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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

Happy New Year! It is a pleasure to present you the 174$^{\rm th}$ issue of the AGB Newsletter.

Prestigious Chandrasekhar Fellowships are announced, to work at the Indian Institute of Astrophysics.

Do have a look also at the 3D simulations announced at the end of the newsletter, and marvel about how the ever (?) increasing computing power allows us to mimic reality more and more comprehensively.

Don't forget the workshop on mass return from stars to galaxies, at STScI in March
http://www.stsci.edu/institute/conference/mass-loss-return

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

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Where are the AGB descendants (or their signatures) from the first stars created after the Big Bang?

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

Analysis of chemical abundances in planetary nebulae with [WC] central stars. I. Line intensities and physical conditions

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Planetary nebulae (PNe) around Wolf–Rayet [WR] central stars ([WR]PNe) constitute a particular photoionized nebula class that represents about 10% of the PNe with classified central stars. We analyse deep high-resolution spectrophotometric data of 12 [WR] PNe. This sample of [WR]PNe represents the most extensive analysed so far, at such high spectral resolution. We aim to select the optimal physical conditions in the nebulae to be used in ionic abundance calculations that will be presented in a forthcoming paper.
We acquired spectra at Las Campanas Observatory with the 6.5-m telescope and the Magellan Inamori Kyocera (MIKE) spectrograph, covering a wavelength range from 3350 Å to 9400 Å. The spectra were exposed deep enough to detect, with signal-to-noise ratio higher than three, the weak optical recombination lines (ORLs) of O II, C II, and other species. We detect and identify about 2980 emission lines, which, to date, is the most complete set of spectrophotometric data published for this type of objects. From our deep data, numerous diagnostic line ratios for T_e and n_e are determined from collisionally excited lines (CELs), ORLs, and continuum measurements (H I Paschen continuum in particular). Densities are closely described by the average of all determined values for objects with $n_e < 10^4$ cm^{-3}, and by n_e([Cl III]) for the densest objects. For some objects, n_e([Ar IV]) is adopted as the characteristic density of the high ionization zone. For T_e, we adopt a three-zone ionization scheme, where the low ionization zone is characterised by T_e([N II]), the medium ionization zone by T_e([O III]), and the highest ionization one by T_e([Ar IV]) when available. We compute T_e from the H I Paschen discontinuity and from He I lines.
For each object, T_e(H I) is, in general, consistent with T_e derived from CELs, although it has a very large error. Values of T_e(He I) are systematically lower than the T_e derived from CELs. When comparing T_e(H I) and T_e(He I) it is unclear whether the behaviour of both temperatures agrees with the predictions of the temperature fluctuations paradigm, owing to the large errors in T_e(H I). We do not find any evidence of low-temperature, high-density clumps in our [WR]PNe from the analysis of faint O II and N II plasma diagnostics, although uncertainties dominate the observed line ratios in most objects. The behaviour of T_e([O III])/T_e([N II]), which is smaller for high ionization degrees, can be reproduced by a set of combined matter-bounded and radiation-bounded models, although, for the smallest temperature ratios, a too high metallicity seem to be required.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1111.4992

High-resolution spectroscopic observations of two *s*-process-enriched and carbon-poor post-AGB stars: GLMP 334 and IRAS 15482−5741

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The study of post-AGB stars provides important information on the *s*-process inside asymptotic giant branch (AGB) stars. We determined the atmospheric parameters and abundance patterns of two post-AGB stars: GLMP 334 and IRAS 15482−5741 to better understand their evolutionary state and the nature of the *s*-element enhancement of these stars.

We used high-resolution optical spectroscopy. Atmospheric parameters and abundances were determined in the local-thermodynamic-equilibrium model atmospheres of Kurucz (1993) using the spectral analysis code MOOG. Spectroscopic observations are compared with nucleosynthesis AGB models of different initial masses and s-process efficiencies. Theoretical interpretations are presented and discussed. The observed distribution of neutron capture elements can be fitted with particular choices of AGB initial masses and of the ^{13}C neutron source (^{13}C-pocket strengths) obtained at the adopted [Fe/H] for each star, but the low [C/Fe] observed is incompatible with model predictions. The problem can be solved by increasing the metallicity by 0.2 dex, which is inside the spectroscopic uncertainty. The abundances of carbon and nitrogen observed in these stars may support the occurrence of an extra-mixing episode, the "cool bottom process", even if its exact effect cannot be theoretically quantified yet.

