THE AGB NEWSLETTER

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Editorial

Dear Colleagues,

Happy New Year! It is our pleasure to present you the 127th issue of the AGB Newsletter. Perhaps not as thick as recent issues have been, due undoubtedly to the holiday season, it nonetheless features very interesting work, e.g. several papers on the molecular envelopes of carbon-rich central stars — the famous carbon star IRC +10216 (two papers!), proto-planetary nebula CRL 618, and silicate carbon star EU And — and the paper by Petitjean, Ledoux & Srianand on the rôle of AGB stars (amongst others) in the nitrogen and oxygen enrichment of high-redshift galaxies.

Last month (year)'s Food for Thought continued on how we should call the mixing processes that seem to be operating in some stars and the physical cause for which has not yet been identified with certainty. Noam Soker sent us his view:

"I strongly oppose any the term "Extended Envelope Mixing".

The 'extended' implies we are talking about the outer part of the envelope. The term extended envelope has been used before to an extended envelope above the star: Just type "extended envelope"+AGB in google, and you see that the first citations there refer to the outer envelope (I did not check the rest, but assume most, or even all, refer to the outer envelope).

The use of "Extended Envelope Mixing" means mixing from outside the star.

A different term must be used: "Inner boundary mixing" (IBM), "Inner convection mixing" (ICM), and so on."

The next issue will be distributed on the 1st of February; the deadline for contributions is the 31st of January.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Mixing processes should be called "Inner boundary mixing" (IBM), "Inner convection mixing" (ICM), and so on.

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)

High-resolution spectroscopic observations of the peculiar planetary nebula Me 1-1

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Aims : We determined the atmospheric parameters and evolutionary state of the cool stellar component of the peculiar planetary nebula Me 1-1 and analyzed its spatio-kinematic structure.
Methods : High-resolution optical spectroscopy was used in an abundance analysis of the cool component in Me 1-1. Narrow-band images were used to study the nebula.
Results :The stellar parameters derived for the cool star in Me 1-1 are $T_{\rm eff} = 4500$ K and $\log g = 2.0$, which correspond to a spectral type of K(1-2) II. This star is rapidly rotating with a projected rotational velocity of $v_{\rm rot} = 90$ km s^{-1}. Its estimated mass is 3.5 M$_\odot$ with a distance of 6 Kpc and a luminosity of 370 L$_\odot$. The cool star in Me 1-1 has nearly solar iron and calcium abundances. Barium, a monitor of s-process nucleosynthesis, is not enriched. We show that this cool star has reached the base of the RGB and its accreted matter has been diluted by the deepening convective envelope. The images strongly suggest that Me 1-1 is an edge-on ring with incipient bipolar lobes. The central star is displaced $\sim$ 400 AU from the center of the nebula. The expansion velocity of the ring ranges from 10 and 13 km s^{-1} in the different emission lines. Broad ($\simeq$ 600 km s^{-1}) wings are detected in the Hα emission, probably with a stellar origin. A comparison of Me 1-1 with other ring-like planetary nebula shows that most of them host off-center binary central stars.

Accepted for publication in Astronomy & Astrophysics

Combining Visual and Photoelectric Observations of Semi-Regular Red Variables

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Combining visual observations of SR variables with measurements of them using a photoelectric photometer is discussed then demonstrated using data obtained for the bright, southern SR variable θ Aps. Combining such observations is useful in that it can provide a more comprehensive set of data by extending the temporal coverage of the light curve. Typically there are systematic differences in the visual and photometric datasets that must be corrected for.

