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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 170th issue of the AGB Newsletter, featuring no less than 36 journal papers besides no-less interesting proceedings articles. Popular topics in this volume range from type Ia supernovae, merging white dwarves, bipolar planetary nebulae, water fountains, silicates, mass loss, elemental abundances, atomic data, radiative transfer, stellar interiors and asteroseismology, to population studies and the chemical enrichment of the interstellar medium throughout the history of the Universe.

Don't miss the announcements of Nuclei in the Cosmos (if only because it takes place in a beautiful spot on this planet), and the Fizeau exchange programme.

The next issue is planned to be distributed at the start of October 2011.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

3D simulations of stellar interiors can be tested with asteroseismological data

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

A circumbinary disk in the final stages of common envelope and the core-degenerate scenario for Type Ia supernovae

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We study the final stages of the common envelope (CE) evolution and find that a substantial fraction of the ejected mass does not reach the escape velocity. To reach this conclusion we use a self-similar solution under simplifying assumptions. Most of the gravitational energy of a companion white dwarf (WD) is released in the envelope of a massive asymptotic giant branch (AGB) or the red giant branch (RGB) star in a very short time. This rapid energy release forms a blast wave in the envelope. We follow the blast wave propagation from the center of the AGB outwards, and show that $\sim$ 1–10 per cent of the ejected envelope remains bound to the remnant binary system. We suggest that due to angular momentum conservation and further interaction with the binary system, the fallback material forms a circumbinary disk around the post-AGB Core and the companion WD. The interaction of the circumbinary disk with the binary system will reduce the orbital separation much more than expected from the dynamical phase (where the envelope is ejected) of the CE alone. The smaller orbital separation favors a merger at the end of the CE phase or a short time after, while the core is still hot. This is another channel to form a massive WD with super-Chandrasekhar mass that might explode as a type Ia supernova. We term this the core-degenerate (CD) scenario.

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Disordered silicates in space: a study of laboratory spectra of "amorphous" silicates

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We present a laboratory study of silicate glasses of astrophysically relevant compositions including olivines, pyroxenes and melilites. With emphasis on the classic Si–O stretching feature near 10 μm, we compare infrared spectra of our new samples with laboratory spectra on ostensibly similar compositions, and also with synthetic silicate spectral data commonly used in dust modeling. Several different factors affect spectral features including sample chemistry (e.g., polymerization, Mg/Fe ratio, oxidation state and Al-content) and different sample preparation techniques lead to variations in porosity, density and water content. The convolution of chemical and physical effects makes it difficult to attribute changes in spectral parameters to any given variable. It is important that detailed chemical and structural characterization be provided along with laboratory spectra. In addition to composition and density, we measured the glass transition temperatures for the samples which place upper limits on the formation/processing temperatures of these solids in space. Popular synthetically-generated optical functions do not have spectral features that match any of our glass samples. However, the $\sim$ 10 μm feature generated by the synthetic data rarely exactly matches the shape and peak position of astronomically observed silicate features. Our comparison with the synthetic spectra allows astronomers to determine likely candidates amongst our glass samples for matching astronomical observations.

Accepted for publication in Astrophysical Journal

From bipolar to elliptical: Simulating the morphological evolution of Planetary Nebulae

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The majority of Proto-planetary nebulae (PPN) are observed to have bipolar morphologies. The majority of mature PN are observed to have elliptical shapes. In this paper we address the evolution of PPN/PN morphologies attempting to understand if a transition from strongly bipolar to elliptical shape can be driven by changes in the parameters of the mass loss process. To this end we present 2.5D hydrodynamical simulations of mass loss at the end stages of stellar evolution for intermediate mass stars. We track changes in wind velocity, mass loss rate and mass loss geometry. In particular we focus on the transition from mass loss dominated by a short duration jet flow (driven during the PPN phase) to mass loss driven by a spherical fast wind (produced by the central star of the PN). We address how such changes in outflow characteristics can change the nebula from a bipolar to an elliptical morphology. Our results show that including a period of jet formation in the temporal sequence of PPN to PN produces realistic nebular synthetic emission geometries. More importantly such a sequence provides insight, in principle, into the apparent difference in morphology statistics characterizing PPN and PN systems. In particular we find that while jet driven PPN can be expected to be dominated by bipolar morphologies, systems that begin with a jet but are followed by a spherical fast wind will evolve into elliptical nebulae. Furthermore, we find that spherical nebulae are highly unlikely to ever derive from either bipolar PPN or elliptical PN.

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Silicate features in Galactic and extragalactic post-AGB discs

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Aims. In this paper we study the *Spitzer* and TIMMI2 infrared spectra of post-AGB disc sources, both in the Galaxy and the LMC. Using the observed infrared spectra we determine the mineralogy and dust parameters of the discs, and look for possible differences between the Galactic and extragalactic sources. *Methods.* Modelling the full spectral range observed allows us to determine the dust species present in the disc and different physical parameters such as grain sizes, dust abundance ratios, and the dust and continuum temperatures. *Results.* We find that all the discs are dominated by emission features of crystalline and amorphous silicate dust. Only a few sample sources show features due to CO_2 gas or carbonaceous molecules such as PAHs and C_{60} fullerenes. Our analysis shows that dust grain processing in these discs is strong, resulting in large average grain sizes and a very high crystallinity fraction. However, we do not find any correlations between the derived dust parameters and properties of the central source.

There also does not seem to be a noticeable difference between the mineralogy of the Galactic and LMC sources. Even though the observed spectra are very similar to those of protoplanetary discs around young stars, showing similar mineralogy and strong grain processing, we do find evidence for fundamental differences in the physical and chemical processes of the dust processing.

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A 3D photoionization model of the extreme Planetary Nebula NGC 6302

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We present a 3D photoionization model of the planetary nebula NGC 6302, one of the most complex and enigmatic objects of its kind. It's highly bipolar geometry and dense massive disk, coupled with the very wide range of ions present, from neutral species up to Si^{8+}, makes it one of the ultimate challenges to nebular photoionization modelling. Our MOCASSIN model is composed of an extremely dense geometrically thin circumstellar disk and a large pair of diffuse bipolar lobes, a combination which was necessary to reproduce the observed emission-line spectrum. The masses of these components, 2.2 $M_\odot$ and 2.5 $M_\odot$ respectively, gives a total nebular mass of 4.7 $M_\odot$, of which 1.8 $M_\odot$ (39%) is ionized. Discrepancies between our model fit and the observations are attributed to complex density inhomogeneities in the nebula. The potential to resolve such discrepancies with more complex models is confirmed by exploring a range of models introducing small-scale structures. Compared to solar abundances helium is enhanced by 50%, carbon is slightly subsolar, oxygen is solar, and nitrogen is enhanced by a factor of 6. These all imply a significant $3^{\rm rd}$ dredge-up coupled with hot-bottom burning CN-cycle conversion of dredged-up carbon to nitrogen. Aluminium is also depleted by a factor of 100, consistent with depletion by dust grains.
The central star of NGC 6302 is partly obscured by the opaque circumstellar disk, which is seen almost edge-on, and as such its properties are not well constrained. However, emission from a number of high-ionization 'coronal' lines provides a strong constraint on the form of the high-energy ionizing flux. We model emission from the central star using a series of stellar model atmospheres, the properties of which are constrained from fits to the high-ionization nebular emission lines. Using a solar abundance stellar atmosphere we are unable to fit all of the observed line fluxes, but a substantially better fit was obtained using a 220,000 K hydrogen-deficient stellar atmosphere with $\log g = 7.0$ and $L_\star = 14,300$ $L_\odot$. The H-deficient nature of the central star atmosphere suggests that it has undergone some sort of late thermal pulse, and fits to evolutionary tracks imply a central star mass of 0.73–0.82 $M_\odot$. Timescales for these evolutionary tracks suggest the object left the top of the asymptotic giant branch ~ 2100 years ago, in good agreement with studies of the recent mass-loss event that formed one pair of the bipolar lobes. Based on the modelled nebular mass and central star mass we estimate the initial mass of the central star to be 5.5 $M_\odot$, in approximate agreement with that derived from evolutionary tracks.

