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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

Happy New Year! It is our pleasure to present you the 150$^{\rm th}$ issue of the AGB Newsletter. A bit slimmer than usual, no-doubt because of the festive season, but nonetheless no-less interesting.

The next issue is planned to be distributed on the 1$^{\rm st}$ of February 2010.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What are the three most pertinent outstanding questions on AGB stars, to be answered in this new decade?

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

The effects of thermohaline mixing on low-metallicity asymptotic giant branch stars

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We examine the effects of thermohaline mixing on the composition of the envelopes of low-metallicity asymptotic giant branch (AGB) stars. We have evolved models of 1, 1.5 and 2 $M_\odot$ from the pre-main sequence to the end of the thermally pulsing asymptotic giant branch with thermohaline mixing applied throughout the simulations. In agreement with other authors, we find that thermohaline mixing substantially reduces the abundance of ^{3}He on the upper part of the red giant branch in our lowest mass model. However, the small amount of ^{3}He that remains is enough to drive thermohaline mixing on the AGB. We find that thermohaline mixing is most efficient in the early thermal pulses and its efficiency drops from pulse to pulse. Nitrogen is not substantially affected by the process, but we do see substantial changes in ^{13}C. The ^{12}C to ^{13}C ratio is substantially lowered during the early thermal pulses but the efficacy of the process is seen to diminish rapidly. As the process stops after a few pulses, the ^{12}C to ^{13}C ratio is still able to reach values of 10^3–10^4, which is inconsistent with the values measured in carbon-enhanced metal-poor stars. We also note a surprising increase in the ^{7}Li abundance, with $\log_{10}(\epsilon\ ^7\mathrm{Li})$ reaching values of over 2.5 in the 1.5 $M_\odot$ model. It is thus possible to get stars which are both C- and Li-rich at the same time. We compare our models to measurements of carbon and lithium in carbon-enhanced metal-poor stars which have not yet reached the giant branch. These models can simultaneously reproduced the observed C and Li abundances of carbon-enhanced metal-poor turn-off stars that are Li-rich, but the observed nitrogen abundances still cannot be matched.

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The active and passive populations of Extremely Red Objects

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The properties of galaxies with the reddest observed R–K colors (Extremely Red Objects, EROs), including their apparent division into passive and obscured active objects with roughly similar number densities, are a known challenge for models of galaxy formation. In this paper we produce mock catalogues generated by interfacing the predictions of the MORGANA model with the spectro-photometric + radiative transfer code GRASIL and IR template library to show that the model correctly reproduces number counts, redshift distributions and active fractions of $R-K>5$ sources. We test the robustness of our results against different dust attenuations and, most importantly, against the inclusion of TP-AGB stars in Simple Stellar Populations (SSPs) used to generate galaxy spectra, and find that the inclusion of TP-AGBs has a relevant effect, in that it allows to increase by a large factor the number of very red active objects at all color cuts. When we compare the physical properties of model EROs with those of all galaxies at similar redshift, we find that EROs are not a peculiar class of galaxies: though the oldest and the most obscured galaxies have a higher probability of being selected, many EROs have intermediate properties, so the population does not show bimodal properties. We predict that criteria based on optical colors are a poor discriminant of ERO activity, while deep observations in the FIR, from 100 to 500 μm, are the most efficient way to constrain the SSFR of these objects; we give predictions for future Herschel observations, and show that a few objects will be detected in deep fields at best. Finally, we test whether a simple evolutionary sequence for the formation of $z=0$ massive galaxies, going through a sub-mm-bright phase and then a ERO phase, are typical in this galaxy formation model. We find that

this sequence holds for $\sim 25\%$ of $z = 0$ massive galaxies, while the model typically shows a more complex connection between sub-mm, ERO and massive galaxies.