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Available from arXiv:0711.4873

The self-enrichment scenario in intermediate metallicity Globular Clusters

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We present stellar yields computed from detailed models of intermediate mass asymptotic giant branch stars of low metallicity. In this work, the whole main microphysics inputs have been updated, and in particular α-enhancement is explicitly taken into account both in the opacities and equation of state. The target of this work is to provide a basis to test the reliability of the AGB self-enrichment scenario for Globular Clusters of intermediate metallicity. These Globular Clusters exhibit well defined abundance patterns, which have often been interpreted as a consequence of the pollution of the interstellar medium by the ejecta of massive AGBs. We calculated a grid of intermediate mass models with metallicity $Z = 0.001$; the evolutionary sequences are followed from the pre-Main sequence along the whole AGB phase. We focus our attention on those elements largely studied in the spectroscopic investigations of Globular Clusters stars, i.e. oxygen, sodium, aluminum, magnesium and fluorine. The predictions of our models show an encouraging agreement with the demand of the self-enrichment scenario for what concerns the abundances of oxygen, aluminum, fluorine and magnesium. The question of sodium is more tricky, due to the large uncertainties of the cross-sections of the Ne-Na cycle. The present results show that only a relatively small range of initial masses (M =5,6 $M_{\odot}$) can be responsible for the self enrichment.

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A search for *ortho*-benzyne (o-C_6H_4) in CRL 618

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Polycyclic aromatic hydrocarbons (PAHs) have been proposed as potential carriers of the unidentified infrared bands (UIRs) and the diffuse interstellar bands (DIBs). PAHs are not likely to form by gas-phase or solid-state interstellar chemistry, but rather might be produced in the outflows of carbon-rich evolved stars. PAHs could form from acetylene addition to the phenyl radical (C_6H_5), which is closely chemically related to benzene (C_6H_6) and *ortho*-benzyne (o-C_6H_4). To date, circumstellar chemical models have been limited to only a partial treatment of benzene-related chemistry, and so the expected abundances of these species are unclear. A detection of benzene has been reported in the envelope of the proto-planetary nebula (PPN) CRL 618, but no other benzene-related species has been detected in this or any other source. The spectrum of o-C_6H_4 is significantly simpler and stronger than that of C_6H_5, and so we conducted deep Ku-, K- and Q-band searches for o-C_6H_4 with the Green Bank Telescope. No transitions were detected, but an upper limit on the column density of 8.4×10^{13} cm^{-2} has been determined. This limit can be used to constrain chemical models of PPNe, and this study illustrates the need for complete revision of these models to include the full set of benzene-related chemistry.

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Line Broadening in Field Metal-poor Red Giant and Red Horizontal Branch Stars

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We report 349 radial velocities for 45 metal-poor field red giant and red horizontal branch stars, with time coverage ranging from 1 to 21 years. We have identified one new spectroscopic binary, HD 4306, and one possible such system, HD 184711. We also report 57 radial velocities for 11 of the 91 stars reported on previously by Carney et al. (2003). All but one of the 11 stars had been found to have variable radial velocities. New velocities for the long-period spectroscopic binaries BD−1 2582 and HD 108317 have extended the time coverage to 21.7 and 12.5 years, respectively, but in neither case have we yet completed a full orbital period. As was found in the previous study, radial velocity "jitter" is present in many of the most luminous stars. Excluding stars showing spectroscopic binary orbital motion, all 7 of the red giants with estimated $M_{\rm V}$ values more luminous than −2.0 display jitter, as well as 3 of the 14 stars with $-2.0 < M_{\rm V} \leq -1.4$. We have also measured the line broadening in all the new spectra, using synthetic spectra as templates. Comparison with results from high-resolution and higher signal-to-noise (S/N) spectra employed by other workers shows good agreement down to line broadening levels of 3 km s^{-1}, well below our instrumental resolution of 8.5 km s^{-1}. As the previous work demonstrated, most of the most luminous red giants show significant line broadening, as do many of the red horizontal branch stars, and we discuss briefly possible causes. The line broadening appears related to velocity jitter, in that both appear primarily among the highest luminosity red giants.