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Global modeling of radiatively driven accretion of metals from compact debris disks onto the white dwarfs

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Recent infrared observations have revealed presence of compact (radii $\lesssim R_\odot$) debris disks around more than a dozen of metal-rich white dwarfs (WD), likely produced by tidal disruption of asteroids. Accretion of high-Z material from these disks may account for the metal contamination of these WDs. It was previously shown using local calculations that the Poynting–Robertson (PR) drag acting on the dense, optically thick disk naturally drives metal accretion onto the WD at the typical rate $\dot{M}_{\rm PR} \approx 10^8$ g s^{-1}. Here we extend this local analysis by exploring global evolution of the debris disk under the action of the PR drag for a variety of assumptions about the disk properties. We find that massive disks (mass $\gtrsim 10^{20}$ g), which are optically thick to incident stellar radiation inevitably give rise to metal accretion at rates $\dot{M} \gtrsim 0.2 \dot{M}_{\rm PR}$. The magnitude of $\dot{M}$ and its time evolution are determined predominantly by the initial pattern of the radial distribution of the debris (i.e. ring-like vs. disk-like) but not by the total mass of the disk. The latter determines only the disk lifetime, which can be several Myr or longer. Evolution of an optically thick disk generically results in the development of a sharp outer edge of the disk. We also find that the low mass ($\lesssim 10^{20}$ g), optically thin disks exhibit $\dot{M} \ll \dot{M}_{\rm PR}$ and evolve on characteristic timescale $\sim 10^5$–10^6 yr, independent of their total mass.

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Dust-driven mass loss from carbon stars as a function of stellar parameters – II. Effects of grain size on wind properties

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It is well established that the winds of carbon-rich AGB stars (carbon stars) can be driven by radiation pressure on grains of amorphous carbon and collisional transfer of momentum to the gas. This has been demonstrated convincingly by different numerical wind models that include time-dependent dust formation. To simplify the treatment of dust opacities, radiative cross sections are usually computed using the assumption that the dust grains are small compared to wavelengths around the stellar flux maximum. Considering the typical grain sizes that result from these models, however, the applicability of this small-particle limit (SPL) seems questionable.
We explore grain size effects on wind properties of carbon stars, using a generalized description of radiative cross sections valid for particles of arbitrary sizes. The purpose of the study is to investigate under which circumstances the SPL may give acceptable results, and to quantify the possible errors that may occur when the SPL does not hold.
The time-dependent description of grain growth in our detailed radiation-hydrodynamical models gives information about dust particle radii in every layer at every instant of time. Theses grain radii are used for computing opacities and determining the radiative acceleration of the dust-gas mixture. From the largenumber of models presented in the first paper of this series based on SPL dust opacities; Mattsson et al. 2010) we selected two samples, i.e. a group of models with strong, well-developed outflows that are probably representative of the majority of wind-forming models, and another group, close to thresholds in stellar parameter space for dust-driven winds, which are referred to as critical cases.
We show that in the critical cases the effect of the generalized description of dust opacities can be significant, resulting in more intense mass loss and higher wind velocities compared to models using SPL opacities. For well-developed winds, however, grain size effects on mass-loss rates and wind velocities are found to be small. Both groups of models tend towards lower degrees of dust condensation compared to corresponding SPL models, owing to a self-regulating feedback between grain growth and radiative acceleration. Consequently, the "dust-loss rates" are lower in the models with the generalized treatment of grain opacities.
We conclude that our previous results on mass-loss rates obtained with SPL opacities are reliable within a wide region of stellar parameter space, except for critical cases close to thresholds of dust-driven outflows where SPL models will tend to underestimate the mass loss rates and wind velocities.

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Physical structure of the Planetary Nebula NGC 3242 from the hot bubble to the nebular envelope

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One key feature of the interacting stellar winds model of the formation of planetary nebulae (PNe) is the presence of shock-heated stellar wind confined in the central cavities of PNe. This so-called hot bubble should be detectable in X-rays. Here we present XMM–*Newton* observations of NGC 3242, a multiple-shell PN whose shell morphology is consistent with the interacting stellar winds model. Diffuse X-ray emission is detected within its inner shell with a plasma temperature $\sim 2.35 \times 10^6$ K and an intrinsic X-ray luminosity $\sim 2 \times 10^{30}$ ergs s^{-1} at the adopted distance of 0.55 kpc. The observed X-ray temperature and luminosity are in agreement with "ad hoc" predictions of models including heat conduction. However, the chemical abundances of the X-ray-emitting plasma seem to imply little evaporation of cold material into the hot bubble, whereas the thermal pressure of the hot gas is unlikely to drive the nebular expansion as it is lower than that of the inner shell rim. These inconsistencies are compounded by the apparent large filling factor of the hot gas within the central cavity of NGC 3242.

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Dynamical opacity-sampling models of Mira variables. II: Time-dependent atmospheric structure and observable properties of 4 M-type model series

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We present 4 model series of the CODEX dynamical opacity-sampling models of Mira variables with solar abundances, designed to have parameters similar to *o* Cet, R Leo and R Cas. We demonstrate that the CODEX models provide a clear physical basis for the molecular shell scenario used to explain interferometric observations of Mira variables. We show that these models generally provide a good match to photometry and interferometry at wavelengths between the near-infrared and the radio, and make the model outputs publicly available. These model also demonstrate that, in order to match visible and infrared observations, the Fe-poor silicate grains that form within 3 continuum radii must have small grain radii and therefore can not drive the winds from O-rich Mira variables.

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A grid of NLTE corrections for magnesium and calcium in late-type giant and supergiant stars: application to Gaia

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We investigate NLTE effects for magnesium and calcium in the atmospheres of late-type giant and supergiant stars. The aim of this paper is to provide a grid of NLTE/LTE equivalent width ratios $W/W\star$ of Mg and Ca lines for the

following range of stellar parameters: $T_{\rm eff} \in [3500, 5250]$ K, $\log g \in [0.5, 2.0]$ dex and [Fe/H] $\in [-4.0, 0.5]$ dex. We use realistic model atoms with the best physics available and taking into account the fine structure. The Mg and Ca lines of interest are in optical and near IR ranges. A special interest concerns the lines in the Gaia spectrograph (RVS) wavelength domain [8470, 8740] Å. The NLTE corrections are provided as function of stellar parameters in an electronic table as well as in a polynomial form for the Gaia/RVS lines.

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H_2O maser polarization of the water fountains IRAS 15445−5449 and IRAS 18043−2116

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We present the morphology and linear polarization of the 22-GHz H_2O masers in the high-velocity outflow of two post-AGB sources, d46 (IRAS 15445−5449) and b292 (IRAS 18043−2116). The observations were performed using The Australia Telescope Compact Array. Different levels of saturated maser emission have been detected for both sources. We also present the mid-infrared image of d46 overlaid with the distribution of the maser features that we have observed in the red-shifted lobe of the bipolar structure. The relative position of the observed masers and a previous radio continuum observation suggests that the continnum is produced along the blue-shifted lobe of the jet. It is likely due to synchrontron radiation, implying the presence of a strong magnetic field in the jet. The fractional polarization levels measured for the maser features of d46 indicate that the polarization vectors are tracing the poloidal component of the magnetic field in the emitting region. For the H_2O masers of b292 we have measured low levels of fractional linear polarization. The linear polarization in the H_2O maser region of this source likely indicates a dominant toroidal or poloidal magnetic field component. Since circular polarization was not detected it is not possible to determine the magnetic field strength. However, we present a 3-σ evaluation of the upper limit intensity of the magnetic field in the maser emitting regions of both observed sources.