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Available from arXiv:0911.5346

Morphological structures of Planetary Nebulae

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Since various structural components of planetary nebulae manifest themselves differently, a combination of optical, infrared, submm, and radio techniques is needed to derive a complete picture of planetary nebulae. The effects of projection can also make the derivation of the true 3-D structure difficult. Using a number of examples, we show that bipolar and multipolar nebulae are much more common than usually inferred from morphological classifications of apparent structures of planetary nebulae.
We put forward a new hypothesis that the bipolar and multipolar lobes of PN are not regions of high-density ejected matter, but the result of ionization and illumination. The visible bright regions are in fact volume of low densities (cleared by high-velocity outflows) where the UV photons are being channelled through. We suggest that multipolar nebulae with similar lobe sizes are not caused by simultaneous ejection of matter in several directions, but by leakage of UV photons into those directions.

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Effects of rotation on the evolution and asteroseismic properties of red giants

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The influence of rotation on the properties of red giants is studied in the context of the asteroseismic modelling of these stars. While red giants exhibit low surface rotational velocities, we find that the rotational history of the star has a large impact on its properties during the red giant phase. In particular, for stars massive enough to ignite He burning in non-degenerate conditions, rotational mixing induces a significant increase of the stellar luminosity and shifts the location of the core helium burning phase to a higher luminosity in the HR diagram. This of course results in a change of the seismic properties of red giants at the same evolutionary state. As a consequence the inclusion of rotation significantly changes the fundamental parameters of a red giant star as determined by performing an asteroseismic calibration. In particular rotation decreases the derived stellar mass and increases the age. Depending on the rotation law assumed in the convective envelope and on the initial velocity of the star, non-negligible values of rotational splitting can be reached, which may complicate the observation and identification of non-radial oscillation modes for red giants exhibiting moderate surface rotational velocities. By comparing the effects of rotation and overshooting, we find that the main-sequence widening and the increase of the H-burning lifetime induced by rotation ($v \sin i = 150$ km s^{-1}) are well reproduced by non-rotating models with an overshooting parameter of 0.1, while the increase of luminosity during the post-main sequence evolution is better reproduced by non-rotating models with overshooting parameters twice as large. This is due to the fact that rotation not only increases the size of the convective core but also changes the chemical composition of the radiative zone.

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Evidence of grain growth in the disk of the bipolar proto-planetary nebula M 1-92

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We investigate the dust size and dust shell structure of the bipolar proto-planetary nebula M 1-92 by means of radiative transfer modeling. Our models consists of a disk and bipolar lobes that are surrounded by an AGB shell, each component having different dust characteristics. The upper limit of the grain size $a_{\rm max}$ in the lobes is estimated to be 0.5 μm from the polarization value in the bipolar lobe. The $a_{\rm max}$ value of the disk is constrained with the disk mass (0.2 $M_{\odot}$), which was estimated from a previous CO emission line observation. We find a good model with $a_{\rm max}$ = 1000.0 μm, which provides an approximated disk mass of 0.15 $M_{\odot}$. Even taking into account uncertainties such as the gas-to-dust mass ratio, a significantly larger dust of $a_{\rm max} > 100.0$ μm, comparing to the dust in the lobe, is expected. We also estimated the disk inner radius, the disk outer radius, and the envelope mass to be 30 $R_{\star}$ (=9 AU), 4500 AU, and 4 $M_{\odot}$, respectively, where $v_{\rm exp}$ is the expansion velocity. If the dust existing in the lobes in large separations from the central star undergoes little dust processing, the dust sizes preserves the ones in the dust formation. Submicron-sized grains are found in many objects besides M 1-92, suggesting that the size does not depend much on the object properties, such as initial mass of the central star and chemical composition of the stellar system. On the other hand, the grain sizes in the disk do. Evidence of large grains has been reported in many bipolar PPNs, including M 1-92. This result suggests that disks play an important role in grain growth.