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Rotation and Macroturbulence in Metal-poor Field Red Giant and Red Horizontal Branch Stars

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We report the results for rotational velocities, $V_{\rm rot} \sin i$, and macroturbulence dispersions, $\zeta_{\rm RT}$, for 12 metal-poor field red giant branch (RGB) stars and 7 metal-poor field red horizontal branch (RHB) stars. The results are based on Fourier transform analyses of absorption line profiles from high-resolution ($R \approx 120,000$), high-S/N (≈ 215 per pixel; ≈ 345 per resolution element) spectra obtained with the Gecko spectrograph at CFHT. The stars were selected from the studies of 20 RHB and 116 RGB stars from Carney et al. (2003, 2007), based primarily on larger-than-average line broadening values. We find that $\zeta_{\rm RT}$ values for the metal-poor RGB stars are very similar to those for metal-rich disk giants studied earlier by Gray and his collaborators. Six of the RGB stars have small rotational values, less than 2.0 km s^{-1}, while five show significant rotation/enhanced line broadening, over 3 km s^{-1}. We confirm the rapid rotation rate for RHB star HD 195636, found earlier by Preston (1997). This star's rotation is comparable to that of the fastest known rotating blue horizontal branch (BHB) stars, when allowance is made for differences in radii and moments of inertia. The other six RHB stars have somewhat lower rotation but show a trend to higher values at higher temperatures (lower radii). Comparing our results with those for BHB stars from Kinman et al. (2000), we find that the fraction of rapidly rotating RHB stars is somewhat lower than is found among BHB stars. The number of rapidly rotating RHB stars is also smaller than we would have expected from the observed rotation of the RGB stars. We devise two empirical methods to translate the line broadening results obtained by Carney et al. (2003, 2007)

into $V_{\rm rot} \sin i$ for all the RGB and RHB stars they studied. Binning the RGB stars by luminosity, we find that most metal-poor field RGB stars show no detectable sign, on average, of rotation, which is not surprising given the stars' large radii. However, the most luminous stars, with $M_{\rm V} \leq -1.5$, do show net rotation, with mean values of 2 to 4 km s^{-1}, depending on the algorithm employed, and also show signs of radial velocity jitter and mass loss. This "rotation" may in fact prove to be due to other line broadening effects, such as shock waves or pulsation.

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Detection of circumstellar CH_2CHCN, CH_2CN, CH_3CCH and H_2CS

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We report on the detection of vinyl cyanide (CH_2CHCN), cyanomethyl radical (CH_2CN), methylacetylene (CH_3CCH) and thioformaldehyde (H_2CS) in the C-rich star IRC +10216. These species, which are all known to exist in dark clouds, are detected for the first time in the circumstellar envelope around an AGB star. The four molecules have been detected trough pure rotational transitions in the course of a 3 mm line survey carried out with the IRAM 30-m telescope. The molecular column densities are derived by constructing rotational temperature diagrams. A detailed chemical model of the circumstellar envelope is used to analyze the formation of these molecular species. We have found column densities in the range $5 \times 10^{12} - 2 \times 10^{13}$ cm^{-2}, which translates to abundances relative to H_2 of several 10^{-9}. The chemical model is reasonably successful in explaining the derived abundances through gas phase synthesis in the cold outer envelope. We also find that some of these molecules, CH_2CHCN and CH_2CN, are most probably excited trough infrared pumping to excited vibrational states. The detection of these species stresses the similarity between the molecular content of cold dark clouds and C-rich circumstellar envelopes. However, some differences in the chemistry are indicated by the fact that in IRC +10216 partially saturated carbon chains are present at a lower level than those which are highly unsaturated, while in TMC-1 both types of species have comparable abundances.

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An Explosive End to Intermediate-Mass Zero-Metallicity Stars and Early Universe Nucleosynthesis

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We use the Cambridge stellar evolution code STARS to model the evolution of 5 $M_\odot$ and 7 $M_\odot$ zero-metallicity stars. With enhanced resolution at the hydrogen and helium burning shell in the AGB phases, we are able to model the entire thermally pulsing asymptotic giant branch (TP-AGB) phase. The helium luminosities of the thermal pulses are significantly lower than in higher metallicity stars so there is no third dredge-up. The envelope is enriched in nitrogen by hot-bottom burning of carbon that was previously mixed in during second dredge-up. There is no *s*-process enrichment owing to the lack of third dredge up. The thermal pulses grow weaker as the core mass increases and they eventually cease. From then on the star enters a quiescent burning phase which lasts until carbon ignites at the centre of the star when the CO core mass is 1.36 $M_\odot$. With such a high degeneracy and a core mass so close to the Chandrasekhar mass, we expect these stars to explode as type 1.5 supernovae, very similar to Type Ia supernovae but inside a hydrogen rich envelope.

