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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 149$^{\rm th}$ issue of the AGB Newsletter, which on this occasion was prepared and mailed from a hotel room in Grenoble — the birthplace of this newsletter! (And host of the 3$^{\rm rd}$ Torino workshop on AGB Nucleosynthesis, in 1998!)

You can read about the rôle of AGB stars in galactic ecology, about water fountains and other post-AGB phenomena, white dwarves having narrowly escaped supernova, white dwarves about to merge, and nucleosynthesis (of course!).

The AGB community has gained yet another philosopher: congratulations Sundar, on your degree award — and Good Luck in Paris!

...and there's already an opportunity for a new Ph.D. candidate to start, in vibrant Bonn, researching the rôle of magnetic fields in driving and shaping outflows.

The next issue is planned to be distributed on the 3$^{\rm rd}$ of January 2010.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

We can calculate third dredge-up from first principles, without the need to tune a fudge parameter.

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)

Refereed Journal Papers

H91α radio recombination line and 3.5 cm continuum observations of the Planetary Nebula NGC 3242

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We present high sensitivity H91α and 3.5 cm radio continuum observations toward the planetary nebula NGC 3242. The electron temperature determined assuming local thermodynamic equilibrium is consistent within $\sim$ 10% with that derived from optical lines and the Balmer discontinuity. The line emission and the continuum emission have very similar spatial distribution, suggesting that at this wavelength there is no other continuum process present in a significant manner. In particular, we conclude that emission from spinning dust is not important at this wavelength. In this radio recombination line the nebula presents a radial velocity structure consistent with that obtained from observations of optical lines.

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Evidence for intermediate-age stellar populations in early-type galaxies from K-band spectroscopy

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The study of stellar populations in early-type galaxies in different environments is a powerful tool for constraining their star formation histories. This study has been traditionally restricted to the optical range, where dwarfs around the turn-off and stars at the base of the RGB dominate the integrated light at all ages. The near-infrared spectral range is especially interesting since in the presence of an intermediate-age population, AGB stars are the main contributors. In this letter, we measure the near-infrared indices Na I and $D_{\rm CO}$ for a sample of 12 early-type galaxies in low density environments and compare them with the Fornax galaxy sample presented by Silva et al. The analysis of these indices in combination with Lick/IDS indices in the optical range reveals i) the Na I index is a metallicity indicator as good as C4668 in the optical range, and ii) $D_{\rm CO}$ is a tracer of intermediate-age stellar populations. We find that low-mass galaxies in low density environments show higher Na I and $D_{\rm CO}$ than those located in Fornax cluster, which points towards a late stage of star formation for the galaxies in less dense environments, in agreement with results from other studies using independent methods.

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Available from arXiv:0909.5385

CO $J = 3$–2 emission from the "Water Fountain" sources IRAS 16342−3814 and IRAS 18286−0959

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We observed CO $J = 3$–2 emission from the "water fountain" sources, which exhibit high-velocity collimated stellar jets traced by water maser emission, with the Atacama Submillimeter Telescope Experiment (ASTE) 10 m telescope. We detected the CO emission from two sources, IRAS 16342−3814 and IRAS 18286−0959. The IRAS 16342−3814 CO emission exhibits a spectrum that is well fit to a Gaussian profile, rather than to a parabolic profile, with a velocity width (FWHM) of 158 ± 6 km s^{-1} and an intensity peak at $v_{\rm LSR} = 50 \pm 2$ km s^{-1}. The mass-loss rate of the star is estimated to be $\sim 2.9 \times 10^{-5}$ M$_\odot$ yr^{-1}. Our morpho-kinematic models suggest that the CO emission is optically thin and associated with a bipolar outflow rather than with a (cold and relatively small) torus. The IRAS 18286−0959 CO emission has a velocity width (FWHM) of 3.0 ± 0.2 km s^{-1}, smaller than typically seen in AGB envelopes. The narrow velocity width of the CO emission suggests that it originates from either an interstellar molecular cloud or a slowly-rotating circumstellar envelope that harbors the water maser source.