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The detached dust and gas shells around the carbon star U Ant

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Context: Geometrically thin, detached shells of gas have been found around a handful of carbon stars. The current knowledge on these shells is mostly based on CO radio line data. However, imaging in scattered stellar light adds important new information as well as allows studies of the dust shells.
Aims: Previous observations of scattered stellar light in the circumstellar medium around the carbon star U Ant were taken through filters centred on the resonance lines of K and Na. These observations could not separate the scattering by dust and atoms. The aim of this paper is to remedy this situation.
Methods: We have obtained polarization data on stellar light scattered in the circumstellar medium around U Ant through filters which contain no strong lines, making it possible to differentiate between the two scattering agents. Kinematic, as well as spatial, information on the gas shells were obtained through high-resolution echelle spectrograph observations of the K I and Na D lines.
Results: We confirm the existence of two detached shells around U Ant. The inner shell (at a radius of $\approx 43''$ and a width of $\approx 2''$) consists mainly of gas, while the outer shell (at a radius of $\approx 50''$ and a width of $\approx 7''$) appears to consist exclusively of dust. Both shells appear to have an over-all spherical geometry. The gas shell mass is estimated to be 2×10^{-3} $M_{\odot}$, while the mass of the dust shell is estimated to be 5×10^{-5} $M_{\odot}$. The derived expansion velocity, from the K I and Na D lines, of the gas shell, 19.5 km s^{-1}, agrees with that obtained from CO radio line data. The inferred shell age is 2700 years. There is structure, e.g., in the form of arcs, inside the gas shell, but it is not clear whether these are due to additional shells.
Conclusions: Our results support the hypothesis that the observed geometrically thin, detached shells around carbon stars are the results of brief periods of intense mass loss, probably associated with thermal pulses, and subsequent wind–wind interactions. The separation into a gas and a dust shell, with different widths, is most likely the effect of

different dynamical evolutions of the two media after their ejection.

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The ISO Long Wavelength Spectrometer line spectrum of VY Canis Majoris and other oxygen-rich evolved stars

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The far-infrared spectra of circumstellar envelopes around various oxygen-rich stars were observed using the ISO Long Wavelength Spectrometer (LWS). We have examined high signal-to-noise ISO LWS observations of the luminous supergiant star, VY CMa, with the aim of identifying all of the spectral lines. By paying particular attention to water lines, we aim to separate the lines due to other species, in particular, to prepare for forthcoming observations that will cover the same spectral range using Herschel PACS and at higher spectral resolution using Herschel HIFI and SOFIA. We have developed a fitting method to account for blended water lines using a simple weighting scheme to distribute the flux. We have applied this approach to several other stars which we compare with VY CMa. We present line fluxes for the unblended H_2O and CO lines, and present detections of several possible $\nu_2 = 1$ vibrationally excited water lines. We also identify blended lines of OH, one unblended and several blended lines of NH_3, and one possible detection of H_3O^+.

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Updated stellar yields from Asymptotic Giant Branch models

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An updated grid of stellar yields for low to intermediate-mass thermally-pulsing Asymptotic Giant Branch (AGB) stars are presented. The models cover a range in metallicity $Z = 0.02, 0.008, 0.004$, and 0.0001, and masses between 1 $M_\odot$ to 6 $M_\odot$. New intermediate-mass ($M \geq 3$ $M_\odot$) $Z = 0.0001$ AGB models are also presented, along with a finer mass grid than used in previous studies. The yields are computed using an updated reaction rate network that includes the latest NeNa and MgAl proton capture rates,with the main result that between ~ 6 to 30 times less Na is produced by intermediate-mass models with hot bottom burning. In low-mass AGB models we investigate the effect on the production of light elements of including some partial mixing of protons into the intershell region during the deepest extent of each third dredge-up episode. The protons are captured by the abundant ^{12}C to form a ^{13}C pocket. The ^{13}C pocket increases the yields of ^{19}F, ^{23}Na, the neutron-rich Mg and Si isotopes, ^{60}Fe, and ^{31}P. The increase in ^{31}P is by factors of ~ 4 to 20, depending on the metallicity. Any structural changes caused by the addition of the ^{13}C pocket into the He-intershell are ignored. However, the models considered are of low mass and any such feedback is likely to be small. Further study is required to test the accuracy of the yields from the partial-mixing models. For each mass and metallicity, the yields are presented in a tabular form suitable for use in galactic chemical evolution studies or for comparison to the composition of planetary nebulae.

