THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 226th issue of the AGB Newsletter. Let us know if you can't find your favourite topic!

Have a look at the announcement at the back of the newsletter, for a special issue of Geochimica et Cosmochimica Acta to commemorate Ernst Zinner.

The next issue is planned to be distributed around the 1st of June.

Editorially Yours,
Jacco van Loon, Ambra Nanni and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Are intergalactic PNe isolated?

Reactions to this statement or suggestions for next month's statement can be e-mailed to astro.agbnews@keele.ac.uk (please state whether you wish to remain anonymous)

Refereed Journal Papers

Chemical abundances and kinematics of barium stars

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In this paper we present an homogeneous analysis of photospheric abundances based on high-resolution spectroscopy of a sample of 182 barium stars and candidates. We determined atmospheric parameters, spectroscopic distances, stellar masses, ages, luminosities and scale height, radial velocities, abundances of the Na, Al, α-elements, iron-peak elements, and s-process elements Y, Zr, La, Ce, and Nd. We employed the local-thermodynamic-equilibrium model atmospheres of Kurucz and the spectral analysis code MOOG. We found that the metallicities, the temperatures and the surface gravities for barium stars can not be represented by a single gaussian distribution. The abundances of α-elements and iron peak elements are similar to those of field giants with the same metallicity. Sodium presents some degree of enrichment in more evolved stars that could be attributed to the NeNa cycle. As expected, the barium stars show overabundance of the elements created by the s-process. By measuring the mean heavy-element abundance pattern as given by the ratio [s/Fe], we found that the barium stars present several degrees of enrichment. We also obtained the [hs/ls] ratio by measuring the photospheric abundances of the Ba-peak and the Zr-peak elements. Our results indicated that the [s/Fe] and the [hs/ls] ratios are strongly anti-correlated with the metallicity. Our kinematical analysis showed that 90% of the barium stars belong to the thin disk population. Based on their luminosities, none of the barium stars are luminous enough to be an AGB star, nor to become self-enriched in the s-process elements. Finally, we determined that the barium stars also follow an age–metallicity relation.

Accepted for publication in Monthly Notices of the Royal Astronomical Society

The Gaia–ESO Survey: A simple explanation for the Li-rich giant problem

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The discovery of lithium-rich giants contradicts expectations from canonical stellar evolution. Although multiple scenarios have been proposed to preserve or produce Li, no model can explain the ensemble properties of Li-rich giants. We report on the serendipitous discovery of 20 Li-rich giants observed through the Gaia–ESO Survey. Our sample is one of the largest in the literature, and includes nine towards the CoRoT fields. We explore all mechanisms proposed to explain Li-rich giants. While the planet accretion scenario was presented to reconcile observations of Li-rich giants across the RGB/AGB, this is inconsistent with recent studies of close-in giant planets. We highlight recent observations of the difference in hot Jupiter occurrence rates around dwarf and sub-giant stars as evidence for their tidal destruction when the convective envelope expands. Therefore any close-in giant planet is likely to be engulfed well before the host evolves up the RGB/AGB. When this occurs, simulations indicate a giant planet will provide a small reservoir of unburnt Li to replenish the stellar photospheric abundance, and subsequently induce deep mixing to produce additional Li. We argue these two independent lines of evidence actually predict the existence of Li-rich giants, and suggests they should be preferentially found before the luminosity bump at near-solar metallicities, consistent with observations. This scenario explains (indeed, predicts) the majority properties of Li-rich giants, leaving a minority population of evolved metal-poor Li-rich giants which are explainable by internal mixing processes associated with late evolutionary stages, or mass transfer from more evolved AGB stars.

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Available from arXiv:1603.03038