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High velocity precessing jets from the water fountain IRAS 18286−0959 revealed by VLBA observations

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We report the results of multi-epoch VLBA observations of the 22.2-GHz water maser emission associated with the "water fountain" IRAS 18286−0959. We suggest that this object is the second example of a highly collimated bipolar precessing outflow traced by water maser emission, the other is W 43A. The detected water emission peaks are distributed over a velocity range from -50 km s^{-1} to 150 km s^{-1}. The spatial distribution of over 70% of the identified maser features is found to be highly collimated along a spiral jet (jet 1) extended southeast to northwest, the remaining features appear to trace another spiral jet (jet 2) with a different orientation. The two jets form a "double-helix" pattern which lies across $\sim$ 200 milliarcseconds. The maser distribution is reasonably fit by a model consisting of two bipolar precessing jets. The 3D velocities of jet 1 and jet 2 are derived to be 138 km s^{-1} and 99 km s^{-1}, respectively. The precession period of jet 1 is about 56 years. For jet 2, three possible models are tested and they give different values for the kinematic parameters. We propose that the appearance of two jets is the result of a

single driving source with significant proper motion.

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Discovery of a super-Li rich turnoff star in the metal poor globular cluster NGC 6397

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We report on the discovery of a super-Li rich turn-off star in the old (12 Gyr), metal poor ([Fe/H] = -2.1 dex) globular cluster (GC) NGC 6397, based on high-resolution MIKE/*Magellan* spectra. This star shows an unusually high lithium abundance of $A(\mathrm{Li})_{\mathrm{NLTE}} = 4.03 \pm 0.06 \pm 0.14$ dex (or, 4.21, accounting for possible contamination from a binary companion) that lies above the canonical Li-plateau by a factor of 100. This is the highest Li enhancement found in a Galactic GC dwarf star to date. We discuss several enhancement mechanisms, but none can unambiguously explain such a high overabundance. The spectrum of the star shows a possible indication of binarity, but its line strengths and chemical element abundance ratios are fully compatible with other turn-off stars in this GC, seemingly ruling out mass transfer from an AGB companion as origin of the high A(Li). A possible cause is an interaction with a red giant that has undergone cool bottom processing.

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An EVLA study of dusty disks and tori with large grains in dying stars

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We report the results of a pilot multiwavelength survey in the radio continuum (X, Ka and Q bands, i.e. from 3.6 cm to 7 mm) carried out with the EVLA in order to confirm the presence of very large dust grains in dusty disks and torii around the central stars in a small sample of post-AGB objects, as inferred from millimeter and sub-millimeter observations. Supporting mm-wave observations were also obtained with CARMA towards three of our sources. Our EVLA survey has resulted in a robust detection of our most prominent submm emission source, the pre-planetary nebula IRAS 22036+5306, in all three bands, and the disk-prominent post-AGB object, RV Tau, in one band. The observed fluxes are consistent with optically-thin free-free emission, and since they are insignificant compared to their submm/mm fluxes, we conclude that the latter must come from substantial masses of cool, large (mm-sized) grains. We find that the power-law emissivity in the cm-to-submm range for the large grains in IRAS 22036 is ν^{β}, with $\beta = 1$–1.3. Furthermore, the value of β in the 3 to 0.85-mm range for the three disk-prominent post-AGB sources ($\beta \leq 0.4$) is significantly lower than that of IRAS 22036, suggesting that the grains in post-AGB objects with circumbinary disks are likely larger than those in the dusty waists of pre-planetary nebulae.

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Strong variable ultraviolet emission from Y Gem: Accretion activity in an AGB Star with a binary companion?

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Binarity is believed to dramatically affect the history and geometry of mass loss in AGB and post-AGB stars, but observational evidence of binarity is sorely lacking. As part of a project to look for hot binary companions to cool AGB stars using the GALEX archive, we have discovered a late-M star, Y Gem, to be a source of strong and variable UV emission. Y Gem is a prime example of the success of our technique of UV imaging of AGB stars in order to search for binary companions. Y Gem's large and variable UV flux makes it one of the most prominent examples of a late AGB star with a mass accreting binary companion. The UV emission is most likely due to emission associated with accretion activity and a disk around a main-sequence companion star. The physical mechanism generating the UV emission is extremely energetic, with an integrated luminosity of a few $\times$ $L_\odot$ at its peak. We also find weak CO $J = 2$–1 emission from Y Gem with a very narrow line profile (FWHM of 3.4 km s^{-1}). Such a narrow line is unlikely to arise in an outflow, and is consistent with emission from an orbiting, molecular reservoir of radius 300 AU. Y Gem may be the progenitor of the class of post-AGB stars which are binaries and possess disks but no outflows.

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3D LTE spectral line formation with scattering in red giant stars

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We investigate the effects of coherent isotropic continuum scattering on the formation of spectral lines in local thermodynamic equilibrium (LTE) using 3D hydrodynamical and 1D hydrostatic model atmospheres of red giant stars. Detailed radiative transfer with coherent and isotropic continuum scattering is computed for 3D hydrodynamical and 1D hydrostatic models of late-type stellar atmospheres using the SCATE code. Opacities are computed in LTE, while a coherent and isotropic scattering term is added to the continuum source function. We investigate the effects of scattering by comparing continuum flux levels, spectral line profiles and curves of growth for different species with calculations that treat scattering as absorption. Rayleigh scattering is the dominant source of scattering opacity in the continuum of red giant stars. Photons may escape from deeper, hotter layers through scattering, resulting in significantly higher continuum flux levels beneath a wavelength of $\lambda \lesssim 5000$ Å. The magnitude of the effect is determined by the importance of scattering opacity with respect to absorption opacity; we observe the largest changes in continuum flux at the shortest wavelengths and lowest metallicities; intergranular lanes of 3D models are more strongly affected than granules. Continuum scattering acts to increase the profile depth of LTE lines: continua gain more brightness than line cores due to their larger thermalization depth in hotter layers. We thus observe the strongest changes in line depth for high-excitation species and ionized species, which contribute significantly to photon thermalization through their absorption opacity near the continuum optical surface. Scattering desaturates the line profiles, leading to larger abundance corrections for stronger lines, which reach -0.5 dex at 3000 Å for Fe II lines in 3D with excitation potential $\chi = 2$ eV at [Fe/H] $= -3.0$. The corrections are less severe for low-excitation lines, longer wavelengths, and higher metallicity. Velocity fields increase the effects of scattering by separating emission from granules and intergranular lanes in wavelength. 1D calculations exhibit similar scattering abundance corrections for weak lines, but those for strong lines are generally smaller compared to 3D models and depend on the choice of microturbulence. Continuum scattering should be taken into account for computing realistic spectral line profiles at wavelengths $\lambda \lesssim 4000$ Å in metal-poor giant stars. Profile shapes are strongly affected by velocity fields and horizontal inhomogeneities, requiring

a treatment based on 3D hydrodynamical rather than classical 1D hydrostatic model atmospheres.