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Formation of late-type spiral galaxies: gas return from stellar populations regulates disk destruction and bulge growth

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Spiral galaxies have most of their stellar mass in a large rotating disk, and only a modest fraction in a central spheroidal bulge. This poses a major challenge for cosmological models of galaxy formation. Galaxies form at the centre of dark matter halos through a combination of hierarchical merging and gas accretion along cold streams, and should rapidly grow their bulge through mergers and instabilities. Cosmological simulations predict galaxies to have most of their mass in the central bulge, and therefore an angular momentum much below the observed level, except in dwarf galaxies. We propose that the continuous return of fresh gas by stellar populations over cosmic times could solve this issue. A population of stars formed at a given instant typically returns half of its initial mass in the form of gas over 10 billion years, and the process is not dominated by rapid supernovae explosions but by the long-term mass-loss from low- and intermediate-mass stars. Using simulations of galaxy formation, we show that this recycling of gas can strongly affect the structural evolution of massive galaxies, potentially solving the bulge fraction issue: we find that the bulge-to-disk ratio of a massive galaxy can be divided by a factor of 3. The continuous recycling of baryons through star formation and stellar mass loss helps the growth of disks and their survival to interactions and mergers. Instead of forming only early-type, spheroid-dominated galaxies (S0 and ellipticals), the standard cosmological model can then successfully account for massive late-type, disk-dominated spiral galaxies (Sb–Sc).

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Rotational spectroscopy of AlO: low-N transitions in the $X^2\Sigma^+$ ground state

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The detection of rotational transitions of the AlO radical at millimeter wavelengths from an astronomical source has recently been reported. In view of this, rotational transitions in the ground $X^2\Sigma^+$ state of AlO have been reinvestigated. Comparisons between Fourier Transform and microwave data indicate a discrepancy regarding the derived value of γ_D in the $v = 0$ level of the ground state. This discrepancy is discussed in the light of comparisons between experimental data and synthesized rotational spectra in the $v = 0$, 1 and 2 levels of $X^2\Sigma^+$. A list of calculated rotational lines in $v = 0$, 1 and 2 of the ground state up to $N' = 11$ is presented which should aid astronomers in analysis and interpretation of observed AlO data and also facilitate future searches for this radical.

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Available from arXiv:0910.5813

Planetary Nebulae detected in the *Spitzer* Space Telescope GLIMPSE II legacy survey

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We report the result of a search for the infrared counterparts of 37 planetary nebulae (PNs) and PN candidates in the *Spitzer* Galactic Legacy Infrared Mid-Plane Survey Extraordinaire II (GLIMPSE II) survey. The photometry and images of these PNs at 3.6, 4.5, 5.8, 8.0, and 24 μm, taken through the Infrared Array Camera (IRAC) and the Multiband Imaging Photometer for Spitzer (MIPS), are presented. Most of these nebulae are very red and compact in the IRAC bands, and are found to be bright and extended in the 24 μm band. The infrared morphology of these objects are compared with Hα images of the Macquarie-AAO-Strasbourg (MASH) and MASH II PNs. The implications for morphological difference in different wavelengths are discussed. The IRAC data allow us to differentiate between PNs and H II regions and be able to reject non-PNs from the optical catalogue (e.g., PNG 352.1−00.0). Spectral energy distributions (SEDs) are constructed by combing the IRAC and MIPS data with existing near-, mid-, and far-IR photometry measurements. The anomalous colors of some objects allow us to infer the presence of aromatic emission bands. These multi-wavelength data provide useful insights into the nature of different nebular components contributing to the infrared emission of PNs.

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Two white dwarfs with oxygen-rich atmospheres

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Stars with masses in the range 7–10 $M_\odot$ end their lives either as massive white dwarfs or weak type II supernovae, and there are only limited observational constraints of either channel. Here we report the detection of two white dwarfs with large photospheric oxygen abundances, implying that they are bare oxygen-neon cores and that they may have descended from the most massive progenitors that avoid core-collapse.