An ultramassive 1.28 $M_\odot$ white dwarf in NGC 2099

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With the Keck I Low-Resolution Imaging Spectrometer we have observed nine white dwarf candidates in the very rich open cluster NGC 2099 (M 37). The spectroscopy shows seven to be DA white dwarfs, one to be a DB white dwarf, and one to be a DZ white dwarf. Three of these DA white dwarfs are consistent with singly evolved cluster membership: an ultramassive ($1.28^{+0.05}_{-0.08}$ $M_\odot$) and two intermediate-mass (0.70 and 0.75 $M_\odot$) white dwarfs. Analysis of their cooling ages allows us to calculate their progenitor masses and establish new constraints on the initial–final mass relation. The intermediate-mass white dwarfs are in strong agreement with previous work over this mass regime. The ultramassive white dwarf has $V = 24.5$ mag, ~ 2 mag fainter than the other two remnants. The spectrum of this star has lower quality, so the derived stellar properties (e.g., $T_{\rm eff}$, $\log g$) have uncertainties that are several times higher than the brighter counterparts. We measure these uncertainties and establish the star's final mass as the highest-mass white dwarf discovered thus far in a cluster, but we are unable to calculate its progenitor mass because at this high mass and cooler $T_{\rm eff}$ its inferred cooling age is highly sensitive to its mass. At the highest temperatures, however, this sensitivity of cooling age to an ultramassive white dwarf's mass is only moderate. This demonstrates that future investigations of the upper-mass end of the initial–final mass relation must identify massive, newly formed white dwarfs (i.e., in young clusters with ages 50–150 Myr).

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Dust-driven winds of AGB stars: The critical interplay of atmospheric shocks and luminosity variations

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Winds of AGB stars are thought to be driven by a combination of pulsation-induced shock waves and radiation pressure on dust. In dynamic atmosphere and wind models, the stellar pulsation is often simulated by prescribing a simple sinusoidal variation in velocity and luminosity at the inner boundary of the model atmosphere. We experiment with different forms of the luminosity variation in order to assess the effects on the wind velocity and mass-loss rate, when progressing from the simple sinusoidal recipe towards more realistic descriptions. Using state-of-the-art dynamical models of C-rich AGB stars, a range of different asymmetric shapes of the luminosity variation and a range of phase shifts of the luminosity variation relative to the radial variation are tested. These tests are performed on two stellar atmosphere models. The first model has dust condensation and, as a consequence, a stellar wind is triggered, while the second model lacks both dust and wind. The first model with dust and stellar wind is very sensitive to moderate changes in the luminosity variation. There is a complex relationship between the luminosity minimum, and dust condensation: changing the phase corresponding to minimum luminosity can either increase or decrease mass-loss rate and wind velocity. The luminosity maximum dominates the radiative pressure on the dust, which in turn, is important for driving the wind. These effects of changed luminosity variation are coupled with the dust formation. In contrast there is very little change to the structure of the model without dust. Changing the luminosity variation, both by introducing a phase shift and by modifying the shape, influences wind velocity and the mass-loss rate. To improve wind models it would probably be desirable to extract boundary conditions from 3D dynamical interior models or stellar pulsation models.

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The diverse origins of neutron-capture elements in the metal-poor star HD 94028: Possible detection of products of *i*-process nucleosynthesis

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We present a detailed analysis of the composition and nucleosynthetic origins of the heavy elements in the metal-poor ([Fe/H] = -1.62 ± 0.09) star HD 94028. Previous studies revealed that this star is mildly enhanced in elements produced by the slow neutron-capture process (*s* process; e.g., [Pb/Fe] = $+0.79 \pm 0.32$) and rapid neutron-capture process (*r* process; e.g., [Eu/Fe] = $+0.22\pm0.12$), including unusually large molybdenum ([Mo/Fe] = $+0.97\pm0.16$) and ruthenium ([Ru/Fe] = $+0.69 \pm 0.17$) enhancements. However, this star is not enhanced in carbon ([C/Fe] = -0.06 ± 0.19). We analyze an archival near-ultraviolet spectrum of HD 94028, collected using the Space Telescope Imaging Spectrograph on board the *Hubble* Space Telescope, and other archival optical spectra collected from ground-based telescopes. We report abundances or upper limits derived from 64 species of 56 elements. We compare these observations with *s*-process yields from low-metallicity AGB evolution and nucleosynthesis models. No combination of *s*- and *r*-process patterns can adequately reproduce the observed abundances, including the super-solar [As/Ge] ratio ($+0.99 \pm 0.23$) and the enhanced [Mo/Fe] and [Ru/Fe] ratios. We can fit these features when including an additional contribution from the intermediate neutron-capture process (*i* process), which perhaps operated by the ingestion of H in He-burning convective regions in massive stars, super-AGB stars, or low-mass AGB stars. Currently, only the *i* process appears capable of consistently producing the super-solar [As/Ge] ratios and ratios among neighboring heavy elements found in HD 94028. Other metal-poor stars also show enhanced [As/Ge] ratios, hinting that operation of the *i* process may have been common in the early Galaxy.