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Time scales of the s process — from minutes to ages

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A discussion of the time scales in the s process appears to be an approriate aspect to discuss at the occasion of Roberto's 70$^{\rm th}$ anniversary, the more as this subject has been repeatedly addressed during the 20 years of collaboration between Torino and Karlsruhe. The two chronometers presented in this text were selected to illustrate the intense mutual stimulation of both groups. Based on a reliable set of accurate stellar (n, γ) cross sections determined mostly at FZK, the Torino group succeeded to develop a comprehensive picture of the various s-process scenarios, which are most valuable for understanding the composition of the solar system as well as for the interpretation of an increasing number of astronomical observations.

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The evolution of planetary nebulae VII. On the chemical composition of the metal-poor PN G 135.9+55.9

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The actual value of the oxygen abundance of the metal-poor planetary nebula PN G 135.9+55.9 has frequently been debated in the literature. We wanted to clarify the situation by making an improved abundance determination based on a study that includes both new accurate observations and new models. We made observations using the method of integral field spectroscopy with the PMAS instrument, and also used ultraviolet observations that were measured with HST–STIS. In our interpretation of the reduced and calibrated spectrum we used for the first time, recent radiation hydrodynamic models, which were calculated with several setups of scaled values of mean Galactic disk planetary nebula metallicities. For evolved planetary nebulae, such as PN G 135.9+55.9, it turns out that departures from thermal equilibrium can be significant, leading to much lower electron temperatures, hence weaker emission in collisionally excited lines. Based on our time-dependent hydrodynamic models and the observed emission line [O III] λ5007, we found a very low oxygen content of about 1/80 of the mean Galactic disk value. This result is consistent with emission line measurements in the ultraviolet wavelength range. The C/O and Ne/O ratios are unusually high and similar to those of another halo object, BoBn-1.

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The low wind expansion velocity of metal-poor carbon stars in the Halo and the Sagittarius stream

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We report the detection, from observations using the James Clerk Maxwell Telescope, of CO $J = 3 \rightarrow 2$ transition lines in six carbon stars, selected as members of the Galactic Halo and having similar infrared colors. Just one Halo star had been detected in CO before this work. Infrared observations show that these stars are red ($J - K > 3$), due to the presence of large dusty circumstellar envelopes. Radiative transfer models indicates that these stars are losing mass with rather large dust mass-loss rates in the range 1–3.3 $\times 10^{-8}$ $M_{\odot}$ yr^{-1}, similar to what can be observed in the Galactic disc. We show that two of these stars are effectively in the Halo, one is likely linked to the stream of the Sagittarius Dwarf Spheroidal galaxy (Sgr dSph), and the other three stars certainly belong to the thick disc. The wind expansion velocities of the observed stars are low compared to carbon stars in the thin disc and are lower for the stars in the Halo and the Sgr dSph stream than in the thick disc. We discuss the possibility that the low expansion velocities result from the low metallicity of the Halo carbon stars. This implies that metal-poor carbon stars lose mass at a rate similar to metal-rich carbon stars, but with lower expansion velocities, as predicted by recent theoretical models. This result implies that the current estimates of mass-loss rates from carbon stars in Local Group galaxies will have to be reconsidered.

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Ghosts in the attic: Mapping the stellar content of the nearby S0 Galaxy NGC 5102

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The spatial distribution of stars in the nearby S0 galaxy NGC 5102 is investigated using images obtained with WIRCam and MegaCam on the Canada–France–Hawaii Telescope. With the exception of gaps between detector elements, the entire galaxy is surveyed in r′ and i′, while the J and K_s data extend out to 6 kpc (7 disk scale lengths). A modest population of main sequence (MS) stars with $M_V < -3.5$ and ages 70 Myr are detected throughout the disk, with the majority located in the southern half of the galaxy. The ratio of C stars to bright M giants is consistent with an overall increase in the star formation rate within the past 1 Gyr. Star-forming activity during the interval 0.1–2 Gyr was more centrally concentrated than during the past 100 Myr. The structure of the disk changes near 5 kpc (5.5 disk scale lengths). RSGs and bright AGB stars are traced out to a radius of 14 kpc (15.6 scale lengths) along the southern portion of the major axis, while a tentative detection is also made of bright AGB stars at a projected distance of 16 kpc along the south east minor axis. A large clump of AGB stars that subtends an arcmin is identified to the west of the galaxy center. It is argued that this is the remnant of a companion galaxy that triggered past episodes of elevated star-forming activity.