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A distance scale of planetary nebulae based on mid-infrared data

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Some of the most successful statistical methods for obtaining distances of planetary nebulae (PNe) are based on their apparent sizes and radio emission intensities. These methods have the advantage of being "extinction-free" and are especially suited to be applied to PNe situated at large distances. A similar method, based on the mid-infrared (MIR) emission of PNe, would have the advantage of being applicable to the large databases created after the various all-sky or Galactic Plane infrared surveys, such as IRAS, MSX, ISOGAL, GLIMPSE, etc. In this work we propose a statistical method to calculate the distance of PNe based on the apparent nebular radius and the MIR flux densities. We show that the specific intensity between 8 and 21 μm is proportional to the brightness temperature $T_{\rm b}$ at 5 GHz. Using MIR flux densities at 8, 12, 15 and 21 μm from the MSX survey, we calibrate the distance scale with a statistical method by Stanghellini et al. 2008 (SSV). The database used in the calibration consisted of 67 Galactic PNe with MSX counterparts and distances determined by SSV. We apply the method to a sample of PNe detected at 8 μm in the GLIMPSE infrared survey, and determine the distance of a sample of PNe located along the Galactic Plane and Bulge.

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White dwarfs in the UKIRT Infrared Deep Sky Large Area Survey: the substellar companion fraction

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We present a near-infrared photometric search for unresolved substellar companions and debris disks around white dwarfs in the UKIRT Infrared Deep Sky Survey Large Area Survey. We cross-correlate the SDSS DR4 and McCook & Sion catalogues of white dwarfs with the UKIDSS DR8 producing 3109 and 163 unique matches respectively. Cooling models are fitted to the optical photometry of a subsample of DA white dwarfs and extended to the near-infrared. A comparison is then made with the observed photometry to identify those stars with a near-infrared excess consistent with the presence of a cool companion or debris disk. Where present, we have estimated the approximate spectral type of any putative companion, or an upper limit on the temperature of a debris disk. In total we identify 14–16 new candidate white dwarf + very low mass stellar systems, 9–11 candidate white dwarf + brown dwarf systems, and 3 candidate white dwarf + debris disks. We place lower limits on the unresolved ($< 2''$) companions to all DA white dwarfs and thus assess the sensitivity of UKIDSS to such objects. We use this result to estimate unresolved binary fractions of $f(\mathrm{WD+dL}) > 0.4 \pm 0.3\%$, $f(\mathrm{WD+dT}) > 0.2\%$ and $f(\mathrm{WD+BD}) > 0.5 \pm 0.3\%$.

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A barium central star binary in the Type-I diamond ring planetary nebula Abell 70

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Abell 70 (PN G 038.1−25.4, hereafter A 70) is a planetary nebula (PN) known for its diamond ring appearance due a superposition with a background galaxy. The previously unstudied central star is found to be a binary consisting of a G8IV–V secondary at optical wavelengths and a hot white dwarf (WD) at UV wavelengths. The secondary shows Ba II and Sr II features enhanced for its spectral type that, combined with the chromospheric Hα emission and possible 20–30 km s^{-1} radial velocity amplitude, firmly classifies the binary as a Barium star. The proposed origin of Barium stars is intimately linked to PNe whereby wind accretion pollutes the companion with dredged-up material rich in carbon and s-process elements when the primary is experiencing thermal pulses on the Asymptotic Giant Branch (AGB). A 70 provides further evidence for this scenario together with the other very few examples of Barium central stars. The nebula is found to have Type-I chemical abundances with helium and nitrogen enrichment, which when combined with future abundance studies of the central star, will establish A 70 as a unique laboratory for studying s-process AGB nucleosynthesis. We also discuss guidelines to discover more binary central stars with cool secondaries in large orbits that are required to balance our knowledge of binarity in PNe against the currently better studied post common-envelope binary central stars.

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Characterizing the heavy elements in globular cluster M 22 and an empirical s-process abundance distribution derived from the two stellar groups

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We present an empirical s-process abundance distribution derived with explicit knowledge of the r-process component in the low-metallicity globular cluster M 22. We have obtained high-resolution, high signal-to-noise spectra for 6 red giants in M 22 using the MIKE spectrograph on the *Magellan–Clay* Telescope at Las Campanas Observatory. In each star we derive abundances for 44 species of 40 elements, including 24 elements heavier than zinc ($Z = 30$) produced by neutron-capture reactions. Previous studies determined that 3 of these stars (the "$r + s$ group") have an enhancement of s-process material relative to the other 3 stars (the "r-only group"). We confirm that the $r + s$ group is moderately enriched in Pb relative to the r-only group. Both groups of stars were born with the same amount of r-process material, but s-process material was also present in the gas from which the $r + s$ group formed. The s-process abundances are inconsistent with predictions for AGB stars with $M \leq 3$ M$_\odot$ and suggest an origin in more massive AGB stars capable of activating the ^{22}Ne(α,n)^{25}Mg reaction. We calculate the s-process "residual" by subtracting the r-process pattern in the r-only group from the abundances in the $r + s$ group. In contrast to previous r- and s-process decompositions, this approach makes no assumptions about the r- and s-process distributions in the solar system and provides a unique opportunity to explore s-process yields in a metal-poor environment.

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The young B-star quintuple system HD 155448

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Until now, HD 155448 has been known as a post-AGB star and listed as a quadruple system. In this paper, we study the system in depth and reveal that the B component itself is a binary and that the five stars HD 155448 A, B1, B2, C, and D likely form a comoving stellar system. From a spectroscopic analysis we derive the spectral types and find that all components are B dwarfs (A: B1V, B1: B6V, B2: B9V, C: B4Ve, D: B8V). Their stellar ages put them close to the ZAMS, and their distance is estimated to be ~ 2 kpc. Of particular interest is the C component, which shows strong hydrogen and forbidden emission lines at optical wavelengths. All emission lines are spatially extended in the eastern direction and appear to have a similar velocity shift, except for the [O I] line. In the IR images, we see an arc-like shape to the northeast of HD 155448 C. From the optical up to 10 μm, most circumstellar emission is located at distances between $\sim 1.0''$ and $3.0''$ from HD 155448 C, while in the Q band the arc-like structure appears to be in contact with HD 155448 C. The *Spitzer* and VLT/VISIR mid-IR spectra show that the circumstellar material closest to the star consists of silicates, while polycyclic aromatic hydrocarbons (PAH) dominate the emission at distances $> 1''$, with bands at 8.6, 11.3, and 12.7 μm. We consider several scenarios to explain the unusual, asymmetric, arc-shaped geometry of the circumstellar matter. The most likely explanation is an outflow colliding with remnant matter from the star formation process.

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Kinematics of red variables in the Solar Neighborhood I. Basic data obtained by an SiO maser survey

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In order to study the streaming motions of miras in the Solar neighborhood, we newly surveyed 379 red variables in the SiO maser lines at 42.821 and 43.122 GHz with the Nobeyama 45m radio telescope. Accurate radial velocities were obtained for 229 (220 new) detected stars. The sample is selected from optical variables found by new automated surveys: the Northern Sky Variability Survey and the All Sky Automated Survey. The new sample consists of the "bluer" objects compared with those observed in the previous SiO surveys. The distances to the objects are estimated using the period–luminosity relation, and they are mostly less than 3 kpc from the Sun. The longitude–velocity diagram reveals three prominent groups of stars deviant from the circular Galactic rotation with a flat rotation curve. In addition to the Hercules group of stars which was studied before, we found two new deviant groups: one toward

the Perseus arm and the other toward the Sagittarius arm. These two groups both exhibit anomalous motions toward the Galactic center, which seem to be consistent with the noncircular motions of these spiral arms found in the recent VLBI proper-motion measurements for maser gas clumps.

