explain observations from a variety of other objects such as low metallicity post-AGB stars, Sakurai's Object and some stardust grains within primitive meteorites. From a theoretical perspective, i-process conditions are being uncovered in a range of stellar sites: low-mass asymptotic giant branch (AGB) stars, super-AGB stars, massive stars and novæ. Because the reaction pathway proceeds far away from the valley of stability and hence the nuclear reaction rates are currently relatively poorly known, the input of the nuclear astrophysics community is paramount.

This session aims to be truly interdisciplinary, with researchers of nuclear astrophysics, stellar evolution, stellar observation, and Galactic chemical evolution with the goal of answering the questions:

- Where are the sites of i-process nucleosynthesis?
- What constraints on this process can be derived from current/forthcoming observational studies?
- Which nuclear reaction rates are the most crucial and which are the most uncertain?
- How important is the i-process for galactic chemical evolution, in particular for the early Galaxy?

Invited speakers

- S. Cristallo (INAF, Osservatorio Astronomico di Teramo)
- C. Hansen (Dark Cosmology Centre, Copenhagen)
- R. Reifarth (Göthe University Frankfurt) + TBC

Registration and abstract submission (oral and poster presentations) is now open through the EWASS 2017 homepage. The deadline for very early registration is February 10$^{\text{th}}$, 2017, whilst early registration is until April 28$^{\text{th}}$, 2017. There is also one day registration available. The deadline for abstract submission is 8$^{\text{th}}$ March 2017.

We hope to see you in Prague in June.

With kind regards,
Carolyn Doherty & Richard Stancliffe

See also http://eas.unige.ch/EWASS2017/session.jsp?id=SS8