THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 204$^{\rm th}$ issue of the AGB Newsletter. A little lighter than usual – you don't need to wait for our "invitation" to post items!

As usual there are quite a few results on planetary nebulæ. Furthermore, some new insight is presented into the composition of (post-)AGB stars and their environments, pulsation (both internal and external) and eruptions...

Unfortunately there is also sad news to report. Tom Lloyd Evans has passed away. Many know and will fondly remember him. Ian Glass has kindly written an obituary, please find it on the next page.

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

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

Food for Thought

This month's thought-provoking statement is:

Is the asymptotic giant branch really asymptotic?

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

Tom Lloyd Evans (2-12-1940 – 12-6-2014)

We regret to announce the sudden passing of Tom Lloyd Evans, a well-known member of the AGB community.

Tom was born in England but grew up in Scotland, where he went to Fettes school. There his interest in astronomy was stimulated by one of his teachers and he was already a serious amateur before he went to St. Andrews university. He graduated with a bachelor's degree in astronomy in 1963 before continuing towards a PhD in the same department.

From 1966 to 1974 he worked at the Radcliffe Observatory in Pretoria, with a hiatus in 1971 at the Royal Observatory, Edinburgh. When the Radcliffe shut down in 1974, he joined the South African Astronomical Observatory. Following his retirement in 2001 he returned to the UK, where he was associated until he died with the Universities of St. Andrews and Nottingham.

In his long career, Tom was interested in many fields. These included star clusters, variables (classical and type II cepheids, RV Tau and R Cr B variables, LPVs), C stars, stars with dusty discs, LMC stars, binaries and chromospherically active stars. The techniques in which he had expertise included photographic photometry, spectroscopy and infrared photometry.

LPV studies included early identifications of long-period variables in the Galactic Centre and the Magellanic Clouds, including the determination of their periods and their usefulness as distance indicators (sometimes with collaborators).

A major long-term interest was the observation in Magellanic Cloud clusters of the evolutionary transition from M via S to C types, especially traced via s-process elements and carbon. A study of C stars with anomalous Si-rich dust showed that they have a high abundance of ^{13}C.

A study of RV Tauri stars showed that they have characteristic mid-IR colours, probably indicating dusty discs. This was used to find further examples including low-amplitude stars in binary systems.

A study of V Hydrae and R Lep showed that characteristic fading of this kind is restricted to the reddest C stars, which are enveloped in dust clouds.

Since his return to Europe, Tom has collaborated with Perer Sarre (Nottingham) and Hans van Winckel (Leuven) and was particularly glad to have had the opportunity to work with students. With Peter Sarre he carried out the first complete study of the silicon dicarbide molecule in stellar spectra, following his discovery of a carbon star with emission bands surrounded by a dusty disk.

Tom was a person with many interests and friendships within and outside astronomy. He was a keen amateur archaeologist, a botanist and a hiker (among other things!). He met his wife Marlene who, with their two children Robert and Anne, survive him, through his interest in Scottish country dancing! He will be sorely missed by his family, friends and collaborators (only a few of whom have been mentioned).

This picture was taken in May this year when Tom was on holiday in the Scottish Highlands.

Refereed Journal Papers

UV spectral analysis of very hot H-deficient [WCE]-type central stars of planetary nebulæ: NGC 2867, NGC 5189, NGC 6905, Pb 6, and Sand 3

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We analysed UV FUSE, IUE, and HST/STIS spectra of five of the hottest [WCE]-type central stars of planetary nebulæ: NGC 2867, NGC 5189, NGC 6905, Pb 6, and Sand 3. The analysis leveraged on our grid of CMFGEN synthetic spectra, which covers the parameter regime of hydrogen deficient central stars of planetary nebulæ and allows a uniform and systematic study of the stellar spectra. The stellar atmosphere models calculated by us include many elements and ionic species neglected in previous analyses, which allowed us to improve the fits to the observed spectra considerably and provided an additional diagnostic line: the Ne VII λ973 Å, which had not been modelled in [WCE] spectra and which presents, in these stars, a strong P-Cygni profile. We report newly derived photospheric and wind parameters and elemental abundances. The central stars of NGC 2867, NGC 5189, and Pb 6 had their temperatures revised upward in comparison with previous investigations and we found the carbon to helium mass ratio of the sample objects to span a wide range of values, $0.42 < \mathrm{C{:}He} < 1.96$. Modelling of the Ne VII λ973 Å P-Cygni profile indicated strong neon overabundances for the central stars of NGC 2867, NGC 5189, NGC 6905, and Pb 6, with Ne mass fractions between 0.01 and 0.04. Nitrogen abundances derived by us for the central stars of NGC 5189, Pb 6, and Sand 3 are higher than previous determinations by factors of 3, 10, and 14, respectively.