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Formation of bipolar planetary nebulae by intermediate-luminosity optical transients

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We present surprising similarities between some bipolar planetary nebulae (PNe) and eruptive objects with peak luminosity between novae and supernovae. The later group is termed ILOT for intermediate luminosity optical transients (other terms are intermediate luminosity red transients and red novae). In particular we compare the PN NGC 6302 and the pre-PNe OH 231.8+4.2, M 1-92 and IRAS 22036+5306 with the ILOT NGC 300 OT2008-1. These similarities lead us to propose that the lobes of some (but not all) PNe and pre-PNe were formed in an ILOT event (or several close sub-events). We suggest that in both types of objects the several months long outbursts are powered by mass accretion onto a main-sequence companion to an AGB (or extreme-AGB) star. Jets launched by an accretion disk around the main-sequence companion shape the bipolar lobes. Some of the predictions that result from our comparison is that the ejecta of some ILOTs will have morphologies similar to those of bipolar PNe, and that the central stars of the PNe that were shaped by ILOTs should have a main-sequence binary companion with an eccentric orbit of several years long period.

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HIFI detection of HF in the carbon star envelope IRC +10216

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We report the detection of emission in the $J = 1$–0 rotational transition of hydrogen fluoride (HF), together with observations of the $J = 1$–0 to $J = 3$–2 rotational lines of $H^{35}Cl$ and $H^{37}Cl$, towards the envelope of the carbon star IRC +10216. High-sensitivity, high-spectral resolution observations have been carried out with the HIFI instrument on board *Herschel*, allowing us to resolve the line profiles and providing insights into the spatial distribution of the emission. Our interpretation of the observations, with the use of radiative transfer calculations, indicates that both HF and HCl are formed in the inner regions of the envelope close to the AGB star. Thermochemical equilibrium calculations predict HF and HCl to be the major reservoirs of fluorine and chlorine in the atmospheres of AGB stars. The abundances relative to H_2 derived for HF and HCl, 8×10^{-9} and 1×10^{-7} respectively, are substantially lower than those predicted by thermochemical equilibrium, indicating that F and Cl are likely affected by significant depletion onto dust grains, although some chlorine may be in the form of atomic Cl. The $H^{35}Cl/H^{37}Cl$ abundance ratio is 3.3 ± 0.3. The low abundance derived for HF in IRC +10216 makes it likely that the fluorine abundance is not enhanced over the solar value by nucleosynthesis in the AGB star, although this conclusion may not be robust because the HF abundance we derive is a lower limit to the elemental abundance of F. These observations suggest that both HF and HCl should be detectable through low J rotational transitions in other evolved stars.

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Testing a predictive theoretical model for the mass loss rates of cool stars

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The basic mechanisms responsible for producing winds from cool, late-type stars are still largely unknown. We take inspiration from recent progress in understanding solar wind acceleration to develop a physically motivated model of the time-steady mass-loss rates of cool main-sequence stars and evolved giants. This model follows the energy flux of magnetohydrodynamic turbulence from a subsurface convection zone to its eventual dissipation and escape through open magnetic flux tubes. We show how Alfvén waves and turbulence can produce winds in either a hot corona or a cool extended chromosphere, and we specify the conditions that determine whether or not coronal heating occurs. These models do not utilize arbitrary normalization factors, but instead predict the mass-loss rate directly from a star's fundamental properties. We take account of stellar magnetic activity by extending standard age–activity–rotation indicators to include the evolution of the filling factor of strong photospheric magnetic fields. We compared the predicted mass loss rates with observed values for 47 stars and found significantly better agreement than was obtained from the popular scaling laws of Reimers, Schröder, and Cuntz. The algorithm used to compute cool-star mass-loss rates is provided as a self-contained and efficient computer code. We anticipate that the results from this kind of model can be incorporated straightforwardly into stellar evolution calculations and population synthesis techniques.

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Atomic data for neutron-capture elements. I. Photoionization and recombination properties of low-charge selenium ions

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We present multi-configuration Breit–Pauli AUTOSTRUCTURE calculations of distorted-wave photoionization (PI) cross sections, and total and partial final-state resolved radiative recombination (RR) and dielectronic recombination (DR) rate coefficients for the first six ions of the trans-iron element Se. These calculations were motivated by the recent detection of Se emission lines in a large number of planetary nebulae. Se is a potentially useful tracer of neutron-capture nucleosynthesis, but accurate determinations of its abundance in photoionized nebulae have been hindered by the lack of atomic data governing its ionization balance. Our calculations were carried out in intermediate coupling with semi-relativistic radial wavefunctions. PI and recombination data were determined for levels within the ground configuration of each ion, and experimental PI cross-section measurements were used to benchmark our results. For DR, we allowed $\delta n = 0$ core excitations, which are important at photoionized plasma temperatures. We find that DR is the dominant recombination process for each of these Se ions at temperatures representative of photoionized nebulae ($\sim 10^4$ K). In order to estimate the uncertainties of these data, we compared results from three different

configuration-interaction expansions for each ion, and also tested the sensitivity of the results to the radial scaling factors in the structure calculations. We find that the internal uncertainties are typically 30–50% for the direct PI cross sections and $\sim 10\%$ for the computed RR rate coefficients, while those for low-temperature DR can be considerably larger (from 15–30% up to two orders of magnitude) due to the unknown energies of near-threshold autoionization resonances. These data are available at the CDS, and fitting coefficients to the total RR and DR rate coefficients are presented. The results are suitable for incorporation into photoionization codes used to numerically simulate astrophysical nebulae, and will enable robust determinations of nebular Se abundances.

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Atomic data for neutron-capture elements II. Photoionization and recombination properties of low-charge krypton ions

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We present multi-configuration Breit–Pauli distorted-wave photoionization (PI) cross sections and radiative recombination (RR) and dielectronic recombination (DR) rate coefficients for the first six krypton ions. These were calculated with the AUTOSTRUCTURE code, using semi-relativistic radial wavefunctions in intermediate coupling. Kr has been detected in several planetary nebulae (PNe) and H II regions, and is a useful tracer of neutron-capture nucleosynthesis. PI, RR, and DR data are required to accurately correct for unobserved Kr ions in ionized nebulae, and hence to determine elemental Kr abundances. PI cross sections have been determined for ground configuration states of Kr^{0}–Kr^{5+} up to 100 Rydbergs. Our Kr^{+} PI calculations were significantly improved through comparison with experimental measurements. RR and DR rate coefficients were determined from the direct and resonant PI cross sections at temperatures $(10^1–10^7)z^2$ K, where z is the charge. We account for $\Delta n = 0$ DR core excitations, and find that DR is the dominant recombination mechanism for all but Kr^{+} at photoionized plasma temperatures. Internal uncertainties are estimated by comparing results computed with three different configuration-interaction expansions for each ion, and by testing the sensitivity to variations in the orbital radial scaling parameters. The PI cross sections are generally uncertain by 30–50% near the ground state thresholds. Near 10^4 K, the RR rate coefficients are typically uncertain by $< 10\%$, while those of DR exhibit uncertainties of factors of 2 to 3, due to the unknown energies of near-threshold autoionizing resonances. With the charge transfer rate coefficients presented in the third paper of this series, these data enable robust Kr abundance determinations in photoionized nebulae for the first time.