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Pulsations and long-term light variability of three candidates to protoplanetary nebulae

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We present new photometric data and analysis of the long-duration UBV photoelectric observations for three candidates to protoplanetary objects — F-supergiants with IR-excesses located at large galactic latitudes, IRAS 18095+2704, IRAS 19386+0155, and IRAS 19500−1709. All three stars have revealed quasiperiodic low-amplitude variabilities caused by pulsations observed against the long-term trends of brightnesses. For IRAS 18095+2704 = V887 Her we have found a pulsation period of 109 days and a linear trend of brightness under the constant colours if being averaged over the year timescale. The light curve of IRAS 19386+0155 = V1648 Aql over 2000–2008 can be approximated by a wave with a main period of 102 days which is modulated by close frequency, with a period of 98 days, that results in brightness oscillations with a variable amplitude. V1648 Aql has also shown synchronous reddening together with a persistent rise of brightness in the V-band. IRAS 19500−1709 = V5112 Sgr experiences irregular pulsations with the periods of 39 and 47 days. The long-term component of the variability of V5112 Sgr may be related to the binary character of this star.

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Radio emissions from substellar companions of evolved cool stars

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A number of substellar companions to evolved cool stars have now been reported. Cool giants are distinct from their progenitor Main Sequence (MS) low-mass stars in a number of ways. First, the mass loss rates of cool giant stars are orders of magnitude greater than for the late-type MS stars. Second, on the cool side of the Linsky–Haisch "dividing line", K and M giant stars are not X-ray sources, although they do show evidence for chromospheres. As a result, cool star winds are largely neutral for those spectral types, suggesting that planetary or brown dwarf magnetospheres will not be effective in standing off the stellar wind. In this case one expects the formation of a bow shock morphology at the companion, deep inside its magnetosphere. We explore radio emissions from substellar companions to giant stars with ionised winds or neutral winds.

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Scaled solar tracks and isochrones in a large region of the Z–Y plane. II. From 2.5 to 20 $M_\odot$ stars

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We extend our theoretical computations for low-mass stars to intermediate-mass and massive stars, for which few databases exist in the literature. Evolutionary tracks and isochrones are computed from 2.50 to 20 $M_\odot$ for a grid of 37 chemical compositions with metal content Z between 0.0001 and 0.070 and helium content Y between 0.23 and 0.40. Synthetic TP-AGB models allow stellar tracks and isochrones to be extended until the end of the thermal pulses along the AGB. We provide software tools for the bidimensional interpolation (in Y and Z) of the isochrones from very old ages down to about 10 million years. The extension of the blue loops and the instability strip of Cepheid stars are compared and the Cepheid mass-discrepancy is discussed. The location of red supergiants in the H–R diagram is in good agreement with the evolutionary tracks for masses from 10 to 20 $M_\odot$. Tracks and isochrones are available in

tabular form for the adopted grid of chemical compositions in the extended plane Z–Y in three photometric systems. An interactive web interface allows users to obtain isochrones of any chemical composition inside the provided Z–Y range and also to simulate stellar populations with different $Y(Z)$ helium-to-metal enrichment laws.

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A star in the M 31 Giant Stream: the highest negative stellar velocity known

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We report on a single star, B 030D, observed as part of a large survey of objects in M 31, which has the unusual radial velocity of -780 km s^{-1}. Based on details of its spectrum, we find that the star is an F supergiant, with a circumstellar shell. The evolutionary status of the star could be one of a post-main-sequence close binary, a symbiotic nova, or less likely, a post-AGB star, which additional observations could help sort out. Membership of the star in the Andromeda Giant Stream can explain its highly negative velocity.

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Twins: The two shortest period non-interacting double degenerate white dwarf stars

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We report on the detection of the two shortest period non-interacting white dwarf binary systems. These systems, SDSS J143633.29+501026.8 and SDSS J105353.89+520031.0, were identified by searching for radial velocity variations in the individual exposures that make up the published spectra from the Sloan Digital Sky Survey. We followed up these systems with time series spectroscopy to measure the period and mass ratios of these systems. Although we only place a lower bound on the companion masses, we argue that they must also be white dwarf stars. With periods of approximately 1 hour, we estimate that the systems will merge in less than 100 Myr, but the merger product will likely not be massive enough to result in a Type 1a supernova.