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Molecular shells in IRC +10216: Evidence for non-isotropic and episodic mass loss enhancement

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We report high angular-resolution VLA observations of cyanopolyyne molecules HC_3N and HC_5N from the carbon rich circumstellar envelope of IRC +10216. The observed low-lying rotational transitions trace a much more extended emitting region than seen in previous observations at higher frequency transitions. We resolve the hollow quasi-spherical distribution of the molecular emissions into a number of clumpy shells. These molecular shells coincide spatially with dust arcs seen in deep optical images of the IRC +10216 envelope, allowing us to study for the first time the kinematics of these features. We find that the molecular and dust shells represent the same density enhancements in the envelope separated in time by ∼120 to ∼360 yrs. From the angular size and velocity spread of the shells, we estimate that each shell typically covers about 10% of the stellar surface at the time of ejection. The distribution of the shells seems to be random in space. The good spatial correspondance between HC_3N and HC_5N emissions is in qualitative agreement with a recent chemical model that takes into account the presence of density-enhanced shells. The broad spatial distribution of the cyanopolyyne molecules, however, would necessitate further study on their formation.

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Activity cycle of the giant star of Z Andromedae and its spin period

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We have reanalyzed the long-term optical light curve (LC) of the symbiotic star Z Andromedae, covering 112–yr of mostly visual observations. Two strictly periodic and one quasi-periodic cycles can be identified in this LC. A $P_1 = 7550$ d quasi periodicity characterizes the repetition time of the outburst episodes of this symbiotic star. Six such events have been recorded so far. During quiescence states of the system, i.e. in time intervals between outbursts, the LC is clearly modulated by a stable coherent period of $P_2 = 759.1$ d. This is the well known orbital period of the Z And binary system that have been measured also spectroscopically. A third coherent period of $P_3 = 658.4$ d is modulating the intense fluctuations in the optical brightness of the system during outbursts. We attribute the trigger of the outbursts phenomenon and the clock that drives it, to a solar type magnetic dynamo cycle that operates in the convection and the outer layers of the giant star of the system. We suggest that the intense surface activity of the giant star during maximum phases of its magnetic cycle is especially enhanced in one or two antipode regions, fixed in the atmosphere of the star and rotating with it. Such spots could be active regions around the North and the South poles of a general magnetic dipole field of the star. The P3 periodicity is half the beat of the binary orbital period of the system and the spin period of the giant. The latter is then either 482 or 1790 d. If only one pole is active on the surface of the giant, P_3 is the beat period itself, and the spin period is 352 d. It could also be 5000 d if the giant is rotating in retrograde direction. We briefly compare these findings in the LC of Z And to similar modulations that were identified in the LC of two other prototype symbiotics, BF Cyg and YY Her.

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Imaging the oxygen-rich disk toward the silicate carbon star EU And

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We present multi-epoch high-angular resolution observations of 22 GHz H_2O masers toward the silicate carbon star EU And to probe the spatio-kinematic distribution of oxygen-rich material. EU And was observed at three epochs (maximum time interval of 14 months) with the Very Long Baseline Array (VLBA). Our VLBA observations of the 22 GHz H_2O masers have revealed that the maser spots are distributed along a straight line across $\sim$20 mas, with a slight hint of an S-shaped structure. The observed spectra show three prominent velocity components at $V_{\mathrm{LSR}} = -42$, -38, and -34 km s^{-1}, with the masers in SW redshifted and those in NE blueshifted. The maser spots located in the middle of the overall distribution correspond to the component at $V_{\mathrm{LSR}} = -38$ km s^{-1}, which approximately coincides with the systemic velocity. These observations can be interpreted as either an emerging helical jet or a disk viewed almost edge-on (a circumbinary or circum-companion disk). However, the outward motion measured in the VLBA images taken 14 months apart is much smaller than that expected from the jet scenario. Furthermore, the mid-infrared spectrum obtained with the Spitzer Space Telescope indicates that the 10 μm silicate emission is optically thin and the silicate grains are of sub-micron size. This lends support to the presence of a circum-companion disk, because an optically thin circumbinary disk consisting of such small grains would be blown away by the intense radiation pressure of the primary (carbon-rich) star. If we assume Keplerian rotation for the circum-companion disk, the mass of the companion is estimated to be 0.5–0.8 $M_{\odot}$. We also identify CO_2 emission features at 13–16 μm in the Spitzer spectrum of EU And–the first unambiguous detection of CO_2 in silicate carbon stars.