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Atomic data for neutron-capture elements III. Charge transfer rate coefficients for low-charge ions of Ge, Se, Br, Kr, Rb, and Xe

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We present total and final-state resolved charge transfer (CT) rate coefficients for low-charge Ge, Se, Br, Kr, Rb, and Xe ions reacting with neutral hydrogen over the temperature range 10^2–10^6 K. Each of these elements has been detected in ionized astrophysical nebulae, particularly planetary nebulae. CT rate coefficients are a key ingredient for the ionization equilibrium solutions needed to determine total elemental abundances from those of the observed ions. A multi-channel Landau–Zener approach was used to compute rate coefficients for projectile ions with charges $q = 2$–5, and for singly-charged ions the Demkov approximation was utilized. Our results for five-times ionized species are lower

limits, due to the incompleteness of level energies in the NIST database. In addition, we computed rate coefficients for charge transfer ionization reactions between the neutral species of the above six elements and ionized hydrogen. The resulting total and state-resolved CT rate coefficients are tabulated and available at the CDS. In tandem with our concurrent investigations of other important atomic processes in photoionized nebulae, this work will enable robust investigations of neutron-capture element abundances and nucleosynthesis via nebular spectroscopy.

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Probing the internal rotation of pre-white dwarf stars with asteroseismology: the case of PG 0122+200

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We put asteroseismological constraints on the internal rotation profile of the GW Vir (PG 1159-type) star PG 0122+200. To this end we employ a state-of-the-art asteroseismological model for this star and we assess the expected frequency splittings induced by rotation adopting a forward approach in which we compare the theoretical frequency separations with the observed ones assuming different types of plausible internal rotation profiles. We also employ two asteroseismological inversion methods for the inversion of the rotation profile of PG 0122+200. We find evidence for differential rotation in this star. We demonstrate that the frequency splittings of the rotational multiplets exhibited by PG 0122+200 are compatible with a rotation profile in which the central regions are spinning about 2.4 times faster than the stellar surface.

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A new stellar mixing process operating below shell convection zones following off-center ignition

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During most stages of stellar evolution the nuclear burning of lighter to heavier elements results in a radial composition profile which is stabilizing against buoyant acceleration, with light material residing above heavier material. However, under some circumstances, such as off-center ignition, the composition profile resulting from nuclear burning can be destabilizing, and characterized by an outwardly increasing mean molecular weight. The potential for instabilities under these circumstances, and the consequences that they may have on stellar structural evolution, remain largely unexplored. In this paper we study the development and evolution of instabilities associated with unstable composition gradients in regions which are initially stable according to linear Schwarzschild and Ledoux criteria. In particular, we explore the mixing taking place under various conditions with multi-dimensional hydrodynamic convection models based on stellar evolutionary calculations of the core helium flash in a 1.25 $M_\odot$ star, the core carbon flash in a 9.3

$M_\odot$ star, and of oxygen shell burning in a star with a mass of 23 $M_\odot$. The results of our simulations reveal a mixing process associated with regions having outwardly increasing mean molecular weight that reside below convection zones. The mixing is not due to overshooting from the convection zone, nor is it due directly to thermohaline mixing which operates on a timescale several orders of magnitude larger than the simulated flows. Instead, the mixing appears to be due to the presence of a wave field induced in the stable layers residing beneath the convection zone which enhances the mixing rate by many orders of magnitude and allows a thermohaline type mixing process to operate on a dynamical, rather than thermal, timescale. The mixing manifests itself in the form of overdense and cold blob-like structures originating from density fluctuations at the lower boundary of convective shell and "shooting" down into the core. They are enriched with nuclearly processed material, hence leaving behind traces of higher mean molecular weight. In these regions we find that initially smooth composition gradients steepen into stair-step like profiles in which homogeneous, mixed regions are separated by composition jumps. These step like profiles are then seen to evolve by a process of interface migration driven by turbulent entrainment. We discuss our results in terms of related laboratory phenomena and associated theoretical developments. We also discuss the degree to which the simulated mixing rates depend on the numerical resolution, and what future steps can be taken to capture the mixing rates accurately.

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Multidimensional hydrodynamic simulations of the hydrogen injection flash

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The injection of hydrogen into the convection shell powered by helium burning during the core helium flash is commonly encountered during the evolution of metal-free and extremely metal-poor low-mass stars. With specifically designed multidimensional hydrodynamic simulations, we aim to prove that an entropy barrier is no obstacle for the growth of the helium-burning shell convection zone in the helium core of a metal-rich Pop I star, i.e. convection can penetrate into the hydrogen-rich layers for these stars, too. We further study whether this is also possible in one-dimensional stellar evolutionary calculations. Our hydrodynamical simulations show that the helium-burning shell convection zone in the helium core moves across the entropy barrier and reaches the hydrogen-rich layers. This leads to mixing of protons into the hotter layers of the core and to a rapid increase of the nuclear energy production at the upper edge of the helium-burning convection shell - the hydrogen injection flash. As a result a second convection zone appears in the hydrogen-rich layers. Contrary to 1D models, the entropy barrier separating the two convective shells from each other is largely permeable to chemical transport when allowing for multidimensional flow, and consequently, hydrogen is continuously mixed deep into the helium core. We find it difficult to achieve such a behavior in one-dimensional stellar evolutionary calculations.

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Kinematic ages of central stars of planetary nebulae

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The age distribution of the central stars of planetary nebulae (CSPN) is estimated using two methods based on their kinematic properties. First, the expected rotation velocities of the nebulae at their Galactocentric distances

are compared with the predicted values for the rotation curve, and the differences are attributed to the different ages of the evolved stars. Adopting the relation between the ages and the velocity dispersions determined by the Geneva–Copenhagen survey, the age distribution can be derived. Second, the U, V, W, velocity components of the stars are determined, and the corresponding age–velocity dispersion relations are used to infer the age distribution. These methods have been applied to two samples of PN in the Galaxy. The results are similar for both samples, and show that the age distribution of the PN central stars concentrates in ages lower than 5 Gyr, peaking at about 1 to 3 Gyr.

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and from http://www.astro.iag.usp.br/∼maciel/research/research.html

NSV 11154 is a new R Coronae Borealis star

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NSV 11154 has been confirmed as a new member of the rare hydrogen-deficient R Coronae Borealis (RCB) stars based on new photometric and spectroscopic data. Using new photometry, as well as archival plates from the *Harvard* archive, we have constructed the historical lightcurve of NSV 11154 from 1896 to the present. The lightcurve shows the sudden, deep, irregularly spaced declines characteristic of RCB stars. The visible spectrum is typical of a cool ($T_{\rm eff}\lesssim$5000 K) RCB star showing no hydrogen lines, strong C_2 Swan bands, and no evidence of ^{13}C. In addition, the star shows small pulsations typical of an RCB star, and an infrared excess due to circumstellar dust with a temperature of $\sim$ 800 K. The distance to NSV 11154 is estimated to be $\sim$ 14.5 kpc. RCB stars are very rare in the Galaxy so each additional star is important to population studies leading to a better understanding the origins of these mysterious stars. Among the known sample of RCB stars, NSV 11154 is unusual in that it lies well above the Galactic Plane (5 kpc) and away from the Galactic Center which suggests that its parent population is neither Thick Disk nor Bulge.

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Disc instability in RS Ophiuchi: a path to Type Ia supernovae?

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We study the stability of disc accretion in the recurrent nova RS Ophiuchi. We construct a one-dimensional time-dependent model of the binary-disc system, which includes viscous heating and radiative cooling and a self-consistent treatment of the binary potential. We find that the extended accretion disc in this system is always unstable to the thermal–viscous instability, and undergoes repeated disc outbursts on $\sim$ 10–20yr time-scales. This is similar to the recurrence time-scale of observed outbursts in the RS Oph system, but we show that the disc's accretion luminosity during outburst is insufficient to explain the observed outbursts. We explore a range of models, and find that in most cases the accretion rate during outbursts reaches or exceeds the critical accretion rate for stable nuclear burning on the white dwarf surface. Consequently we suggest that a surface nuclear burning triggered by disc instability may be responsible for the observed outbursts. This allows the white dwarf mass to grow over time, and we suggest that disc instability in RS Oph and similar systems may represent a path to Type Ia supernovae.