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UBV photometry of the post-AGB star IRAS 22272+5435 = V354 Lac in 1990–2008

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New UBV-photometry obtained in 2000–2008 is presented for the post-AGB star IRAS 22272+5435 = V354 Lac. The star showed semi-regular light variations with varying amplitudes. The maximal amplitude did not exceed: $\Delta V = 0.^{\rm m}5$, $\Delta B = 0.^{\rm m}7$ and $\Delta U = 1.^{\rm m}0$. For 2000–2008, we have found a photometric period near 128 days. The analysis of long-term observations in 1990–2008 reveals variations with two close periods: 128 and 131 days, causing amplitude modulation. The V vs. $B-V$ diagram shows a clear correlation: the star is generally bluer when brighter. From our UBV data, we derive $E(B-V) = 0.5$ and conclude that the spectral type of the star varies between K1

to K7 during pulsations. The mean UBV-data of V354 Lac have not changed during the past 19 years: $V = 8.^{\rm m}60$, $B - V = 2.^{\rm m}06$ and $U - B = 2.^{\rm m}14$.

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Correlation between technetium and lithium in a sample of oxygen-rich AGB variables

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Context: The elements technetium and lithium are two important indicators of internal nucleosynthesis and mixing in late-type stars. Studying their occurrence and abundance can give deep insight into the structure and evolution in the late phases of the stellar life cycle. Aims: The aims of this paper are: 1) to revisit the Tc content of a sample of oxygen-rich (M-type) asymptotic giant branch (AGB) variables and 2) to increase the number of such stars for which the Li abundance has been measured to provide constraints on the theoretical models of extra-mixing processes. Methods: To this end, we analysed high-resolution spectra of 18 sample stars for the presence of absorption lines of Tc and Li. The abundance of the latter was determined by comparing the observed spectra to hydrostatic MARCS model spectra. Bolometric magnitudes were established from near-IR photometry and pulsation periods. Results: We correct the classification with respect to the presence of Tc for a number of stars. We reclassify the star V441 Cyg as Tc-rich, and the unusual Mira star R Hya, as well as W Eri, as Tc-poor. The abundance of Li, or an upper limit to it, was determined for all of the sample stars. In all stars with Tc we also detected Li. Most of them have a Li content slightly below the solar photospheric value, except for V441 Cyg, which is super-Li rich with $\sim$ 1000 times the solar abundance. We also found that, similar to Tc, a lower luminosity limit seems to exist for the presence of Li. Conclusions: We conclude that the higher Li abundance found in the cooler and higher luminosity objects could stem from a Li production mechanism operating on the thermally pulsing AGB. The stellar mass might have a crucial influence on this (extra mixing) production mechanism. Our findings for R Hya and V441 Cyg have some important consequences for these intriguing objects. It was speculated that the declining pulsation period of R Hya is caused by a recent thermal pulse (TP). While not detecting Tc does not rule out a TP, it indicates that the TPs are not strong enough to drive 3DUP in R Hya. The pieces of evidence concerning the mass of V441 Cyg are not entirely conclusive. It could either be a low-mass, intrinsic S-star that produced its large amount of Li by extra-mixing processes, or an intermediate-mass star ($M \gtrsim 4$ M$_\odot$) undergoing Li production via hot bottom burning.

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A 3D radiative transfer framework: VI. PHOENIX/3D example applications

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We demonstrate the application of our 3D radiative transfer framework in the model atmosphere code PHOENIX/3D for a number of spectrum synthesis calculations for very different conditions. The 3DRT framework discussed in the previous papers of this series was added to our general-purpose model atmosphere code PHOENIX/1D and an extended 3D version PHOENIX/3D was created. The PHOENIX/3D code is parallelized via the MPI library using a hierarchical domain decomposition and displays very good strong scaling. We present the results of several test cases for widely different atmosphere conditions and compare the 3D calculations with equivalent 1D models to assess the internal

accuracy of the 3D modeling. In addition, we show the results for a number of parameterized 3D structures. With presently available computational resources it is possible to solve the full 3D radiative transfer (including scattering) problem with the same micro-physics as included in 1D modeling.