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IPHAS and the symbiotic stars. I. Selection method and first discoveries

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The study of symbiotic stars is essential to understand important aspects of stellar evolution in interacting binaries. Their observed population in the Galaxy is however poorly known, and is one to three orders of magnitudes smaller than the predicted population size. IPHAS, the INT Photometric Hα survey of the Northern Galactic plane, gives us the opportunity to make a systematic, complete search for symbiotic stars in a magnitude-limited volume, and discover a significant number of new systems.
A method of selecting candidate symbiotic stars by combining IPHAS and near-IR (2MASS) colours is presented. It allows us to distinguish symbiotic binaries from normal stars and most of the other types of Hα emission line stars in the Galaxy. The only exception are T Tauri stars, which can however be recognized because of their concentration in star forming regions. Using these selection criteria, we discuss the classification of a list of 4338 IPHAS stars with Halpha in emission. 1500 to 2000 of them are likely to be Be stars. Among the remaining objects, 1183 fulfill our photometric constraints to be considered candidate symbiotic stars. The spectroscopic confirmation of three of these objects, which are the first new symbiotic stars discovered by IPHAS, proves the potential of the survey and selection method.

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The Nitrogen and Oxygen abundances in the neutral gas at high redshift

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We study the Oxygen and Nitrogen abundances in the interstellar medium of high-redshift galaxies. We use high resolution and high signal-to-noise ratio spectra of Damped Lyman-α (DLA) systems detected along the line-of-sight to quasars to derive robust abundance measurements from unsaturated metal absorption lines. We present results for a sample of 16 high-redshift DLAs and strong sub-DLAs ($\log N(\mathrm{H\,I}) > 19.5$, $2.4 < z_{\rm abs} < 3.6$) including 13 new measurements. We find that the Oxygen to Iron abundance ratio is pretty much constant with [O/Fe]$= +0.32 \pm 0.10$ for $-2.5 <$[O/H]< -1.0 with a small scatter around this value. The Oxygen abundance follows quite well the Silicon abundance within 0.2dex although the Silicon abundance could be slightly smaller for [O/H]< -2. The distribution of the [N/O] abundance ratio, measured from components that are detected in both species, is somehow double peaked: five systems have [N/O]> -1 and nine systems have [N/O]< -1.15. In the diagram [N/O] versus [O/H], a loose plateau is possibly present at [N/O]$= -0.9$ that is below the so-called primary plateau as seen in local metal-poor dwarf galaxies ([N/O] in the range -0.57 to -0.74). No system is seen above this primary plateau whereas the majority of the systems lie well below with a large scatter. All this suggests a picture in which DLAs undergo successive starbursts. During such an episode, the [N/O] ratio decreases sharply because of the rapid release of Oxygen by massive stars whereas inbetween two bursts, Nitrogen is released by low and intermediate-mass stars with a delay and the [N/O] ratio increases.