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Iron and α-element production in the first one billion years after the Big Bang

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We present measurements of carbon, oxygen, silicon, and iron in quasar absorption systems existing when the universe was roughly one billion years old. We measure column densities in nine low-ionization systems at $4.7 < z < 6.3$ using Keck, Magellan, and VLT optical and near-infrared spectra with moderate to high resolution. The column density ratios among C II, O I, Si II, and Fe II are nearly identical to sub-DLAs and metal-poor ([M/H] ≤ -1) DLAs at lower redshifts, with no significant evolution over $2 \lesssim z \lesssim 6$. The estimated intrinsic scatter in the ratio of any two elements is also small, with a typical r.m.s. deviation of $\lesssim$0.1 dex. These facts suggest that dust depletion and ionization effects are minimal in our $z > 4.7$ systems, as in the lower-redshift DLAs, and that the column density ratios are close to the intrinsic relative element abundances. The abundances in our $z > 4.7$ systems are therefore likely to represent the typical integrated yields from stellar populations within the first gigayear of cosmic history. Due to the time limit imposed by the age of the universe at these redshifts, our measurements thus place direct constraints on the metal production of massive stars, including iron yields of prompt supernovae. The lack of redshift evolution further suggests that the metal inventories of most metal-poor absorption systems at $z \gtrsim 2$ are also dominated by massive stars, with minimal contributions from delayed Type Ia supernovae or AGB winds. The relative abundances in our systems broadly agree with those in very metal-poor, non-carbon-enhanced Galactic Halo stars. This is consistent with the picture in which present-day metal-poor stars were potentially formed as early as one billion years after the Big Bang.

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A second Kelvin–Helmholtz timescale of post helium-flash evolution

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I show that after the "helium flash" abruptly ends its first ascent red giant evolution, a solar-mass star is powered primarily by gravitational contraction of its helium core, rather than by nuclear fusion. Because this energy is released in the core rather than the envelope, the overall structure of the star, and so its luminosity, is driven toward that of a red clump star from its initial position at the tip of the red giant branch (TRGB). This occurs on a first (and well recognized) Kelvin–Helmholtz timescale $t_{\rm KH,1} \sim E_{\rm env}/L_{\rm TRGB} \sim 10^4$ yr, where $E_{\rm env}$ is the thermal energy stored in the envelope and $L_{\rm TRGB}$ is the luminosity at the TRGB. However, once the star assumes the approximate structure of a clump star, it remains powered primarily by contraction for a *second* Kelvin–Helmholtz timescale $t_{\rm KH,2} \sim E_{\rm core}/L_{\rm clump} \sim 10^6$ yr, where $E_{\rm core}$ is the thermal energy stored in the core and $L_{\rm clump}$ is the luminosity

of a clump star. It is this second Kelvin–Helmholtz timescale that determines the overall pace of the moderately violent processes by which the star returns to nuclear-power generation as a full-fledged clump star. The reservoir of gravitational energy acts as ultimate regulator, providing whatever supplemental energy is needed to power $L_{\rm clump}$ and occasionally absorbing the large momentary excesses from helium mini-flashes. As this reservoir is gradually exhausted, helium fusion approaches the level of steady-state clump stars.

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The initial–final mass relation among white dwarfs in wide binaries

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We present the initial–final mass relation derived from 10 white dwarfs in wide binaries that consist of a main sequence star and a white dwarf. The temperature and gravity of each white dwarf was measured by fitting theoretical model atmospheres to the observed spectrum using a χ^2 fitting algorithm. The cooling time and mass was obtained using theoretical cooling tracks. The total age of each binary was estimated from the chromospheric activity of its main sequence component to an uncertainty of about 0.17 dex in $\log t$. The difference between the total age and white dwarf cooling time is taken as the main sequence lifetime of each white dwarf. The initial mass of each white dwarf was then determined using stellar evolution tracks with a corresponding metallicity derived from spectra of their main sequence companions, thus yielding the initial–final mass relation. Most of the initial masses of the white dwarf components are between 1–2 $M_\odot$. Our results suggest a correlation between the metallicity of a white dwarf's progenitor and the amount of post-main-sequence mass loss it experiences – at least among progenitors with masses in the range of 1–2 $M_\odot$. A comparison of our observations to theoretical models suggests that low mass stars preferentially lose mass on the red giant branch.

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Modelling a high-mass red giant observed by CoRoT

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Context: The advent of space-borne photometers such as CoRoT and *Kepler* has opened up new fields in asteroseismology. This is especially true for red giants as only a few of these stars were known to oscillate with small amplitude, solar-like oscillations before the launch of CoRoT.
Aims: The G6 giant HR 2582 (HD 50890) was observed by CoRoT for approximately 55 days. We present here the analysis of its light curve and the characterisation of the star using different observables, such as its location in the Hertzsprung–Russell diagram and seismic observables.
Methods: Mode frequencies are extracted from the observed Fourier spectrum of the light curve. Numerical stellar