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and from ftp://ftp.hs.uni-hamburg.de/pub/outgoing/phoenix/preprints/3DRT_paper6.pdf

An evaluation of the excitation class parameter for the central stars of planetary nebulae

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The three main methods currently in use for estimating the excitation class of planetary nebulae (PNe) central stars are compared and evaluated using 586 newly discovered and previously known PNe in the Large Magellanic Cloud (LMC). In order to achieve this we ran a series of evaluation tests using line ratios derived from de-reddened, flux calibrated spectra. Pronounced differences between the methods are exposed. Diagrams were created by comparing excitation classes with Hβ line fluxes. The best methods are then compared to published temperatures using the Zanstra method and assessed for their ability to reflect central star effective temperatures and evolution. As a result we call for a clarification of the term 'excitation class' according to the different input parameters used. The first method, which we refer to as $\mathrm{Ex_{neb}}$ relies purely on the ratios of certain key emission lines. The second method, which we refer to as $\mathrm{Ex_{\star}}$ includes modeling to create a continuous variable and, for optically thick PNe in the Magellanic Clouds, is designed to relate more closely to intrinsic stellar parameters. The third method, we refer to as $\mathrm{Ex_{[OIII]/H\beta}}$ since the [O III]/Hβ ratio is used in isolation to other temperature diagnostics. Each of these methods is shown to have serious drawbacks when used as an indicator for central star temperature. Finally, we suggest a new method ($\mathrm{Ex_{\rho}}$) for estimating excitation class incorporating both the [O III]/Hβ and the He II 4686/Hβ ratios. Although any attempt to provide accurate central star temperatures using the excitation class derived from nebula lines will always be limited, we show that this new method provides a substantial improvement over previous methods with better agreement to temperatures derived through the Zanstra method.

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VLTI/AMBER spectro-interferometric imaging of VX Sgr's inhomogenous outer atmosphere

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Aims. We aim to explore the photosphere of the very cool late-type star VX Sgr and in particular the existence and

characterization of molecular layers above the continuum forming photosphere. Methods. We obtained interferometric observations with the VLTI/AMBER interferometer using the fringe tracker FINITO in the spectral domain 1.45–2.50 μm with a spectral resolution of ≈ 35 and baselines ranging from 15 to 88 meters. We perform independent image reconstruction for different wavelength bins and fit the interferometric data with a geometrical toy model. We also compare the data to 1D dynamical models of Miras atmosphere and to 3D hydrodynamical simulations of red supergiant (RSG) and asymptotic giant branch (AGB) stars. Results. Reconstructed images and visibilities show a strong wavelength dependence. The H-band images display two bright spots whose positions are confirmed by the geometrical toy model. The inhomogeneities are qualitatively predicted by 3D simulations. At ≈ 2.00 μm and in the region 2.35–2.50 μm, the photosphere appears extended and the radius is larger than in the H band. In this spectral region, the geometrical toy model locates a third bright spot outside the photosphere that can be a feature of the molecular layers. The wavelength dependence of the visibility can be qualitatively explained by 1D dynamical models of Mira atmospheres. The best-fitting photospheric models show a good match with the observed visibilities and give a photospheric diameter of $\Theta = 8.82 \pm 0.50$ mas. The H_2O molecule seems to be the dominant absorber in the molecular layers. Conclusions. We show that the atmosphere of VX Sgr rather resembles Mira/AGB star model atmospheres than RSG model atmospheres. In particular, we see molecular (water) layers that are typical for Mira stars.

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Available from arXiv:0911.4422

The Taurus *Spitzer* Survey: New candidate Taurus members selected using sensitive mid-infrared photometry

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NOTE for the AGB newsletter: This paper is primarily about the YSOs that we found, but we found likely giants and PNe along the way; see the appendix for discussion of some of these sources.

We report on the properties of pre-main-sequence objects in the Taurus molecular clouds as observed in 7 mid- and far-infrared bands with the *Spitzer Space Telescope*. There are 215 previously-identified members of the Taurus star-forming region in our ~ 44 square degree map; these members exhibit a range of *Spitzer* colors that we take to define young stars still surrounded by circumstellar dust (noting that $\sim 20\%$ of the bonafide Taurus members exhibit no detectable dust excesses). We looked for new objects in the survey field with similar *Spitzer* properties, aided by extensive optical, X-ray, and ultraviolet imaging, and found 148 candidate new members of Taurus. We have obtained follow-up spectroscopy for about half the candidate sample, thus far confirming 34 new members, 3 probable new members, and 10 possible new members, an increase of 15–20% in Taurus members. Of the objects for which we have spectroscopy, 7 are now confirmed extragalactic objects, and one is a background Be star. The remaining 93 candidate objects await additional analysis and/or data to be confirmed or rejected as Taurus members. Most of the new members are Class II M stars and are located along the same cloud filaments as the previously-identified Taurus members. Among non-members with *Spitzer* colors similar to young, dusty stars are evolved Be stars, planetary nebulae, carbon stars, galaxies, and AGN.