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The meaning of WISE colours: I. The Galaxy and its satellites

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Through matches with the SDSS catalog we identify the location of various families of astronomical objects in WISE colour space. We identify reliable indicators that separate Galactic/local from extragalactic sources and concentrate here on the objects in our Galaxy and its closest satellites. We develop colour and magnitude criteria that are based only on WISE data to select AGB stars with circumstellar dust shells, and separate them into O-rich and C-rich classes. With these criteria we produce an all-sky map for the count ratio of the two populations. The map reveals differences between the Galactic disk, the Magellanic Clouds and the Sgr dwarf Spheroidal galaxy, as well as a radial gradient in the LMC disk. We find that the C:O number ratio for dusty AGB stars increases with distance from the LMC centre about twice as fast as measured for near-IR selected samples of early AGB stars. Detailed radiative transfer models show that WISE colours are well explained by the emission of centrally heated dusty shells where the dust has standard properties of ISM grains. The segregation of different classes of objects in WISE colour space arises from differences in properties of the dust shells: those around young stellar objects have uniform density distributions while in evolved stars they have steep radial profiles.

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Amplitude variations in pulsating yellow supergiants

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It was recently discovered that the amplitudes of pulsating red giants and supergiants vary significantly on time scales of 20–30 pulsation periods. Here, we analyze the amplitude variability in 29 pulsating yellow supergiants (5 RVa, 4 RVb, 9 SRd, 7 long-period Cepheids, and 4 yellow hypergiants), using visual observations from the AAVSO International Database, and Fourier and wavelet analysis using the AAVSO's VSTAR package. We find that these stars vary in amplitude by factors of up to 10 or more (but more typically 3–5) on a mean timescale (L) of 33 ± 4 pulsation periods (P). Each of the five sub-types shows the same behaviour, which is very similar to that of the pulsating red giants, for which the median L/P was 31. For the RVb stars, the lengths of the cycles of amplitude variability are the same as the long secondary periods, to within the uncertainty of each.

Submitted to JAAVSO
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Does the period of a pulsating star depend on its amplitude?

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Several classes of pulsating variable stars are now known to undergo slow changes in amplitude; these include red giants and supergiants, and yellow supergiants. We have used visual observations from the AAVSO International Database, and wavelet analysis of 39 red giants, 7 red supergiants, and 3 yellow supergiants, to test the hypothesis that an increase in amplitude would result in an increase in period, because of non-linear effects in the pulsation. For most of the stars, the results are complex, and/or indeterminate, due to the limitations of the data, the small amplitude or amplitude variation, or other processes such as random cycle-to-cycle period fluctuations. For the dozen stars which have substantial amplitude variation, and reasonably simple behaviour, there is a 75–80% tendency to show a positive correlation between amplitude and period.

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Evolution of thermally pulsing asymptotic giant branch stars IV. Constraining mass-loss & lifetimes of low mass, low metallicity AGB stars