models are then computed to determine the characteristics of the star (mass, age, etc...) from the comparison with observational constraints.
Results: We provide evidence for the presence of solar-like oscillations at low frequency, between 10 and 20 μHz, with a regular spacing of $(1.7 \pm 0.1)\mu$Hz between consecutive radial orders. Only radial modes are clearly visible. From the models compatible with the observational constraints used here, We find that HR 2582 (HD 50890) is a massive star with a mass in the range 3–5 $M_\odot$, clearly above the red clump. It oscillates with rather low radial order (n = 5–12) modes. Its evolutionary stage cannot be determined with precision: the star could be on the ascending red giant branch (hydrogen shell burning) with an age of approximately 155 Myr or in a later phase (helium burning). In order to obtain a reasonable helium amount, the metallicity of the star must be quite subsolar. Our best models are obtained with a mixing length significantly smaller than that obtained for the Sun with the same physical description (except overshoot). The amount of core overshoot during the main-sequence phase is found to be mild, of the order of 0.1 H_p.
Conclusions: HR 2582 (HD 50890) is an interesting case as only a few massive stars can be observed due to their rapid evolution compared to less massive red giants. HR 2582 (HD 50890) is also one of the few cases that can be used to validate the scaling relations for massive red giants stars and its sensitivity to the physics of the star.

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Four decades of IRC +10 216: Evolution of a carbon rich dust shell resolved at 10 μm with MMT Adaptive Optics and MIRAC4

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The evolved carbon-rich AGB star IRC +10 216 (CW Leo) is the brightest mid-infrared source outside the Solar System, as well as one of the closest examples of an evolved star losing mass. It has a complex and variable circumstellar structure on small scales in the near-IR, and mid-IR interferometry has revealed a dynamic dust formation zone. We have obtained diffraction limited imaging and grism spectroscopy of IRC +10 216 at the 6.5m MMT in the N-band ($\sim$ 8–13 μm). These new observations show that a change has occurred in the dust shell surrounding IRC +10 216 over the last two decades, which is illustrated by a change in the apparent shape of the well known SiC spectral feature at $\sim$ 11 μm and a reduction in the continuum at 13 μm. As expected, our diffraction limited spatial information shows an extended circumstellar envelope. We also demonstrate that the dusty envelope appears to be $\sim$ 30% larger at the wavelengths of the SiC feature, likely due to the increased opacity of SiC. The deconvolved FWHM of the object increases from $0.''43$ ($\sim$ 56 AU) for wavelength < 10 μm to $0.''58$ ($\sim$ 75 AU) at 11.8 μm, then decreases to $0.''5$ ($\sim$ 65 AU) at 12.7 μm. Our estimates of IRC +10 216's size allow us to plausibly tie the change in the spectrum over the last 12.5 years to the evolution of the dusty circumstellar envelope at speeds of 12–17 km s^{-1}.

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Yellow supergiants as supernova progenitors: an indication of strong mass loss for red supergiants?

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The increasing observed number of supernova events allows for finding ever more frequently the progenitor star in archive images. In a few cases, the progenitor star is a yellow supergiant star. The estimated position in the Hertzsprung–Russell diagram of these stars is not compatible with the theoretical tracks of classical single star models. According to several authors, the mass-loss rates during the red supergiant phase could be underestimated. We study

the impact of an increase of these mass-loss rates on the position of 12 to 15 $M_\odot$ stars at the end of their nuclear life, in order to reconcile the theoretical tracks with the observed yellow supergiant progenitors. We perform calculations of 12 to 15 $M_\odot$ rotating stellar models using the Geneva stellar evolution code. To account for the uncertainties in the mass-loss rates during the RSG phase, we increase the mass-loss rate of the star (between 3 and 10 times the standard one) during that phase and compare the evolution of stars undergoing such high mass-loss rates with models computed with the standard mass-loss prescription. We show that the final position of the models in the Hertzsprung–Russell diagram depends on the mass loss they undergo during the red supergiant phase. With an increased mass-loss rate, we find that some models end their nuclear life at positions that are compatible with the observed position of several supernova progenitors. We conclude that an increased mass-loss rate (which physical mechanism still need to be clarified) allows single star models to reproduce simultaneously the estimated position in the HRD of the YSG SN progenitors, as well as the SN type.

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HYPERION: An open-source parallelized three-dimensional dust continuum radiative transfer code

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HYPERION is a new three-dimensional dust continuum Monte-Carlo radiative transfer code that is designed to be as generic as possible, allowing radiative transfer to be computed through a variety of three-dimensional grids. The main part of the code is problem-independent, and only requires an arbitrary three-dimensional density structure, dust properties, the position and properties of the illuminating sources, and parameters controlling the running and output of the code. HYPERION is parallelized, and is shown to scale well to thousands of processes. Two common benchmark models for protoplanetary disks were computed, and the results are found to be in excellent agreement with those from other codes. Finally, to demonstrate the capabilities of the code, dust temperatures, SEDs, and synthetic multi-wavelength images were computed for a dynamical simulation of a low-mass star formation region. HYPERION is being actively developed to include new features, and is publicly available (http://www.hyperion-rt.org).