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The interface between the stellar wind and interstellar medium around R Cassiopeiae revealed by far-infrared imaging

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The circumstellar dust shells of intermediate initial-mass ($\sim$ 1–8 $M_\odot$) evolved stars are generated by copious mass loss during the asymptotic giant branch phase. The density structure of their circumstellar shell is the direct evidence of mass loss processes, from which we can investigate the nature of mass loss. We used the AKARI Infrared Astronomy Satellite and the *Spitzer* Space Telescope to obtain the surface brightness maps of an evolved star R Cas at far-infrared wavelengths, since the temperature of dust decreases as the distance from the star increases and one needs to probe dust at lower temperatures, i.e., at longer wavelengths. The observed shell structure and the star's known proper motion suggest that the structure represents the interface regions between the dusty wind and the interstellar medium. The deconvolved structures are fitted with the analytic bow shock structure to determine the inclination angle of the bow shock cone. Our data show that (1) the bow shock cone of $1–5 \times 10^{-5}$ $M_\odot$ (dust mass) is inclined at 68° with respect to the plane of the sky, and (2) the dust temperature in the bow shock cone is raised to more than 20 K by collisional shock interaction in addition to the ambient interstellar radiation field. By comparison between the apex vector of the bow shock and space motion vector of the star we infer that there is a flow of interstellar medium local to R Cas whose flow velocity is at least 55.6 km s^{-1}, consistent with an environment conducive to dust heating by shock interactions.

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Heavy element abundances in low gravity globular cluster stars: 47 Tuc

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The exploration of chemical abundances in globular cluster giant branch stars has revealed element abundance inhomogeneities between the stars. This study has investigated a sample of giant branch stars in the globular cluster 47 Tucanae, which were observed at a resolution of $R \approx 110,000$ using UVES on the VLT. The analysis of these stars showed non-local thermodynamic equilibrium (LTE) effects on the abundances derived from the sample of atomic lines under an LTE approximation. The stellar parameters for each star were re-determined using only high excitation potential Fe I lines. The resulting chemical abundance analysis showed enhancements in both the light s- and heavy s-process element abundances with mean values of $\langle[\mathrm{ls/Fe}]\rangle = 0.53 \pm 0.09$ dex and $\langle[\mathrm{hs/Fe}]\rangle = 0.40 \pm 0.11$ dex. However no trend was found between the ratio of the heavy to light s-process element abundances, ($[\mathrm{hs/ls}] = -0.13 \pm 0.14$ dex), and metallicity, ($[\mathrm{Fe/H}] = -0.89 \pm 0.09$ dex) due to the small spread in both of these values. This indicates that the heavy element abundance enhancements are not due third dredge-up of internal nucleosynthesis products in these evolved stars. The source of the heavy element enhancements is therefore primordial or pollution event-related in origin.

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Variability in Proto-Planetary Nebulae: I. Light curve studies of 12 carbon-rich objects

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We have carried out long-term (14 years) V and R photometric monitoring of 12 carbon-rich proto-planetary nebulae. The light and color curves display variability in all of them. The light curves are complex and suggest multiple periods, changing periods, and/or changing amplitudes, which are attributed to pulsation. A dominant period has been determined for each and found to be in the range of $\sim$ 150 d for the coolest (G8) to 35–40 d for the warmest (F3). A clear, linear inverse relationship has been found in the sample between the pulsation period and the effective temperature and also an inverse relationship between the amplitude of light variation and the effective temperature. These are consistent with the expectation for a pulsating post-AGB star evolving toward higher temperature at constant luminosity. The published spectral energy distributions and mid-infrared images show these objects to have cool (200 K), detached dust shells and published models imply that intensive mass loss ended 400–2000 years ago. The detection of periods as long as 150 d in these requires a revision in the published post-AGB evolution models that couple the pulsation period to the mass loss rate and that assume that intensive mass loss ended when the pulsation period had decreased to 100 d. This revision will have the effect of extending the time scale for the early phases of post-AGB evolution. It appears that real time evolution in the pulsation periods of individual objects may be detectable on the time scale of two or three decades.