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Chemical enrichment mechanisms in ω Centauri: clues from neutron-capture elements

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In the complex picture of multiple stellar populations in globular clusters (GCs), a special role is played by NGC 5139 (ω Centauri). At variance with the majority of GCs, ω Cen exhibits significant star-to-star variations in metallicity and in relative neutron-capture element abundance ratios with respect to Fe, along with split evolutionary sequences as revealed from colour–magnitude diagrams. Combining information from photometry and spectroscopy, several studies suggested that an age spread of several Gyr has to be invoked to explain (at least partially) some of the observed features. However, a comprehensive understanding of the formation, evolution and chemical enrichment processes is still not at hand. Relatively metal-rich ω Cen stars display neutron-capture abundance distributions dominated by contributions from the s-process, but it is not clear what roles have been played by the so-called main and weak s-process components in generating these abundances. To gain better insight into this question we derived lead (Pb) abundances for several ω Cen cluster members, because this element can only be produced by the main s-process. We analysed high-resolution UVES@VLT spectra of a sample of twelve red-giant branch stars, deriving abundances of Pb and also of Y, Zr, La, Ce, Eu, and the C+N+O sum. Spectral synthesis was applied to all features, taking into account isotopic shifts and/or hyperfine structure as needed. We measured for the first time the Pb content in ω Cen, discovering a clear hint for a Pb production occurring at [Fe/H] > -1.7 dex. Our data suggest that the role of the weak component in the production of s-process elements is negligible. Moreover, evidence gathered from the abundances of other elements indicates that the main component occurring in this GC is peculiar and shifted towards higher mass polluters than the standard one.

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Nucleosynthesis during the merger of white dwarfs and the origin of R Coronae Borealis stars

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Many hydrogen deficient stars are characterised by surface abundance patterns that are hard to reconcile with conventional stellar evolution. Instead, it has been suggested that they may represent the result of a merger episode between a helium and a carbon–oxygen white dwarf. In this Letter, we present a nucleosynthesis study of the merger of a 0.4 $M_\odot$ helium white dwarf with a 0.8 $M_\odot$ carbon–oxygen white dwarf, by coupling the thermodynamic history of Smoothed Particle Hydrodynamics particles with a post-processing code. The resulting chemical abundance pattern, particularly for oxygen and fluorine, is in qualitative agreement with the observed abundances in R Coronae Borealis stars.

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and from http://iopscience.iop.org/2041-8205/737/2/L34/

Conference Papers

When asymmetric cosmic bubbles betray a difficult marriage: the study of binary central stars of Planetary Nebulae

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Planetary Nebulae represent a powerful window into the evolution of low- and intermediate-mass stars that have undergone extensive mass-loss. The nebula manifests itself in an extremely wide variety of shapes, but exactly how the mass lost is shaped into such a diverse range of morphologies is still highly uncertain despite over thirty years of vigorous debate. Binaries have long been thought to offer a solution to this vexing problem. Now, thanks to recent surveys and improved observing strategies, it appears clearly that a binary channel, in particular common-envelope (CE) evolution, is responsible for a large fraction of planetary nebulae. Moreover, as planetary nebulae are just "fresh out of the oven" compared to other post-CE systems, they provide invaluable contributions to the study of common-envelope evolution and to the formation of jets in binary systems. Our studies have also started to identify strong links between binarity and morphology, including a high proportion of bipolar nebulae and rings of low ionisation filaments resembling SN 1987A. Equally important are the newly found binary CSPN with intermediate periods, which appear linked to chemically peculiar stars whose composition was modified by binary evolution. Their study may also reveal much information on mass and angular momentum transfer processes in binary stars. Here we show examples of four PNe for which we have discovered their binary nature, including the discovery of a rare case of a barium-rich cool central star.

Oral contribution, published in "Evolution of compact binaries", ASPC
Available from arXiv:1108.0389

Dust grain growth in the interstellar medium of galaxies at redshifts $4 < z < 6.5$

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To discriminate between different dust formation processes is a key issue in order to understand its properties. We analysed six submillimeter galaxies at redshifts $4 < z < 5$ and nine quasars at $5 < z < 6.4$. We estimated their dust masses from their (sub)millimeter emission and their stellar masses from the spectral energy distribution modelling or from the dynamical and gas masses obtained from the CO line detections. We calculated the dust yields per AGB star and per SN required to explain these dust masses and concluded that AGB stars are not efficient enough to form dust in the majority of these galaxies. SN could be responsible for dust production, but only if dust destruction in the SN shocks is not taken into account. Otherwise even SNe are not efficient enough, which advocates for some other dust production mechanism. We present the hypothesis that grain growth in the interstellar medium is responsible for bulk of the dust mass accumulation in these galaxies.

Oral contribution, published in "Galaxy Evolution: Infrared to Millimeter Wavelength Perspective", Guilin, China, 25–29 October 2010, ASP Conference Series
Available from arXiv:1107.5149

Understanding strong H_2 emission in astronomical environments

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Here I describe recent studies of objects with H_2 emission that is strong relative to other spectral lines. Large telescopes and fast spectrometers have made the 2-μm window accessible even for relatively faint objects. I summarize several environments where strong H_2 2.121-μm emission is observed. The line is hard to excite due to its large excitation potential, and is most emissive in regions that have temperatures that are nearly high enough to dissociate H_2. I outline several case studies. In the Helix planetary nebula strong emission is produced by rapidly flowing molecular gas that is exposed to an intense ionizing radiation field. This advective production of H_2 is a fundamentally non-equilibrium process. In the filaments surrounding brightest cluster galaxies in cool core clusters ionizing particles penetrate into magnetically confined molecular cores and excite the gas. Finally, I outline ongoing work on the Crab Nebula, where the first complete maps of molecular emission have only recently been completed. Both ionizing particles and high-energy photons may be important. Finally I speculate on the origin of the correlation between H_2 / H I intensity ratios and other properties found in Active Galaxies. This is suggestive of a hardening of the radiation field along the Eigenvector 1 sequence. In all of this work I take the approach of understanding H_2 emission along with emission from low and moderate ionization species, a necessary step if we are to really understand the context in which H_2 emission forms.

Oral contribution, published in "Narrow-Line Seyfert 1 Galaxies and Their Place in the Universe", Milan, Italy

Available from arXiv:1107.4485

Table of Contents of: "Red Giants as Probes of the Structure and Evolution of the Milky Way"

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We give here the Table of Contents of the proceedings from the workshop "Red Giants as Probes of the Structure and Evolution of the Milky Way", held in Roma, 15–17 November 2010. Exciting results are blooming, thanks to a convergence between unprecedented asteroseismic data obtained by the satellites CoRoT and *Kepler*, and state-of-the-art models of the internal structure of red giants and of galactic evolution. The pulsation properties now available for thousands of red giants promise to add valuable and independent constraints to current models of structure and evolution of our galaxy. Such a close connection between these domains opens a new very promising gate in our understanding of stars and galaxies. Scientists specialised in galactic evolution, in stellar structure, and in asteroseismology, gathered together in this workshop to discuss the current status and uncertainties involved in modelling the structure and evolution of red giants, as well as open questions regarding the study of stellar populations in the Milky Way.