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and from http://www.hyperion-rt.org

Surface convection and red-giant radius measurements

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Phenomenological models of convection adopt characteristic length scales that are chosen to fit solar or stellar observations. We investigate whether changes in these length scales are required between the Sun and low mass stars on the red giant branch (RGB). The question is addressed jointly in the frameworks of the mixing length theory and the full spectrum of turbulence model. For both models, the convective length scale is assumed to be a fixed fraction of the local pressure scale height. We use constraints provided by the observed effective temperatures and linear radii independently. We consider a sample of 38 nearby giants and subgiants for which surface temperatures and luminosities are known accurately and the radii are determined by interferometry to better than 10%. We computed dedicated models for the few cases where the stellar masses were determined by asteroseismological measurements. First we calibrated the solar models. With the same physics, we then computed RGB models for masses between 0.9

$M_\odot$ and 2.5 $M_\odot$ and metallicities ranging from [Fe/H] = −0.34 to solar. The evolution is followed up to 103 $L_\odot$. Special attention is given to the opacities and the non-grey atmosphere models used as boundary conditions for which the model of convection is the same as in the interior. For both the mixing length theory and the full spectrum of turbulence models, the characteristic solar length scale for convection has to be slightly reduced to fit the lower edge of the observed RGB. The corresponding models also agree more closely with the expected mass distribution on the RGB and the seismic constraints. These results are robust regardless of effective temperatures determined spectroscopically or radii determined interferometrically are used.

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Discovery of shocked H_2 around OH 231.8+4.2

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We present K-band integral field observations of the circumstellar envelope of the evolved star OH 231.8+4.2. Spatial and spectral information were simultaneously acquired using the SINFONI integral field unit, with adaptive optics, on the Very Large Telescope. The observations reveal the discovery of H_2 emission (1) around the centre of the nebula and (2) located in clumps along the Western side of the Northern lobe, presumably associated with the strong shocks that stimulate the previously reported Hα emission at the same location. An observed H_2 1–0/2–1 S(1) line ratio of 8.3 ± 1.9 was calculated for the central field, a value consistent with shock excitation.

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The s process in asymptotic giant branch stars of low metallicity and the composition of carbon-enhanced metal-poor stars

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We present models for the slow neutron-capture process (s process) in asymptotic giant branch (AGB) stars of metallicity [Fe/H] = −2.3 and masses 0.9 $M_\odot$ to 6 $M_\odot$. We encountered different regimes of neutron-capture nucleosynthesis increasing in importance as the stellar mass decreases: the ^{22}Ne(α,n)^{25}Mg reaction activated during the thermal pulses, the ^{13}C(α,n)^{16}O reaction activated in radiative conditions during the interpulse periods, and the ^{13}C(α,n)^{16}O reaction activated during the thermal pulses, also as a result of mild proton ingestion episodes. The models where the ^{13}C burns radiatively (masses $\sim$ 2 $M_\odot$) produce an overall good match to carbon-enhanced metal-poor (CEMP) stars showing s-process enhancements (CEMP-s), except they produce too much Na and F. On the other hand, none of our models can provide a match to the composition of CEMP stars also showing rapid-process enhancements (CEMP-s/r). The models fail to reproduce the observed Eu abundances, and they also fail to reproduce the correlation between the Eu and Ba abundances. They also cannot match the ratio of heavy to light s-process elements observed in many CEMP-s/r stars, which can be more than ten times higher than in the solar system. To explain the composition of CEMP-s/r stars we need to invoke the existence of a different "s/r" neutron-capture process either with features in-between the s and the r processes, or generated by superpositions of different neutron-capture processes in the same astrophysical site or in sites linked to each other – for example, in multiple stellar systems.

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IR photometry and dust-shell models for two carbon stars

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We present $JHKLM$ photometry of the carbon stars ST And and T Lyn acquired in 2000–2010. Along with brightness variations due to pulsations, changes on timescales of 2000–3000 days are also observed. Our combined light curves can be satisfactorily represented with light elements derived from visual observations, but the maxima are delayed relative to the calculated times. A color-index analysis demonstrates that the dust shell of ST And is fairly weak, and is manifest only episodically, while the presence of hot dust was always detected for T Lyn. These results confirm models of spherically symmetric stellar dust shells based on mean-flux data, supplemented with observations in the intermediate IR from the IRAS and AKARI satellites. The visual optical depth of the relatively cool dust shell of ST And assuming a dust temperature at the inner edge of $T_1 = 510$ K is very low: $\tau_V = 0.047$. The dust shell of T Lyn is considerably hotter ($T_1 = 940$ K), with $\tau_V = 0.95$. We estimate the mass-loss rate to be 1.8×10^{-7} M$_\odot$ yr^{-1} for ST And and 3.7×10^{-7} M$_\odot$ yr^{-1} for T Lyn.