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Nitrogen and oxygen abundances in the Local Universe

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We present chemical evolution models aimed at reproducing the observed (N/O) vs. (O/H) abundance pattern of star forming galaxies in the Local Universe. We derive gas-phase abundances from SDSS spectroscopy and a complementary sample of low-metallicity dwarf galaxies, making use of a consistent set of abundance calibrations. This collection of data clearly confirms the existence of a plateau in the (N/O) ratio at very low metallicity, followed by an increase of this ratio up to high values as the metallicity increases. This trend can be interpreted as due to two main sources of nitrogen in galaxies: i) massive stars, which produce small amounts of pure primary nitrogen and are responsible for the (N/O) ratio in the low metallicity plateau; ii) low- and intermediate-mass stars, which produce both secondary and primary nitrogen and enrich the interstellar medium with a time delay relative to massive stars, and cause the increase of the (N/O) ratio. We find that the length of the low-metallicity plateau is almost solely determined by the star formation efficiency, which regulates the rate of oxygen production by massive stars. We show that, to reproduce

the high observed (N/O) ratios at high (O/H), as well as the right slope of the (N/O) vs. (O/H) curve, a differential galactic wind – where oxygen is assumed to be lost more easily than nitrogen – is necessary. No existing set of stellar yields can reproduce the observed trend without assuming differential galactic winds. Finally, considering the current best set of stellar yields, a bottom-heavy initial mass function is favoured to reproduce the data.

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Rotating stars and the formation of bipolar planetary nebulæ II: Tidal spin-up

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We present new binary stellar evolution models that include the effects of tidal forces, rotation, and magnetic torques with the goal of testing Planetary Nebulæ (PNe) shaping via binary interaction. We explore whether tidal interaction with a companion can spin up the AGB envelope. To do so we have selected binary systems with main sequence masses of 2.5 $M_\odot$ and of 0.8 $M_\odot$ and evolve them allowing initial separations of 5, 6, 7, and 8 au. The binary stellar evolution models have been computed all the way to the PNe formation phase or until Roche lobe overflow (RLOF) is reached, whatever happens first. We show that with initial separations of 7 and 8 au, the binary avoids entering into RLOF, and the AGB star reaches moderate rotational velocities at the surface (~ 3.5 and ~ 2 km s^{-1} respectively) during the inter-pulse phases, but after the thermal pulses it drops to a final rotational velocity of only ~ 0.03 km s^{-1}. For the closest binary separations explored, 5 and 6 au, the AGB star reaches rotational velocities of ~ 6 and ~ 4 km s^{-1} respectively when the RLOF is initiated. We conclude that the detached binary models that avoid entering the RLOF phase during the AGB will not shape bipolar PNe, since the acquired angular momentum is lost via the wind during the last two thermal pulses. This study rules out tidal spin-up in non-contact binaries as a sufficient condition to form bipolar PNe.

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The ExoMol database: molecular line lists for exoplanet and other hot atmospheres

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The ExoMol database (www.exomol.com) provides extensive line lists of molecular transitions which are valid over extended temperatures ranges. The status of the current release of the database is reviewed and a new data structure is specified. This structure augments the provision of energy levels (and hence transition frequencies) and Einstein A coefficients with other key properties, including lifetimes of individual states, temperature-dependent cooling functions, Landé g-factors, partition functions, cross sections, k-coefficients and transition dipoles with phase relations. Particular

attention is paid to the treatment of pressure broadening parameters. The new data structure includes a definition file which provides the necessary information for utilities accessing ExoMol through its application programming interface (API). Prospects for the inclusion of new species into the database are discussed.