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Europium, Samarium, and Neodymium Isotopic Fractions in Metal-Poor Stars

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We have derived isotopic fractions of europium, samarium, and neodymium in two metal-poor giants with differing neutron-capture nucleosynthetic histories. These isotopic fractions were measured from new high resolution ($R \sim 120,000$), high signal-to-noise (S/N$\sim$160–1000) spectra obtained with the 2dCoudé spectrograph of McDonald Observatory's 2.7 m Smith telescope. Synthetic spectra were generated using recent high-precision laboratory measurements of hyperfine and isotopic subcomponents of several transitions of these elements and matched quantitatively to the observed spectra. We interpret our isotopic fractions by the nucleosynthesis predictions of the stellar model, which reproduces *s*-process nucleosynthesis from the physical conditions expected in low-mass, thermally-pulsing stars on the AGB, and the classical method, which approximates *s*-process nucleosynthesis by a steady neutron flux impinging upon Fe-peak seed nuclei. Our Eu isotopic fraction in HD 175305 is consistent with an *r*-process origin by the classical method and is consistent with either an *r*- or an *s*-process origin by the stellar model. Our Sm isotopic fraction in HD 175305 suggests a predominantly *r*-process origin, and our Sm isotopic fraction in HD 196944 is consistent with an *s*-process origin. The Nd isotopic fractions, while consistent with either *r*-process or *s*-process origins, have very little ability to distinguish between *any* physical values for the isotopic fraction in either star. This study for the first time extends the *n*-capture origin of multiple rare earths in metal-poor stars from elemental abundances to the isotopic level, strengthening the *r*-process interpretation for HD 175305 and the *s*-process interpretation for HD 196944.

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The enigma of the oldest 'nova': the central star and nebula of CK Vul

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CK Vul is classified as, amongst others, the slowest known nova, a hibernating nova, or a very late thermal pulse object. Following its eruption in AD 1670, the star remained visible for 2 years. A 15″ nebula was discovered in the 1980's, but the star itself has not been detected since the eruption. We here present radio images which reveal an 0.1″ radio source with a flux of 1.5 mJy at 5 GHz. Deep Hα images show a bipolar nebula with a longest extension of 70″, with the previously known compact nebula at its waist. The emission-line ratios show that the gas is shock-ionized, at velocities > 100 km s^{-1}. Dust emission yields an envelope mass of $\sim 5 \times 10^{-2}$ M$_\odot$. Echelle spectra indicate outflow velocities up to 360 km s^{-1}. From a comparison of images obtained in 1991 and 2004 we find evidence for expansion of the nebula, consistent with an origin in the 1670 explosion; the measured expansion is centred on the radio source. No optical or infrared counterpart is found at the position of the radio source. The radio emission is interpreted as thermal free-free emission from gas with $T_{\rm e} \sim 10^4$ K. The radio source may be due to a remnant circumbinary disk, similar to those seen in some binary post-AGB stars. We discuss possible classifications of this unique outburst, including that of a sub-Chandrasekhar mass supernova, a nova eruption on a cool, low-mass white dwarf, or a thermal pulse induced by accretion from a circumbinary disk.

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Mass Outflow and Chromospheric Activity of Red Giant Stars in Globular Clusters I: M 15

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High resolution spectra of 110 selected red giant stars in the globular cluster M 15 (NGC 7078) were obtained with Hectochelle at the MMT telescope in 2005 May, 2006 May, and 2006 October. Echelle orders containing Hα and Ca H & K are used to identify emission and line asymmetries characterizing motions in the extended atmospheres. Emission in Hα is detected to a luminosity of $\log(L/{\rm L}_\odot) = 2.36$, in this very metal deficient cluster, comparable to other studies, suggesting that appearance of emission wings is independent of stellar metallicity. The faintest stars showing Hα emission appear to lie on the asymptotic giant branch (AGB) in M 15. A line-bisector technique for Hα reveals outflowing velocities in all stars brighter than $\log(L/{\rm L}_\odot) = 2.5$, and this outflow velocity increases with stellar luminosity, indicating the mass outflow increases smoothly with luminosity. Many stars lying low on the AGB show exceptionally high outflow velocities (up to 10−15 km s^{-1}) and more velocity variability (up to 6−8 km s^{-1}), than red giant branch (RGB) stars of similar apparent magnitude. High velocities in M 15 may be related to the low cluster metallicity. Dusty stars identified from *Spitzer* Space Telescope infrared photometry as AGB stars are confirmed as cluster members by radial velocity measurements, yet their Hα profiles are similar to those of RGB stars without dust. If substantial mass loss creates the circumstellar shell responsible for infrared emission, such mass loss must be episodic.