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Grids of stellar models with rotation. I. Models from 0.8 to 120 M$_\odot$ at solar metallicity ($Z = 0.014$)

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Many topical astrophysical research areas, such as the properties of planet host stars, the nature of the progenitors of different types of supernovae and gamma ray bursts, and the evolution of galaxies, require complete and homogeneous sets of stellar models at different metallicities in order to be studied during the whole of cosmic history. We present here a first set of models for solar metallicity, where the effects of rotation are accounted for in a homogeneous way.
We computed a grid of 48 different stellar evolutionary tracks, both rotating and non-rotating, at $Z = 0.014$, spanning a wide mass range from 0.8 to 120 M$_\odot$. For each of the stellar masses considered, electronic tables provide data for 400 stages along the evolutionary track and at each stage, a set of 43 physical data are given. These grids thus provide an extensive and detailed data basis for comparisons with the observations. The rotating models start on the ZAMS with a rotation rate $v_{\rm ini}/v_{\rm crit} = 0.4$. The evolution is computed until the end of the central carbon-burning phase, the early AGB phase, or the core helium-flash for, respectively, the massive, intermediate, and both low and very low mass stars. The initial abundances are those deduced by Asplund and collaborators, which best fit the observed abundances of massive stars in the solar neighbourhood. We update both the opacities and nuclear reaction rates, and introduce new prescriptions for the mass-loss rates as stars approach the Eddington and/or the critical velocity. We account for both atomic diffusion and magnetic braking in our low-mass star models.
The present rotating models provide a good description of the average evolution of non-interacting stars. In particular, they reproduce the observed main-sequence width, the positions of the red giant and supergiant stars in the HR diagram, the observed surface compositions and rotational velocities. Very interestingly, the enhancement of the mass loss during the red-supergiant stage, when the luminosity becomes supra-Eddington in some outer layers, helps models above 15–20 M$_\odot$ to lose a significant part of their hydrogen envelope and evolve back into the blue part of the HR diagram. This result has interesting consequences for the blue to red supergiant ratio, the minimum mass for stars to become Wolf–Rayet stars, and the maximum initial mass of stars that explode as type II-P supernovae.

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Nonlinear pulsations of red supergiants

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Excitation of radial oscillations in population I ($X = 0.7$, $Z = 0.02$) red supergiants is investigated using the solution of the equations of radiation hydrodynamics and turbulent convection. The core helium burning stars with masses $8\ \mathrm{M}_\odot \leq M \leq 20\ \mathrm{M}_\odot$ end effective temperatures $T_{\rm eff} < 4000$K are shown to be unstable against radial pulsations in the fundamental mode. The oscillation periods range between 45 and 1180 days. The pulsational instability is due to the κ-mechanism in the hydrogen and helium ionization zones. Radial pulsations of stars with mass $M < 15\ \mathrm{M}_\odot$ are strictly periodic with the light amplitude $\Delta M_{\rm bol} \leq 0.5$ mag. The pulsation amplitude increases with increasing stellar mass and for $M > 15\ \mathrm{M}_\odot$ the maximum expansion velocity of outer layers is as high as one third of the escape velocity. The mean radii of outer mass zones increase due to nonlinear oscillations by $\leq 30\%$ in comparison with the initial equilibrium. The approximate method (with uncertainty of a factor of 1.5) to evaluate the mass of the pulsating red supergiant with the known period of radial oscillations is proposed. The approximation of the pulsation constant Q as a function of the mass-to-radius ratio is given. Masses of seven galactic red supergiants are evaluated using the period–mean density relation.

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Fast core rotation in red-giant stars revealed by gravity-dominated mixed modes

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When the core hydrogen is exhausted during stellar evolution, the central region of a star contracts and the outer envelope expands and cools, giving rise to a red giant, in which convection occupies a large fraction of the star. Conservation of angular momentum requires that the cores of these stars rotate faster than their envelopes, and indirect evidence supports this. Information about the angular momentum distribution is inaccessible to direct observations, but it can be extracted from the effect of rotation on oscillation modes that probe the stellar interior. Here, we report the detection of non-rigid rotation in the interiors of red-giant stars by exploiting the rotational frequency splitting of recently detected mixed modes. We demonstrate an increasing rotation rate from the surface of the star to the stellar core. Comparing with theoretical stellar models, we conclude that the core must rotate at least ten times faster than the surface. This observational result confirms the theoretical prediction of a steep gradient in the rotation profile towards the deep stellar interior.

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The spectroscopic evolution of the symbiotic-like recurrent nova V407 Cygni during its 2010 outburst. II. The circumstellar environment and the aftermath

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The nova outburst of V407 Cyg in 2010 Mar. 10 was the first observed for this star but its close resemblance to the well known symbiotic-like recurrent nova RS Oph suggests that it is also a member of this rare type of Galactic novae. The nova was the first detected at γ-ray energies and is the first known nova explosion for this system. The extensive multiwavelength coverage of this outburst makes it an ideal comparison with the few other outbursts known for similar systems.

We extend our previous analysis of the Mira and the expanding shock from the explosion (Shore et al. 2011, A&A, 527, A98) to detail the time development of the photoionized Mira wind, circumstellar medium, and shocked circumstellar environment to derive their physical parameters and how they relate to large scale structure of the environment, extending the previous coverage to more than 500 days after outburst.