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The evolution and lifetimes of thermally pulsating asymptotic giant branch (TP-AGB) stars suffer from significant uncertainties. In this work, we analyze the numbers and luminosity functions of TP-AGB stars in six quiescent, low

metallicity ([Fe/H] $\lesssim -0.86$) galaxies taken from the ANGST sample, using HST photometry in both optical and near-infrared filters. The galaxies contain over 1000 TP-AGB stars (at least 60 per field). We compare the observed TP-AGB luminosity functions and relative numbers of TP-AGB and RGB stars, to models generated from different suites of TP-AGB evolutionary tracks after adopting star formation histories (SFH) derived from the HST deep optical observations. We test various mass-loss prescriptions that differ in their treatments of mass-loss before the onset of dust-driven winds (pre-dust). These comparisons confirm that pre-dust mass-loss is important, since models that neglect pre-dust mass-loss fail to explain the observed TP-AGB/RGB ratio or the luminosity functions. In contrast, models with more efficient pre-dust mass-loss produce results consistent with observations. We find that for [Fe/H] $\lesssim -0.86$, lower mass TP-AGB stars ($M \lesssim 1$ M$_\odot$) must have lifetimes of ~ 0.5 Myr and higher masses ($M \lesssim 3$ M$_\odot$) must have lifetimes $\lesssim$1.2 Myr. In addition, assuming our best-fitting mass-loss prescription, we show that the third dredge up has no significant effect on TP-AGB lifetimes in this mass and metallicity range.

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The planetary nebula IPHAS X J211420.0+434136 (Ou 5): insights into common-envelope dynamical and chemical evolution

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While analysing the images of the IPHAS (INT/WFC Photometric Hα Survey of the northern Galactic plane) survey, we noticed that the central star of the candidate planetary nebula IPHAS X J211420.0+434136 (also named Ou 5) was clearly variable. This is generally considered as an indication of binarity. To confirm it, we performed a photometric monitoring of the central star, and obtained images and spectra of the nebula. The nebular spectrum confirms that IPHAS X J211420.0+434136 is a planetary nebula of moderately high excitation. It has a remarkable morphology with two nested pairs of bipolar lobes and other unusual features. The light curve of the central star reveals that it is an eclipsing binary system with an orbital period of 8.74 h. It also displays a strong irradiation effect with an amplitude of 1.5 mag. The presence of multiple bipolar outflows adds constraints to the formation of these nebulæ, suggesting the occurrence of discrete ejection events during, or immediately before, the common-envelope phase. IPHAS X J211420.0+434136 also adds evidence to the hypothesis that a significant fraction of planetary nebulæ with close binary central stars have a peculiar nebular chemistry and a relatively low nebular mass. This may point to low-mass, low-metallicity progenitors, with additional effects related to the binary evolution. We also suggest that these objects may be relevant to understand the abundance discrepancy problem in planetary nebulæ.

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Available from http://mnras.oxfordjournals.org/cgi/content/abstract/stu703? ijkey=yC0JomOOXX7AvsB&keytype=ref

A spectroscopic and photometric study of the planetary nebulæ Kn 61 and Pa 5

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We present the first morpho-kinematical analysis of the planetary nebulæ Kn 61 and Pa 5 and explore the nature of their central stars. Our analysis is based on high resolution and medium resolution spectroscopic observations, deep narrow-band imaging, and integral photometry. This material allows us to identify the morphological components and study their kinematics. The direct images and spectra indicate an absence of the characteristic [N II] and [S II] emission lines in both nebulæ. The nebular spectrum of Kn 61 suggests an hydrogen deficient planetary nebula and the stellar spectrum of the central star reveals a hydrogen deficient PG 1159-type star. The [O III] position velocity diagram reveals that Kn 61 is a closed, empty, spherical shell with a thin border and a filamentary surface expanding at 67.6 km s^{-1}, and the shell is currently not expanding isotropically. We derived a kinematic age of $\sim 1.6 \times 10^4$ yr for an assumed distance of 4 kpc. A photometric period of $\sim 5.7(\pm 0.4)$ days has been detected for Kn 61, indicating presence of a possible binary system at its core. A possible link between filamentary, spherical shells and PG 1159-type stars is noted.

The morphology of Pa 5 is dominated by an equatorial toroid and faint polar extensions. The equatorial region of this planetary nebula is expanding at 45.2 km s^{-1}. The stellar spectrum corresponds to a very hot star and is dominated by a steep blue rising continuum and He II, Balmer and Ca II photospheric lines.