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HD 16771: A lithium-rich giant in the red-clump stage

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Aims: We report the discovery of a young lithium rich giant, HD 16771, in the core-helium burning phase that does not seem to fit existing proposals of Li synthesis near the luminosity function bump or during He-core flash. We aim to understand the nature of Li enrichment in the atmosphere of HD 16771 by exploring various Li enhancement scenarios.
Methods: We have collected high-resolution échelle spectra of HD 16771 and derived stellar parameters and chemical abundances for 27 elements by either line equivalent widths or synthetic spectrum analyses.
Results: HD 16771 is a Li-rich ($\log\epsilon(\mathrm{Li}) = +2.67 \pm 0.10$ dex) intermediate mass giant star ($M = 2.4 \pm 0.1$ M$_\odot$) with age $\sim 0.76 \pm 0.13$ Gyr and located at the red giant clump. Kinematics and chemical compositions are consistent with HD 16771 being a member of the Galactic thin disk population. The non-detection of ^{6}Li ($< 3\%$), a low carbon isotopic ratio ($^{12}\mathrm{C}/^{13}\mathrm{C} = 12 \pm 2$), and the slow rotation ($v \sin i = 2.8$ km s^{-1}) all suggest that lithium might have been synthesized in this star. On the contrary, HD 16771 with a mass of 2.4 M$_\odot$ has no chance of encountering luminosity function bump and He-core flash where the possibility of fast deep-mixing for Li enrichment in K giants has been suggested previously.
Conclusions: Based of the evolutionary status of this star, we discuss the possibility that ^{7}Li synthesis in HD 16771 is triggered by the engulfment of close-in planet(s) during the RGB phase.

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The shaping of the multipolar pre-planetary nebula CRL 618 by multidirectional bullets

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In order to understand the formation of the multipolar structures of the pre-planetary nebula CRL 618, we perform 3D simulations using a multidirectional bullet model. The optical lobes of CRL 618 and fast molecular outflows at the tips of the lobes have been found to have similar expansion ages of ~ 100 yr. Additional fast molecular outflows were found near the source along the outflow axes with ages of ~ 45 yr, suggesting a second episode of bullet ejections. Thus, in our simulations, two episodes of bullet ejections are assumed. The shaping process is simulated using the ZEUS-3D hydrodynamics code that includes molecular and atomic cooling. In addition, molecular chemistry is also included to calculate the CO intensity maps. Our results show the following: (1) Multi-epoch bullets interacting with the toroidal dense core can produce the collimated multiple lobes as seen in CRL 618. The total mass of the bullets is ~ 0.034 M$_\odot$, consistent with the observed high-velocity (HV) CO emission in fast molecular outflows. (2) The simulated CO $J = 3$–2 intensity maps show that the low-velocity cavity wall and the HV outflows along the lobes are reasonably consistent with the observations. The position–velocity diagram of the outflows along the outflow axes

shows a linear increase of velocity with distance, similar to the observations. The ejections of these bullets could be due to magnetorotational explosions or nova-like explosions around a binary companion.

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Properties of carbon–oxygen white dwarfs from Monte Carlo stellar models

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We investigate properties of carbon–oxygen white dwarfs with respect to the composite uncertainties in the reaction rates using the stellar evolution toolkit, Modules for Experiments in Stellar Astrophysics (MESA) and the probability density functions in the reaction rate library STARLIB. These are the first Monte Carlo stellar evolution studies that use complete stellar models. Focusing on 3 $M_\odot$ models evolved from the pre main-sequence to the first thermal pulse, we survey the remnant core mass, composition, and structure properties as a function of 26 STARLIB reaction rates covering hydrogen and helium burning using a Principal Component Analysis and Spearman Rank-Order Correlation. Relative to the arithmetic mean value, we find the width of the 95% confidence interval to be $\Delta M_{1\mathrm{TP}} \approx 0.019$ $M_\odot$ for the core mass at the first thermal pulse, $\Delta t_{1\mathrm{TP}} \approx 12.50$ Myr for the age, $\Delta \log(T_\mathrm{c}/\mathrm{K}) \approx 0.013$ for the central temperature, $\Delta \log(\rho_\mathrm{c}/\mathrm{g\ cm^{-3}}) \approx 0.060$ for the central density, $\Delta Y_{\mathrm{e,c}} \approx 2.6 \times 10^{-5}$ for the central electron fraction, $\Delta X_\mathrm{c}(^{22}\mathrm{Ne}) \approx 5.8 \times 10^{-4}$, $\Delta X_\mathrm{c}(^{12}\mathrm{C}) \approx 0.392$, and $\Delta X_\mathrm{c}(^{16}\mathrm{O}) \approx 0.392$. Uncertainties in the experimental $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$, triple-$\alpha$, and $^{14}\mathrm{N}(\mathrm{p},\gamma)^{15}\mathrm{O}$ reaction rates dominate these variations. We also consider a grid of 1 to 6 $M_\odot$ models evolved from the pre main-sequence to the final white dwarf to probe the sensitivity of the initial–final mass relation to experimental uncertainties in the hydrogen and helium reaction rates.