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Available from arXiv:0908.2263

Conference Papers

Planetary nebulae in the inner Milky Way

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New abundances of planetary nebulae located towards the bulge of the Galaxy are derived based on observations made at LNA (Brazil). We present accurate abundances of the elements He, N, S, O, Ar, and Ne for 56 PNe located towards the galactic bulge. The data shows a good agreement with other results in the literature, in the sense that the distribution of the abundances is similar to those works. From the statistical analysis performed, we can suggest a bulge-disk interface at 2.2 kpc for the intermediate mass population, marking therefore the outer border of the bulge and inner border of the disk.

Poster contribution, published in IAU Symp. 265, "Chemical abundances in the Universe: Connecting the first Stars to Planets", Eds. K. Cunha, M. Spite & B. Barbuy
Available from arXiv:0912.2078

Recurrent Novae: Progenitors of SN Ia?

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We present 3D hydrodynamical simulations of the separated binary RS Ophiuchi (RS Oph), a recurrent nova and potential progenitor of a SN Ia. RS Oph is composed of a red giant (RG) and a white dwarf (WD) whose mass is close to the Chandrasekhar limit. In an isothermal scenario, the WD accrets about 10% of a 20 km s^{-1} RG wind by a non-Keplerian accretion disk with strong spiral shocks, and about 2% of a 60 km s^{-1} RG wind by what we term a 'turbulent accretion ball'. A significantly larger impact have the thermodynamics. In an adiabatic scenario only about 0.7% of the 20 km s^{-1} RG wind is accreted. The rate of change of the system separation due to mass and angular momentum loss out of the system is negative in all three cases studied, but is ten times smaller for a fast RG wind (60 km s^{-1}) than for a slow RG wind (20 km s^{-1}). The results demonstrate that existing nova models and observed recurrence times fit well together with 3D wind accretion and that RS Oph is one of the most promising systems to become an SN Ia.

Oral contribution, published in ASTRONUM-2009 "Numerical Modeling of Space Plasma Flows", Chamonix, France, July 2009, ASP Conf. Proc.
Available from arXiv:0912.2498

Measuring the mass-loss evolution at the tip of the Asymptotic Giant Branch

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In the final stages of stellar evolution low- to intermediate-mass stars lose their envelope in increasingly massive stellar winds. Such winds affect the interstellar medium and the galactic chemical evolution as well as the circumstellar envelope where planetary nebulae form subsequently. Characteristics of this mass loss depend on both stellar properties

and properties of gas and dust in the wind formation region. In this paper we present an approach towards studies of mass loss using both observations and models, focusing on the stage where the stellar envelope is nearly empty of mass. In a recent study we measure the mass-loss evolution, and other properties, of four planetary nebulae in the Galactic disk. Specifically we use the method of integral field spectroscopy on faint halos, which are found outside the much brighter central parts of a planetary nebula. We begin with a brief comparison between our and other observational methods to determine mass-loss rates in order to illustrate how they differ and complement each other. An advantage of our method is that it measures the gas component directly requiring no assumptions of properties of dust in the wind. Thereafter we present our observational approach in more detail in terms of its validity and its assumptions. In the second part of this paper we discuss capabilities and assumptions of current models of stellar winds. We propose and discuss improvements to such models that will allow meaningful comparisons with our observations. Currently the physically most complete models include too little mass in the model domain to permit a formation of winds with as high mass-loss rates as our observations show.

Oral contribution, published in "Legacies of the Macquarie/AAO/Strasbourg Hα Planetary Nebula Project", PASA (refereed)
Available from arXiv:0908.2432