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Recurrent and symbiotic novæ in the OGLE data

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We analyse long-term optical photometry for two Galactic recurrent novæ (V745 Sco, V3890 Sgr) and one LMC object (Nova LMC 1990b) observed over several years by the OGLE sky survey. We do not find variability with previously claimed orbital period of V745 Sco. This voids previous findings based on this value, e.g., the distance determination. The quiescence variability of this object is dominated by semiregular pulsations of the red giant secondary (with periods of 136.5 and 77.4 d). The photometry of Nova LMC 1990b reveals unnoticed eruption in 2010 and eclipse-like variability in quiescence with a period of 1.26432(8) d. The photometric properties make this object very similar to U Sco. Finally, we describe eruptions of two likely symbiotic novæ – V5590 Sgr and OGLE-2011-BLG-1444. The secondary of V5590 Sgr is a Mira star with pulsation period of 236 d.

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OGLE-SMC-LPV-00861 (LIN 9): the first proven Z And outburst in a Magellanic symbiotic star

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We report on the discovery of a new Small Magellanic Cloud (SMC) symbiotic star, OGLE-SMC-LPV-00861, previously catalogued as Hα emission line source LIN 9. The OGLE light curve shows multiple-maxima outburst behaviour over ~ 1200 d with a maximum outburst of $\Delta V = 1.5$ mag. An optical spectrum of LIN 9 taken with the Southern African Large Telescope (SALT) at quiescence reveals a K5 red giant with emission lines confirming its symbiotic star nature, demonstrating the potential use of ongoing large time-domain surveys to identify strong symbiotic star candidates. It is the first Magellanic symbiotic star proven to show poorly understood Z And outbursts. At outburst the estimated hot component luminosity is $L \sim 3165$ L$_\odot$, compared to $L \sim 225$ L$_\odot$ at quiescence. Further observations are needed, especially at outburst, to better understand this unique Z And-like system at a known distance, and to provide essential input to physical models of the Z And phenomenon.

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Modelling the 3D morphology and proper motions of the planetary nebula NGC 6302

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We present 3D hydrodynamical simulations of an isotropic fast wind interacting with a previously ejected toroidally-shaped slow wind in order to model both the observed morphology and the kinematics of the planetary nebula (PN) NGC 6302. This source, also known as the Butterfly nebula, presents one of the most complex morphologies ever observed in PNe. From our numerical simulations, we have obtained an intensity map for the Hα emission to make a comparison with the *Hubble* Space Telescope (HST) observations of this object. We have also carried out a proper motion (PM) study from our numerical results, in order to compare with previous observational studies. We have found that the two interacting stellar wind model reproduces well the morphology of NGC 6302, and while the PM in the models are similar to the observations, our results suggest that an acceleration mechanism is needed to explain the Hubble-type expansion found in HST observations.

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CRIRES-VLT high-resolution spectro-astrometry as a tool in the search for disks inside the cores of planetary nebulæ

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The onset of asymmetry in planetary nebulæ (PNe) occurs during the short transition between the end of the asymptotic giant branch (AGB) phase and the beginning of the PN phase. Sources in this transition phase are compact and emit intensely in infrared wavelengths, making high spatial resolution observations in the infrared mandatory to investigate the shaping process of PNe. Interferometric VLTI IR observations have revealed compelling evidence of disks at the cores of PNe, but the limited sensitivity, strong observational constraints, and limited spatial coverage place severe limits on a universal use of this technique. Inspired by the successful detection of proto-planetary disks using spectro-astrometric observations, we apply this technique here for the first time to search for subarcsecond structures in PNe. Our exploratory study using CRyogenic high-resolution Infra-Red Échelle Spectrograph (CRIRES) commissioning data of the proto-PN IRAS 17516−2525 and the young PN SwSt 1 has revealed small-sized structures after the spectro-astrometric analysis of the two sources. In IRAS 17516−2525, the spectro-astrometric signal has a size of only 12 ± 5 mas, as detected in the Brγ line, whereas the structures found in SwSt 1 have sizes of 230 ± 29 mas in the [Fe III] line and 130 ± 21 mas in the Brγ line. The spectroscopic observations required to perform spectro-astrometry of sources in the transition towards the PN phase are less time-consuming and much more sensitive than VLTI IR observations. The results presented here open a new window in the search for the small-sized collimating agents that shape the complex morphologies of extremely axisymmetric PNe.