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Extinction laws toward stellar sources within a dusty circumstellar medium and implications for Type Ia supernovæ

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Many astronomical objects are surrounded by dusty environments. In such dusty objects, multiple scattering processes of photons by circumstellar (CS) dust grains can effectively alter extinction properties. In this paper, we systematically investigate effects of multiple scattering on extinction laws for steady-emission sources surrounded by the dusty CS medium, using a radiation transfer simulation based on the Monte Carlo technique. In particular, we focus on whether and how the extinction properties are affected by properties of CS dust grains, adopting various dust grain models. We confirm that behaviors of the (effective) extinction laws are highly dependent on the properties of CS grains. Especially, the total-to-selective extinction ratio R_V, which characterizes the extinction law, can be either increased or decreased, compared to the case without multiple scattering. We find that the criterion for this behavior is given

by a ratio of albedos in the B and V bands. We also find that either small silicate grains or polycyclic aromatic hydrocarbons (PAHs) are necessary for realizing a low value of R_V as often measured toward Type Ia supernovæ, if the multiple scattering by CS dust is responsible for their non-standard extinction laws. Using the derived relations between the properties of dust grains and the resulting effective extinction laws, we propose that the extinction laws toward dusty objects could be used to constrain the properties of dust grains in CS environments.

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First Detection of $^3He^+$ in the PN IC 418

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The ^{3}He isotope is important to many fields of astrophysics, including stellar evolution, chemical evolution, and cosmology. The isotope is produced in low-mass stars which evolve through the planetary nebula (PN) phase. ^{3}He abundances in PNe can help test models of the chemical evolution of the Galaxy. We present the detection of the $^3He^+$ emission line using the single dish Deep Space Station 63, towards the PN IC 418. We derived a ^{3}He/H abundance in the range $1.74 \pm 0.8 \times 10^{-3}$ to $5.8 \pm 1.7 \times 10^{-3}$, depending on whether part of the line arises in an outer ionized halo. The lower value for ^{3}He/H ratio approaches values predicted by stellar models which include thermohaline mixing, but requires that large amounts of ^{3}He are produced inside low-mass stars which enrich the interstellar medium (ISM). However, this over-predicts the ^{3}He abundance in H II regions, the ISM, and proto-solar grains, which is known to be of the order of 10^{-5}. This discrepancy questions our understanding of the evolution of the ^{3}He, from circumstellar environments to the ISM.

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Bolometric flux estimation for cool evolved stars

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Estimation of bolometric fluxes ($F_{\rm BOL}$) is an essential component of stellar effective temperature determination with optical and near-infrared interferometry. Reliable estimation of $F_{\rm BOL}$ simply from broad-band K-band photometry data is a useful tool in those cases were contemporaneous and/or wide-range photometry is unavailable for a detailed spectral energy distribution (SED) fit, as was demonstrated in Dyck et al. (1974). Recalibrating the intrinsic $F_{\rm BOL}$ versus observed $F_{2.2\mu{\rm m}}$ relationship of that study with modern SED fitting routines, which incorporate the significantly non-blackbody, empirical spectral templates of the INGS spectral library (an update of the library in Pickles 1998) and estimation of reddening, serves to greatly improve the accuracy and observational utility of this relationship. We find that $F_{\rm BOL}$ values predicted are roughly 11% less than the corresponding values predicted in Dyck et al. (1974), indicating the effects of SED absorption features across bolometric flux curves.