Oral contribution, published in "Red Giants as Probes of the Structure and Evolution of the Milky Way", eds. A. Miglio, J. Montalbán & A. Noels, Roma, 15–17 Nov. 2010, Astrophysics and Space Science Proceedings, ISBN 978-3-642-18417-8

Available from arXiv:1108.4406

Adiabatic solar-like oscillations in red giant stars

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Since the detection of non-radial solar-like oscillation modes in red giants with the CoRoT satellite, the interest in the asteroseismic properties of red giants and the link with their global properties and internal structure is substantially increasing. Moreover, more and more precise data are being collected with the space-based telescopes CoRoT and *Kepler*. In this paper we present a survey of the most relevant theoretical and observational results obtained up to now concerning the potential of solar-like oscillations in red giants.

Oral contribution, published in "Red Giants as Probes of the Structure and Evolution of the Milky Way", eds. A. Miglio, J. Montalbán & A. Noels, Roma, 15–17 Nov. 2010, Astrophysics and Space Science Proceedings, ISBN 978-3-642-18417-8
Available from arXiv:1108.4777

Hydrodynamic simulations of shell convection in stellar cores

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Shell convection driven by nuclear burning in a stellar core is a common hydrodynamic event in the evolution of many types of stars. We encounter and simulate this convection (i) in the helium core of a low-mass red giant during core helium flash leading to a dredge-down of protons across an entropy barrier, (ii) in a carbon–oxygen core of an intermediate-mass star during core carbon flash, and (iii) in the oxygen and carbon burning shell above the silicon–sulfur rich core of a massive star prior to supernova explosion. Our results, which were obtained with the hydrodynamics code HERAKLES, suggest that both entropy gradients and entropy barriers are less important for stellar structure than commonly assumed. Our simulations further reveal a new dynamic mixing process operating below the base of shell convection zones.

Oral contribution, published in "Red Giants as Probes of the Structure and Evolution of the Milky Way", Rome, 15–17 November 2010
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Impact of rotational mixing on the global and asteroseismic properties of red giants

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The influence of rotational mixing on the global parameters and asteroseismic properties of red giant stars is reviewed. While red giants are generally characterised by low surface rotational velocities, they may have been rotating much more rapidly during the main sequence, so that the rotational history of a star has a large impact on its properties during the red giant phase. For stars massive enough to ignite helium burning in non-degenerate conditions, rotational mixing leads to 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 results in a change of the seismic properties of red giants and of the fundamental parameters of a red giant star as determined by performing an asteroseismic calibration. For red giants

with a lower mass that undergo the helium flash, rotational mixing decreases the luminosity of the bump at solar metallicity changing thereby the global and asteroseismic properties of these stars.

Oral contribution, published in "Red Giants as Probes of the Structure and Evolution of the Milky Way", eds. A. Miglio, J. Montalbán & A. Noels, Roma, 15–17 Nov. 2010, Astrophysics and Space Science Proceedings, ISBN 978-3-642-18417-8
Available from arXiv:1108.5087

Review Papers

Production of dust by massive stars at high redshift

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The large amounts of dust detected in sub-millimeter galaxies and quasars at high redshift pose a challenge to galaxy formation models and theories of cosmic dust formation. At $z > 6$ only stars of relatively high mass (> 3 $M_\odot$) are sufficiently short-lived to be potential stellar sources of dust. This review is devoted to identifying and quantifying the most important stellar channels of rapid dust formation. We ascertain the dust production efficiency of stars in the mass range 3–40 $M_\odot$ using both observed and theoretical dust yields of evolved massive stars and supernovae (SNe) and provide analytical expressions for the dust production efficiencies in various scenarios. We also address the strong sensitivity of the total dust productivity to the initial mass function. From simple considerations, we find that, in the early Universe, high-mass (> 3 $M_\odot$) asymptotic giant branch stars can only be dominant dust producers if SNe generate $\lesssim 3 \times 10^{-3}$ $M_\odot$ of dust whereas SNe prevail if they are more efficient. We address the challenges in inferring dust masses and star-formation rates from observations of high-redshift galaxies. We conclude that significant SN dust production at high redshift is likely required to reproduce current dust mass estimates, possibly coupled with rapid dust grain growth in the interstellar medium.

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Available from arXiv:1108.0403

Nuclear astrophysics: the unfinished quest for the origin of the elements

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Half a century has passed since the foundation of nuclear astrophysics. Since then, this discipline has reached its maturity. Today, nuclear astrophysics constitutes a multidisciplinary crucible of knowledge that combines the achievements in theoretical astrophysics, observational astronomy, cosmochemistry and nuclear physics. New tools and developments have revolutionized our understanding of the origin of the elements: supercomputers have provided astrophysicists with the required computational capabilities to study the evolution of stars in a multidimensional framework; the emergence of high-energy astrophysics with space-borne observatories has opened new windows to observe the Universe, from a novel panchromatic perspective; cosmochemists have isolated tiny pieces of stardust embedded in primitive meteorites, giving clues on the processes operating in stars as well as on the way matter condenses to form solids; and nuclear physicists have measured reactions near stellar energies, through the combined efforts using stable and radioactive ion beam facilities. This review provides comprehensive insight into the nuclear history of the Universe and related topics: starting from the Big Bang, when the ashes from the primordial explosion were transformed to hydrogen, helium, and

few trace elements, to the rich variety of nucleosynthesis mechanisms and sites in the Universe. Particular attention is paid to the hydrostatic processes governing the evolution of low-mass stars, red giants and asymptotic giant-branch stars, as well as to the explosive nucleosynthesis occurring in core-collapse and thermonuclear supernovae, gamma-ray bursts, classical novae, X-ray bursts, superbursts, and stellar mergers.

Published in Reports on Progress in Physics, 74, 096901 (2011)
Available from arXiv:1107.2234

Announcements

Fizeau exchange visitors program – call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff).

The deadline for applications is the 15th of September for visits starting 1st of November.

The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of the AGB-community!

Looking forward to your applications,
Josef Hron & Laszlo Mosoni
(for the European Interferometry Initiative)

See also www.european-interferometry.eu

Nuclei in the Cosmos XII
Cairns, 5–10 August 2012

Dear Colleague,

Nuclei in the Cosmos (NIC) brings together nuclear experimentalists, nuclear theorists, astronomers, theoretical astrophysicists, cosmochemists, and others interested in the scientific questions at the interface between nuclear physics and astrophysics. The XII conference of this series will be held on

5–10 August 2012 at the Cairns Convection Centre in Cairns, Australia

We would like to cordially invite you to attend the meeting. You can find more information, including a preliminary program, on the NICXII webpage – http://www.nic2012.org

We would also be grateful if you could forward this information to anyone who might be interested in attending.

NICXII is jointly organized by the Australian National University and Monash University (major sponsors), Swinburne University, the Australian Astronomical Observatory, the University of Adelaide, the Australian Nuclear Science and Technology Organisation (ANSTO), the University of Canterbury (NZ), and the University of Melbourne.

Please note that the "NICXII School" will be held in Canberra the week before NICXII and the 75^{th} Annual Meeting of the Meteoritical Society will be held in Cairns the week following NICXII
(12–17 August 2012 – http://shrimp.anu.edu.au/metsoc2012)

Cairns is a beautiful city sitting in the Australian tropics between the Great Barrier reef and tropical rainforest. The Great Barrier Reef can be reached in less than an hour by boat. Various parks and attractions take advantage of the natural surroundings, including a cableway that extends over World Heritage rainforest. The conference venue is the Cairns Convention Centre, located in the city centre and walking distance to a large number of accommodations suited for any budget.

To be certain of receiving further notifications regarding the conference fill out the expression of interest form at http://www.nic2012.org or email your contact details to nic@asnevents.net.au

We will be delighted to welcome you in Cairns in 2012!

The Local Organizing Committee of NICXII

See also www.nic2012.org