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Abundance analysis for long-period variables. II. RGB and AGB stars in the globular cluster 47 Tuc

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Asymptotic giant branch (AGB) stars play a key role in the enrichment of galaxies with heavy elements. Due to their large amplitude variability, the measurement of elemental abundances is a highly challenging task that has not been solved in a satisfactory way yet. Following our previous work we use hydrostatic and dynamical model atmospheres to simulate observed high-resolution near-infrared spectra of 12 variable and non-variable red giants in the globular cluster 47 Tuc. The 47 Tuc red giants are independently well-characterized in important parameters (mass, metallicity, luminosity). The principal aim was to compare synthetic spectra based on the dynamical models with observational spectra of 47 Tuc variables. Assuming that the abundances are unchanged on the upper giant branch in these low-mass stars, our goal is to estimate the impact of atmospheric dynamics on the abundance determination. We present new measurements of the C/O and $^{12}C/^{13}C$ ratio for 5 non-variable red giants in 47 Tuc. The equivalent widths measured for our 7 variable stars strongly differ from the non-variable stars and cannot be reproduced by either hydrostatic or dynamical model atmospheres. Nevertheless, the dynamical models fit the observed spectra of long-period variables much better than any hydrostatic model. For some spectral features, the variations in the line intensities predicted by dynamical models over a pulsation cycle give similar values as a sequence of hydrostatic models with varying temperature and constant surface gravity. (abbreviated)

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Carbon-rich dust past the asymptotic giant branch: aliphatics, aromatics, and fullerenes in the Magellanic Clouds

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Infrared spectra of carbon-rich objects which have evolved off the asymptotic giant branch reveal a range of dust properties, including fullerenes, polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons, and several unidentified features, including the 21-μm emission feature. To test for the presence of fullerenes, we used the position and width of the feature at 18.7–18.9 μm and examined other features at 17.4 and 6–9 μm. This method adds three new fullerene sources to the known sample,but it also calls into question three previous identifications. We confirm that the strong 11-μm features seen in some sources arise primarily from SiC, which may exist as a coating around carbonaceous cores and result from photoprocessing. Spectra showing the 21-μm feature usually show the newly defined Class D PAH profile at 7–9 μm. These spectra exhibit unusual PAH profiles at 11–14 μm, with weak contributions at 12.7 μm, which we define as Class D1, or show features shifted to $\sim$ 11.4, 12.4, and 13.2 μm, which we define as Class D2. Alkyne hydrocarbons match the 15.8-μm feature associated with 21-μm emission. Sources showing fullerene emission but no PAHs have blue colors in the optical, suggesting a clear line of sight to the central source. Spectra with 21-μm features and Class D2 PAH emission also show photometric evidence for a relatively clear line of sight to the central source. The multiple associations of the 21-μm feature with aliphatic hydrocarbons suggest that the carrier is related to this material in some way.

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Conference Paper

The FRUITY database on AGB stars: past, present and future

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We present and show the features of the FRUITY database, an interactive web-based interface devoted to the nucleosynthesis in AGB stars. We describe the current available set of AGB models (largely expanded with respect to the original one) with masses in the range $1.3 < M/\mathrm{M}_\odot < 3.0$ and metallicities $-2.15 <$ [Fe/H] $< +0.15$. We illustrate the details of our *s*-process surface distributions and we compare our results to observations. Moreover, we introduce a new set of models where the effects of rotation are taken into account. Finally, we shortly describe next planned upgrades.

Oral contribution, published in "Nuclear Physics in Astrophysics VI"
Available from arXiv:1405.3392

Announcement

The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments

We are pleased to announce the publication of the proceedings of the conference *The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments*, held in Taipei, 18–22 November 2013.

The editorial board: Anja Andersen, Maarten Baes, Haley Gomez, Ciska Kemper and Darach Watson

See also http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=207