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Stellar yields from metal-rich asymptotic giant branch models

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We present new theoretical stellar yields and surface abundances for three grids of metal-rich asymptotic giant branch (AGB) models. Post-processing nucleosynthesis results are presented for stellar models with initial masses between 1 $M_\odot$ and 7.5 $M_\odot$ for $Z = 0.007$, and 1 $M_\odot$ and 8 $M_\odot$ for $Z = 0.014$ (solar) and $Z = 0.03$. We include stellar surface abundances as a function of thermal pulse on the AGB for elements from C to Bi and for a selection of isotopic ratios for elements up to Fe and Ni (e.g., $^{12}C/^{13}C$), which can be obtained from observations of molecules in stars and from the laboratory analysis of meteoritic stardust grains. Ratios of elemental abundances of He/H, C/O, and N/O are also included, which are useful for direct comparison to observations of AGB stars and their progeny including planetary nebulæ. The integrated elemental stellar yields are presented for each model in the grid for hydrogen, helium and all stable elements from C to Bi. Yields of Li are also included for intermediate-mass models with hot bottom burning. We present the first *slow* neutron-capture (*s*-process) yields for super-solar metallicity AGB stars with $Z = 0.03$, and the first complete *s*-process yields for models more massive than 6 $M_\odot$ at all three metallicities.

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Collision strengths and transition probabilities for Co III forbidden lines

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In this paper we compute the collision strengths and their thermally-averaged Maxwellian values for electron transitions between the fifteen lowest levels of doubly-ionised cobalt, Co^{2+}, which give rise to forbidden emission lines in the visible and infrared region of spectrum. The calculations also include transition probabilities and predicted relative line emissivities. The data are particularly useful for analysing the thermodynamic conditions of supernova ejecta.

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AKARI/IRC near-infrared spectral atlas of Galactic planetary nebulæ

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Near-infrared (2.5–5.0 μm) low-resolution ($\lambda/\Delta\lambda \sim 100$) spectra of 72 Galactic planetary nebulæ (PNe) were obtained with the Infrared Camera (IRC) in the post-helium phase. The IRC, equipped with a $1' \times 1'$ window for spectroscopy of a point source, was capable of obtaining near-infrared spectra in a slit-less mode without any flux loss due to a slit. The spectra show emission features including hydrogen recombination lines and the 3.3–3.5 μm hydrocarbon features. The intensity and equivalent width of the emission features were measured by spectral fitting. We made a catalog providing unique information on the investigation of the near-infrared emission of PNe. In this paper, details of the observations and characteristics of the catalog are described.

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Selecting M-giants with infra-red photometry: Distances, metallicities and the Sagittarius stream

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Using a spectroscopically confirmed sample of M-giants, M-dwarfs and quasars from the LAMOST survey, we assess how well WISE & 2MASS color cuts can be used to select M-giant stars. The WISE bands are very efficient at separating M-giants from M-dwarfs and we present a simple classification that can produce a clean and relatively complete sample of M-giants. We derive a new photometric relation to estimate the metallicity for M-giants, calibrated using data from the APOGEE survey. We find a strong correlation between the $(W1 - W2)$ color and [M/H], where almost all of the scatter is due to photometric uncertainties. We show that previous photometric distance relations, which are mostly based on stellar models, may be biased and devise a new empirical distance relation, investigating trends with metallicity and star formation history. Given these relations, we investigate the properties of M-giants in the Sagittarius stream. The offset in the orbital plane between the leading and trailing tails is reproduced and, by identifying distant M-giants in the direction of the Galactic anti-center, we confirm that the previously detected debris in the outer halo is the apocenter of the trailing tail. We also find tentative evidence supporting an existing overdensity near the leading tail in the Northern Galactic hemisphere, possibly an extension to the trailing tail (so-called Branch C). We have measured the metallicity distribution along the stream, finding a clear metallicity offset between the leading and trailing tails, in agreement with models for the stream formation. We include an online table of M-giants to facilitate further studies.

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On the red giant branch mass loss in 47 Tucanæ: Constraints from the horizontal branch morphology

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We obtain stringent constraints on the actual efficiency of mass loss for red giant branch stars in the Galactic globular cluster 47 Tuc, by comparing synthetic modelling based on stellar evolution tracks with the observed distribution of stars along the horizontal branch in the colour–magnitude diagram. We confirm that the observed, wedge-shaped distribution of the horizontal branch can only be reproduced by accounting for a range of initial He abundances, in agreement with inferences from the analysis of the main sequence, and a red giant branch mass loss with a small dispersion. We carefully investigated several possible sources of uncertainty that could affect the results of the horizontal branch modelling, stemming from uncertainties in both stellar model computations and cluster properties, such as heavy element abundances, reddening, and age. We determine a firm lower limit of ~ 0.17 $M_\odot$ for the mass lost by red giant branch stars, corresponding to horizontal branch stellar masses between ~ 0.65 $M_\odot$ and ~ 0.73 $M_\odot$ (the range driven by the range of initial helium abundances). We also derive that in this cluster the amount of mass lost along the asymptotic giant branch stars is comparable to the mass lost during the previous red giant branch phase. These results confirm, for this cluster, the disagreement between colour–magnitude diagram analyses and inferences from recent studies of the dynamics of the cluster stars, which predict a much less efficient red giant branch mass loss. A comparison between the results from these two techniques applied to other clusters is required to gain more insights about the origin of this disagreement.