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Conference Paper

Heavy element abundances in planetary nebulae: A theorist's perspective

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The determination of heavy element abundances from planetary nebula (PN) spectra provides an exciting opportunity to study the nucleosynthesis occurring in the progenitor asymptotic giant branch (AGB) star. We perform post-processing calculations on AGB models of a large range of mass and metallicity to obtain predictions for the production of neutron-capture elements up to the first s-process peak at strontium. We find that solar metallicity intermediate-mass AGB models provide a reasonable match to the heavy element composition of Type I PNe. Likewise, many of the Se and Kr enriched PNe are well fitted by lower mass models with solar or close-to-solar metallicities. However the most Kr-enriched objects, and the PN with sub-solar Se/O ratios are difficult to explain with AGB nucleosynthesis models. Furthermore, we compute s-process abundance predictions for low-mass AGB models of very low metallicity ([Fe/H] ≈ -2.3) using both scaled solar and an α-enhanced initial composition. For these models, O is dredged to the surface, which means that abundance ratios measured relative to this element (e.g., [X/O]) do not provide a reliable measure of initial abundance ratios, or of production within the star owing to internal nucleosynthesis.

Oral contribution, published in Legacies of the Macquarie/AAO/Strasbourg Hα Planetary Nebula Project, PASA (refereed)
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Review Papers

Star clusters as simple stellar populations

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In this paper I review to what extent we can understand the photometric properties of star clusters, and low mass unresolved galaxies in general, in terms of population synthesis models designed to describe Simple Stellar Populations (SSPs), i.e., groups of stars born at the same time, in the same region of space, and out of a gas cloud of homogeneous chemical composition. The photometric properties predicted by these models do not readily match the observations of most star clusters, unless we take into account properly the expected variation in the number of stars occupying sparsely populated evolutionary stages due to stochastic fluctuations in the IMF. In this case, population synthesis models reproduce remarkably well the full observed ranges of integrated colors and absolute magnitudes of star clusters or various ages and metallicities. The disagreement between model predictions and the observations of cluster colors and magnitudes may indicate problems or deficiencies in the modeling, and not necessarily tell us that star clusters do not behave as SSPs. Matching the photometric properties of star clusters using SSP models is a necessary condition for clusters to be considered simple stellar populations, but not a sufficient one. Composite models, with a complex star formation history, also match the observed cluster colors.

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Chemical evolution of star clusters

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I discuss the chemical evolution of star clusters, with emphasis on old globular clusters, in relation to their formation histories. Globular clusters clearly formed in a complex fashion, under markedly different conditions from any younger clusters presently known. Those special conditions must be linked to the early formation epoch of the Galaxy and must not have occurred since. While a link to the formation of globular clusters in dwarf galaxies has been suggested, present-day dwarf galaxies are not representative of the gravitational potential wells within which the globular clusters formed. Instead, a formation deep within the proto-Galaxy or within dark-matter minihaloes might be favoured. Not all globular clusters may have formed and evolved similarly. In particular, we may need to distinguish Galactic halo from Galactic bulge clusters.

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Available from arXiv:0911.0792

The physical properties of red supergiants

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Red supergiants (RSGs) are an evolved He-burning phase in the lifetimes of moderately high mass (10–25 $M_{\odot}$) stars.

The physical properties of these stars mark them as an important and extreme stage of massive stellar evolution, but determining these properties has been a struggle for many years. The cool extended atmospheres of RSGs place them in an extreme position on the Hertzsprung–Russell diagram and present a significant challenge to the conventional assumptions of stellar atmosphere models. The dusty circumstellar environments of these stars can potentially complicate the determination of their physical properties, and unusual RSGs in the Milky Way and neighboring galaxies present a suite of enigmatic properties and behaviors that strain, and sometimes even defy, the predictions of stellar evolutionary theory. However, in recent years our understanding of RSGs, including the models and methods applied to our observations and interpretations of these stars, has changed and grown dramatically. This review looks back at some of the latest work that has progressed our understanding of RSGs, and considers the many new questions posed by our ever-evolving picture of these cool massive stars.