We use optical spectra obtained at high resolution with the Nordic Optical Telescope (NOT) ($R \approx 45,000$ to 65,000) and medium resolution Ondřejov Observatory ($R \approx 12,000$) data and compare the line variations with publicly available archival measurements at 30 GHz OVNR and at X-rays with Swift during the first four months of the outburst, through the end of the epoch of strong XR emission. We use nebular diagnostics and high resolution profile variations to derive the densities and locations of the extended emission.

We find that the higher the ionization and/or the higher the excitation energy, the more closely the profiles resemble the He II/Ca V-type high velocity shock profile discussed in Paper I. This also accounts for the comparative development of the [N II] and [O III] isoelectronic transitions: the [O III] 4363Å profile does not show the low velocity peaks while the excited [N II] 5754Å does. If nitrogen is mainly N^{+3} or higher in the shock, the upper state of the [N II] nebular lines will contribute but if the oxygen is O^{+2} then this line is formed by recombination, masking the nebular contributor, and the lower states are collisionally quenched but emit from the low density surroundings. Absorption lines of Fe-peak ions formed in the Mira wind were visible as P Cyg profiles at low velocity before Day 69, around the time of the X-ray peak and we identified many absorption transitions without accompanying emission for metal lines. The H Balmer lines showed strong P Cyg absorption troughs that weakened during the 2010 observing period, through Day 128. The Fe-peak line profiles and flux variations were different for permitted and forbidden transitions: the E1 transitions were not visible after Day 128 but had shown a narrow peak superimposed on an extended (200 km s^{-1}) blue wing, while the M1 and E2 transitions persisted to Day 529, the last observation, and showed extended redshifted wings up of the same velocity. We distinguish the components from the shock, the photoionized environment, and the chromosphere and inner Mira wind using spectra taken more than one year after outburst. The multiple shells and radiative excitation phenomenology are similar to those recently cited for GRBs and SNIa.

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On the progenitors of Galactic novae

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Of the approximately 400 known Galactic classical novae, only ten of them, the recurrent novae, have been seen to

erupt more than once. At least eight of these recurrents are known to harbor evolved secondary stars, rather than the main sequence secondaries typical in classical novae. In this paper, we propose a new nova classification system, based solely on the evolutionary state of the secondary, and not (like the current schemes) based on the properties of the outbursts. Using archival optical and near-infrared photometric observations of a sample of thirty eight quiescent Galactic novae we show that the evolutionary state of the secondary star in a quiescent system can be predicted and several objects are identified for follow-up observations; CI Aql, V2487 Oph, DI Lac and EU Sct.

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Principal component analysis on chemical abundances spaces

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In preparation for the HERMES chemical tagging survey of about a million Galactic FGK stars, we estimate the number of independent dimensions of the space defined by the stellar chemical element abundances [X/Fe]. This leads to a way to study the origin of elements from observed chemical abundances using Principal Component Analysis. We explore abundances in several environments, including solar neighbourhood thin/thick disk stars, halo metal-poor stars, globular clusters, open clusters, the Large Magellanic Cloud and the Fornax dwarf spheroidal galaxy. By studying solar-neighbourhood stars, we confirm the universality of the r-process that tends to produce [n-capture elements/Fe] in a constant ratio. We find that, especially at low metallicity, the production of r-process elements is likely to be associated with the production of α-elements. This may support the core-collapse supernovae as the r-process site. We also verify the over-abundances of light s-process elements at low metallicity, and find that the relative contribution decreases at higher metallicity, which suggests that this lighter elements primary process may be associated with massive stars. We also verify the contribution from the s-process in low-mass AGB stars at high metallicity. Our analysis reveals two types of core-collapse supernovae: one produces mainly α-elements, the other produces both α-elements and Fe-peak elements with a large enhancement of heavy Fe-peak elements which may be the contribution from hypernovae. Excluding light elements that may be subject to internal mixing, K and Cu, we find that the [X/Fe] chemical abundance space in the solar neighbourhood has about 6 independent dimensions both at low metallicity ($-3.5 <$ [Fe/H] < -2) and high metallicity ([Fe/H] > -1). However the dimensions come from very different origins in these two cases. The extra contribution from low mass AGB stars at high metallicity compensates the dimension loss due to the homogenization of the core-collapse supernovae ejecta. Including the extra dimensions from [Fe/H], K, Cu and the light elements, the number of independent dimensions of the [X/Fe]+[Fe/H] chemical space in the solar neighbourhood for HERMES is about 8 to 9. Comparing fainter galaxies and the solar neighbourhood, we find that the chemical space for fainter galaxies such as Fornax and the Large Magellanic Cloud has a higher dimensionality. This is consistent with the slower star formation history of fainter galaxies. We find that open clusters have more chemical space dimensions than the nearby metal-rich field stars. This suggests that a survey of stars in a larger Galactic volume than the solar neighbourhood may show about 1 more dimension in its chemical abundance space.