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Silicate condensation in Mira variables

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We study whether the condensation of silicate dust in Mira envelopes could be caused by cluster formation by the abundant SiO molecules. For a simplified model of the pulsational motions of matter in the the outer layers of a Mira variable which is guided by a numerical model for Mira pulsations, the equations of dust nucleation and growth are solved in the co-moving frame of a fixed mass element. It is assumed that seed particles form by clustering of SiO molecules. The calculation of the nucleation rate is based on the experimental data of Nuth & Donn (1982). The quantity of dust formed is calculated by a moment method and the calculation of radiation pressure on the dusty gas is based on a dirty silicate model. Dust nucleation occurs in the model at the upper culmination of the trajectory of a gas parcel where it stays for a considerable time at low temperatures while subsequent dust growth occurs during the descending part of the motion and continues after the next shock reversed motion. It is found that sufficient dust forms that radiation pressure exceeds gravitational pull of the stars such that the mass element is finally driven out of the star. Nucleation of dust particles by clustering of the abundant SiO molecules could be the mechanism that triggers silicate dust formation in Miras.

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The detection of dust around NN Ser

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Eclipse timing variations observed from the post common-envelope binary (PCEB) NN Ser offer strong evidence in favour of circumbinary planets existing around PCEBs. If real, these planets may be accompanied by a disc of dust. We here present the ALMA detection of flux at 1.3 mm from NN Ser, which is likely due to thermal emission from a dust disc of mass $\sim 0.8 \pm 0.2$ $M_\oplus$. We performed simulations of the history of NN Ser to determine possible origins of this dust, and conclude that the most likely origin is, in fact, common-envelope material which was not expelled from the system and instead formed a circumbinary disc. These discs have been predicted by theory but previously remained undetected. While the presence of this dust does not prove the existence of planets around NN Ser, it adds credibility to the possibility of planets forming from common-envelope material in a 'second-generation' scenario.

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Morphology and kinematics of the gas envelope of Mira Ceti

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Observations of ^{12}CO(3–2) emission of the circumbinary envelope of Mira Ceti, made by ALMA are analysed. The observed Doppler velocity distribution is made of three components: a blue-shifted south–eastern arc, which can be described as a ring in slow radial expansion, ~ 1.7 km s^{-1}, making an angle of $\sim 50^\circ$ with the plane of the sky and born some 2000 years ago; a few arcs, probably born at the same epoch as the blue-shifted arc, all sharing Doppler

velocities red-shifted by approximately 3 ± 2 km s^{-1} with respect to the main star; the third, central region dominated by the circumbinary envelope, displaying two outflows in the south–western and north–eastern hemispheres. At short distances from the star, up to $\sim 1''.5$, these hemispheres display very different morphologies: the south–western outflow covers a broad solid angle, expands radially at a rate between 5 and 10 km s^{-1} and is slightly red shifted; the north–eastern outflow consists of two arms, both blue-shifted, bracketing a broad dark region where emission is suppressed. At distances between $\sim 1''.5$ and $\sim 2''.5$ the asymmetry between the two hemispheres is significantly smaller and detached arcs, particularly spectacular in the north–eastern hemisphere are present. Close to the stars, we observe a mass of gas surrounding Mira B, with a size of a few tens of au, and having Doppler velocities with respect to Mira B reaching ± 1.5 km s^{-1}, which we interpret as gas flowing from Mira A toward Mira B.