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Observational constraints on AGB mass loss and its effect on AGB evolution

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This review discusses some of the observational constraints on what we know about the mass loss experienced by stars in the Asymptotic Giant Branch (AGB) phase of evolution. Mass loss affects the maximum mass attained by the core of an AGB star and hence its fate as a white dwarf or potentially a supernova. The way mass loss depends on stellar initial parameters and time affects the yield from AGB stars, in terms of elemental abundances and types of dust. The rôle of pulsation, dust formation, chromospheres and other mechanisms which may contribute to mass loss are assessed against observational evidence, and suggestions are made for observations which could force significant new progress in this field in the first decades of the 21st century. A better understanding of AGB mass loss may be gained from a combination with studies of first ascent red giant branch (RGB) stars and red supergiants, through population studies and in different environments.

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and from http://www.astro.keele.ac.uk/~jacco/research/cefalu2007.pdf

Low temperature mean opacities for the carbon-rich regime

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Asymptotic Giant Branch (AGB) stars undergo a change in their chemical composition during their evolution. This in turn leads to an alteration of the radiative opacities, especially in the cool layers of the envelope and the atmosphere, where molecules are the dominant opacity sources. A key parameter in this respect is the number ratio of carbon to oxygen atoms (C/O). In terms of low temperature mean opacities, a variation of this parameter usually cannot be followed in stellar evolution models, because up to now tabulated values were only available for scaled solar metal mixtures (with $C/O \sim 0.5$). We thus present a set of newly generated tables containing Rosseland mean opacity coefficients covering both the oxygen-rich ($C/O < 1$) and the carbon-rich ($C/O > 1$) regime. We compare our values to existing tabular data and investigate the relevant molecular opacity contributors.

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Dynamos and Chemical Mixing in Evolved Stars

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In low-mass Red Giant Branch (RGB) and Asymptotic Giant Branch (AGB) stars, anomalous mixing must transport material near the hydrogen-burning shell to the convective envelope. Recently, it was suggested that buoyant magnetic

flux tubes could supply the necessary transport rate (Busso et al. 2007). The fields are assumed to originate from a dynamo operating in the stellar interior. Here, we show what is required of an $\alpha - \Omega$ dynamo in the envelope of an AGB star to maintain these fields. Differential rotation and rotation drain via turbulent dissipation and Poynting flux, so if shear can be resupplied by convection, then large-scale toroidal field strengths of $\langle B_\phi \rangle \simeq 3 \times 10^4$ G can be sustained at the base of the convection zone.

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The Bipolar Engines of post-AGB stars: Transient Dynamos and Common Envelopes

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The physical mechanism(s) responsible for transitioning from a spherical Asymptotic Giant Branch (AGB) star to an asymmetric post-AGB (pAGB) object is poorly understood. In particular, excess momenta in the outflows of pAGB objects suggest that a binary may be required to supply an additional source of energy and angular momentum. The extraction of rotational energy from the engine is likely fundamental and may be facilitated if a dynamo is operating in the interior. In this regard, single star magnetic outflow models have been proposed as mechanisms for producing and shaping PNe, however these models neglect the back-reaction of the large-scale magnetic field on the flow. Here we present a transient $\alpha - \Omega$ dynamo operating in the envelope of an AGB star in (1) an isolated setting and (2) a common envelope in which the secondary is a low-mass companion in-spiraling in the AGB interior. The back reaction of the fields on the shear is included and differential rotation and rotation deplete via turbulent dissipation and Poynting flux. For an isolated star, the shear must be resupplied in order to sufficiently sustain the dynamo. We comment on the energy requirements that convection must satisfy to accomplish this. For the common envelope case, a robust dynamo can result as the companion provides an additional source of energy and angular momentum.

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Available from arXiv:0707.3792

Announcement

ASPC 378: Why Galaxies Care About AGB Stars: Their Importance as Actors and Probes

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