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Low resolution spectroscopy of hot post-AGB candidates II. LS, LSS, LSE stars and additional IRAS sources

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Hot (OB) post-AGB stars are immediate progenitors of planetary nebulae (PNe). Very few hot post-AGB stars are known. Detecting new hot post-AGB candidates and follow-up multi-wavelength studies will enable us to further understand the processes during the post-AGB evolution that lead to the formation of PNe. Case–Hamburg OB star surveys and their extension (LS, LSS, LSE catalogues) and IRAS (point source) catalogues are good sources for detecting new hot post-AGB candidates from low resolution spectrosocopy. Spectral types are determined from low resolution optical spectra of 44 stars selected from LS, LSS, and LSE catalogues. Unlike the stars in the first paper, the stars in this paper were selected using criteria other than positional coincidence with an IRAS source with far-IR (IRAS) colours similar to post-AGB supergiants and PNe. These included high galactic latitude spectral types of O, B, A supergiants, emission lines in the spectrum and known spectral peculiarity. From the present study we find that LSS 1179, LSS 1222, lSS 1256, LSS 1341, LSS 1394, LSS 2241, LSS 2429, LSS 4560, LSE 16, LSE 42 and LSE 67 to be new hot post-AGB candidates. Further study of these candidates is needed.

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High resolution spectroscopy of the high velocity hot post-AGB star LS III +52°24 (IRAS 22023+5249)

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The first high-resolution ($R = 50,000$) optical spectrum of the B-type star, LS III +52°24, identified as the optical counterpart of the hot post-AGB candidate IRAS 22023+52 24 (I22023) is presented. We report the detailed identifications of the observed absorption and emission features in the full wavelength range (4290–9015 Å) as well as the atmospheric parameters and photospheric abundances (LTE).The nebular parameters (T_e, N_e) are also derived. We estimate $T_{\rm eff} = 24,000$ K, $\log g = 3.0$, and microturbulent velocity of 7 km s^{-1}, and the derived abundances indicate a slightly metal-deficient evolved star with C/O < 1. The observed P-Cygni profiles of hydrogen and helium clearly indicate on-going post-AGB mass loss. The presence of [N II] and [S II] lines and the non-detection of [O III] indicate that photoionisation has just started. The observed spectral features, large heliocentric radial velocity, atmospheric parameters, and chemical composition indicate that I22023 may be evolving into a compact, young low-excitation planetary nebula. Our optical spectroscopic analysis together with the recent *Spitzer* detection of double-dust chemistry (the simultaneous presence of carbonaceous molecules and amorphous silicates) in I22023 and other B-type post-AGB candidates may point to a binary system with a dusty disk as the stellar origin commom to the hot post-AGB stars with O-rich central stars.

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An incisive look at the symbiotic star SS Leporis. Milli-arcsecond imaging with PIONIER/VLTI

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Context: Determining the mass transfer in a close binary system is of prime importance for understanding its evolution. SS Leporis, a symbiotic star showing the Algol paradox and presenting clear evidence of ongoing mass transfer, in which the donor has been thought to fill its Roche lobe, is a target particularly suited to this kind of study.
Aims: Since previous spectroscopic and interferometric observations have not been able to fully constrain the system morphology and characteristics, we go one step further to determine its orbital parameters, for which we need new interferometric observations directly probing the inner parts of the system with a much higher number of spatial frequencies.
Methods: We use data obtained at eight different epochs with the VLTI instruments AMBER and PIONIER in the H and K bands. We performed aperture synthesis imaging to obtain the first model-independent view of this system. We then modelled it as a binary (whose giant is spatially resolved) that is surrounded by a circumbinary disc.
Results: Combining these interferometric measurements with previous radial velocities, we fully constrain the orbit of the system.We then determine the mass of each star and significantly revise the mass ratio. The M giant also appears to be almost twice smaller than previously thought. Additionally, the low spectral resolution of the data allows the flux of both stars and of the dusty disc to be determined along the H and K bands, and thereby extracting their temperatures.
Conclusions: We find that the M giant actually does not stricto sensus fill its Roche lobe. The mass transfer is more likely to occur through the accretion of an important part of the giant wind. We finally rise the possibility for an enhanced mass loss from the giant, and we show that an accretion disc should have formed around the A star.

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The collimated outflows of the planetary nebula Hu 1-2: proper motion and radial velocity measurements

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Hu 1-2 is a planetary nebula that contains an isolated knot located northwestern of the main nebula, which could be related to a collimated outflow. We present a subsarcsecond Hα+[N II] image and a high-resolution, long-slit spectrum of Hu 1-2 that allow us to identify the southeastern counterpart of the northwestern knot and to establish their high velocity ($>$ 340 km s^{-1}), collimated bipolar outflow nature. The detection of the northwestern knot in POSS red plates allows us to carry out a proper motion analysis by combining three POSS red plates and two narrow-band Hα+[N II] CCD images, with a time baseline of $\simeq$ 57 yr. A proper motion of 20 ± 6 mas yr^{-1} along position angle $312° \pm 15°$, and a dynamical age of 1375^{+590}_{-320} yr are obtained for the bipolar outflow. The measured proper motion and the spatio-kinematical properties of the bipolar outflow yield a lower limit of 2.7 kpc for the distance to Hu 1-2.