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Thesis

The mass-loss return from Asymptotic Giant Branch stars to the Large Magellanic Cloud using data from the SAGE survey

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The asymptotic giant branch (AGB) phase is the penultimate stage of evolution for low- and intermediate-mass stars. Nucleosynthesis products transported from the helium-fusing shell to the outer, cooler regions form gas molecules and dust grains whose chemistry depends on whether oxygen or carbon is more abundant on the surface. Radiation pressure causes the oxygen- or carbon-rich dust to flow outward, dragging the gas along. Such outflows inject a significant amount of material into the interstellar medium (ISM), seeding new star formation. AGB mass loss is thus a crucial component of galactic chemical evolution. The Large Magellanic Cloud (LMC) is an excellent site for AGB studies. Over 40,000 AGB candidates have been identified using photometric data from the *Spitzer* Space Telescope Surveying The Agents of a Galaxy's Evolution (SAGE) mid-infrared (MIR) survey, including about 35,000 oxygen-rich, 7000 carbon-rich and 1400 "extreme" sources. For the first time, SAGE photometry reveals two distinct populations of O-rich sources in the LMC: a faint population that gradually evolves into C-rich stars and a bright, massive population that circumvents this evolution, remaining O-rich.

This work aims to quantify the mass-loss return from AGB stars to the LMC, a rough estimate for which is derived from the amount of MIR dust emission in excess of that from starlight. I show that this excess flux is a good proxy for the mass-loss rate, and I calculate the total AGB injection rate to be (5.9–13) $\times 10^{-3}$ $M_{\odot}$ yr^{-1}. A more accurate determination requires detailed dust radiative transfer (RT) modeling. For this purpose, I present a grid of C-rich AGB models generated by the RT code 2DUST, spanning a range of effective temperatures, gravities, dust shell radii and optical depths as well as a baseline set of dust properties obtained by modeling a carbon star, data for which was acquired as part of the spectroscopic follow-up to SAGE. AGB stars are the best laboratories for dust studies, and the development of a model grid will reinforce future research in this field.

Ph.D. thesis, 101 pages, 7 tables, 31 figures
Available from arXiv:0911.0799

Job Advert

PhD position in the study of evolved stars

Applications are invited for a three-year PhD position in the Emmy Nöther research group led by Dr. Wouter Vlemmings on the topic of 'Magnetic fields during the birth and death of stars' at the Argelander Institute for Astronomy (AIfA).

The thesis will aim at a better understanding of the final evolution of low-mass stars. The project will focus on the long-standing issue of the mass-loss driving mechanism(s) in these stars and the shaping of the outflow into the diverse shapes found among planetary nebulae. In particular, the rôle of magnetic fields will be addressed. The thesis will be based on radio-interferometric observations using current and upcoming facilities such as ALMA, VLBA, e-VLA, e-MERLIN, SMA and IRAM PdB.

The successful candidate will join the active Emmy Nöther research group which also has close ties to the local ALMA Regional Center (ARC) node and its growing submillimeter-interferometry research group. The successful candidate will benefit from strong collaborations with researchers at a number of foreign institutes.

Interested candidates should hold the equivalent of a Masters degree, including a substantial thesis, in Astronomy or Physics by the start of the appointment. Previous experience with interferometric data analysis is not required but would be an asset.

Interested candidates should send a CV, education history with transcripts of study record, and a brief description of research interests, and arrange for the submission of two letters of recommendation to (PDF email submissions preferred):

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Applications received before 15 January 2010 will receive full consideration, but applications will be accepted until the position is filled.

More information about the group and institute can be found at:
http://www.astro.uni-bonn.de/ wouter/EN/ (EN group homepage)
http://www.astro.uni-bonn.de/english/index.php (AIfA)

See also http://www.astro.uni-bonn.de/∼wouter/EN/