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Novae from isolated white dwarfs as a source of helium for second generation stars in globular clusters

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We explore the possible contribution of classical and recurrent novae from isolated white dwarfs accreting from the intracluster medium to the abundances of "second generation" globular cluster stellar populations. We show that under reasonable assumptions the helium abundances of clusters can be enhanced substantially by these novae and argue that novae should be considered as an important, and perhaps even dominant channel in the evolution of the intracluster medium. We also discuss a possible test for whether helium enhancement really is the cause of the multiple main sequences in globular clusters that is independent of the positions of stars in the color–magnitude diagram.

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Conference Papers

Evidence for pulsation-driven mass loss from δ Cephei

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We found the first direct evidence that the Cepheid class namesake, δ Cephei, is currently losing mass. These observations are based on data obtained with the *Spitzer* Space Telescope in the infrared, and with the Very Large Array in the radio. We found that δ Cephei is associated with a vast circumstellar structure, reminiscent of a bow shock. This structure is created as the wind from the star interacts with the local interstellar medium. We measure an outflow velocity of ≈ 35.5 km s^{-1} and a mass-loss rate of $\approx 10^{-7}$–10^{-6} M$_\odot$ yr^{-1}. The very low dust content of the outflow suggests that the wind is possibly pulsation-driven, rather than dust-driven as common for other classes of evolved stars.

Oral contribution, published in "20$^{\rm th}$ Stellar Pulsation Conference" ("Impact of New Instruments and Insights in Stellar Pulsation"), Granada, Spain, September 2011
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Classical and recurrent nova outbursts

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Over the last 40 years, multi-frequency observations, coupled with advances in theoretical modelling, have led to a much fuller understanding of the nova phenomenon. Here I give a brief review of the current state of knowledge of classical and recurrent novae including their central systems; the causes and consequences of their outbursts; sub-types, and possible relationships to Type Ia supernovae. Particular attention is paid to the recurrent nova RS Ophiuchi as it shows a wealth of phenomena associated with its 2006 outburst. Finally, some open questions and avenues for future work are summarised.

Oral contribution, published in "11$^{\text{th}}$ Asian–Pacific Regional IAU Meeting" (2011), NARIT Conference Series, Vol. 1, 2012, eds. S. Komonjinda, Y. Kovalev & D. Ruffolo (Review)
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Photoionization modeling of the Galactic planetary nebulae Abell 39 and NGC 7027

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We estimate distances to the spherical planetary nebula Abell 39 and the bipolar planetary nebula NGC 7027 by interpolating from a wide grid of photoionization models using the 3-D code, MOCASSIN. We find preliminary distances of 1.5 kpc and 0.9 kpc respectively, with uncertainties of about 30%.

Poster contribution, published in IAU Symposium 283 "Planetary Nebulae: an Eye to the Future"
Available from arXiv:1112.3184

XSL: The X-Shooter Spectral Library

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We are building a new spectral library with the X-Shooter instrument on ESO's VLT: XSL, the X-Shooter Spectral Library. We present our progress in building XSL, which covers the wavelength range from the near-UV to the near-IR with a resolution of $R \sim 10,000$. At the time of writing we have collected spectra for nearly 240 stars. An important feature of XSL is that we have already collected spectra of more than 100 Asymptotic Giant Branch stars in the Galaxy and the Magellanic Clouds.

Oral contribution, published in GREAT-ESF Workshop: "Stellar Atmospheres in the Gaia Era"
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Job Advert

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See also http://www.iiap.res.in/postdoc.htm

Announcement

3-D magneto-hydrodynamic simulations of stellar interiors and surfaces

Dear Colleagues,

Ben Brown, who is developing 3-D MHD simulations of rotating stellar interiors, has recently released a movie of the evolution of magnetic fields in the Sun. (The movie portrays the solar interior above the radiative zone and the solar surface.) Among other things, the movie animates periodic field reversals and surface activity as well as the migration pattern of sunspots.

Please see Ben's web page, http://www.astro.wisc.edu/∼bpbrown/Welcome.html, or
http://www.wired.com/wiredscience/2011/08/science-simulation-videos/?pid=1746.

I'd like to call this to your attention for two reasons: the representation of the results is great fun to watch (and to use in classes), and the model represents a significant step forward in understanding magnetized fluid motions within stars. Models like this of AGB stars with thermal pulses are underway by Herwig, Karakas, and others. We all look forward to seeing the results.

Have a happy 2012,
Bruce Balick
University of Washington

See also http://www.astro.wisc.edu/∼bpbrown/Welcome.html