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Wide field CO mapping in the region of IRAS 19312+1950

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We report the results of a wide field CO mapping in the region of IRAS 19312+1950. This IRAS object exhibits $SiO/H_2O/OH$ maser emission, and is embedded in a chemically-rich molecular component, of which the origin is still unknown. In order to reveal the entire structure and gas mass of the surrounding molecular component for the first time, we have mapped a wide region around IRAS 19312+1950 in the ^{12}CO $J = 1$–0, ^{13}CO $J = 1$–0 and C^{18}O $J = 1$–0 lines using the Nobeyama 45m telescope. In conjunction with the archival CO maps, we investigated a region with a size up to $20' \times 20'$ around this IRAS object. We calculated CO gas mass assuming the LTE condition, a stellar velocity against to the interstellar medium assuming an analytic model of a bow shock, and absolute luminosity using the latest archival data and trigonometric parallax distance. The derived gas mass (225 $M_\odot$ – 478 $M_\odot$) of the molecular component and the relatively large luminosity (2.63×10^4 $L_\odot$) suggest that the central $SiO/H_2O/OH$ maser source seems to be a red supergiant (RSG) rather than an asymptotic giant branch (AGB) star or post-AGB star.

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Collimation and asymmetry of the hot blast wave from the recurrent nova V745 Sco

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The recurrent symbiotic nova V745 Sco exploded on 2014 February 6 and was observed on February 22 and 23 by the *Chandra* X-ray Observatory Transmission Grating Spectrometers. By that time the supersoft source phase had already ended and *Chandra* spectra are consistent with emission from a hot, shock-heated circumstellar medium with temperatures exceeding 10^7 K. X-ray line profiles are more sharply peaked than expected for a spherically-symmetric blast wave, with a full width at zero intensity of approximately 2400 km s^{-1}, a full width at half maximum of 1200 ± 30 km s^{-1} and an average net blueshift of 165 ± 10 km s^{-1}. The red wings of lines are increasingly absorbed toward longer wavelengths by material within the remnant. We conclude that the blast wave was sculpted by an aspherical circumstellar medium in which an equatorial density enhancement plays a role, as in earlier symbiotic nova explosions. Expansion of the dominant X-ray emitting material is aligned close to the plane of the sky and most consistent with an orbit seen close to face-on. Comparison of an analytical blast wave model with the X-ray spectra, *Swift* observations and near-infrared line widths indicates the explosion energy was approximately 10^{43} erg, and confirms an ejected mass of approximately 10^{-7} $M_{\odot}$. The total mass lost is an order of magnitude lower than the accreted mass required to have initiated the explosion, indicating the white dwarf is gaining mass and is a supernova Type 1a progenitor candidate.

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EG Andromedæ: A new orbit and additional evidence for a photoionized wind

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We analyze a roughly 20 yr set of spectroscopic observations for the symbiotic binary EG And. Radial velocities derived from echelle spectra are best-fit with a circular orbit having orbital period of $P = 483.3 \pm 1.6$ d and semi-amplitude of $K = 7.34 \pm 0.07$ km s^{-1}. Combined with previous data, these observations rule out an elliptical orbit at the 10-σ level. Equivalent widths of H I Balmer emission lines and various absorption features vary in phase with the orbital period. Relative to the radius of the red giant primary, the apparent size of the H II region is consistent with a model where a hot secondary star with effective temperature $T_h \approx 75,000$ K ionizes the wind from the red giant.

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Conference Papers

HASH: the Hong Kong/AAO/Strasbourg Hα planetary nebula database

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By incorporating our major recent discoveries with re-measured and verified contents of existing catalogues we provide, for the first time, an accessible, reliable, on-line SQL database for essential, up-to date information for all known Galactic planetary nebulæ (PNe). We have attempted to: i) reliably remove PN mimics/false IDs that have biased previous studies and ii) provide accurate positions, sizes, morphologies, multi-wavelength imagery and spectroscopy. We also provide a link to CDS/Vizier for the archival history of each object and other valuable links to external data. With the HASH interface, users can sift, select, browse, collate, investigate, download and visualise the entire currently known Galactic PNe diversity. HASH provides the community with the most complete and reliable data with which to undertake new science.

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Proof of shock-excited H_2 in low-ionization structures of PNe

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We report the detection of near-IR H_2 lines emission from low-ionization structures (LISs) in planetary nebulæ. The deepest, high-angular resolution H_2 1–0 S(1) at 2.122 μm, and H_2 2–1 S(1) at 2.248 μm images of K 4-47 and NGC 7662, obtained using NIRI at Gemini-North, are presented here. K 4-47 reveals a remarkable high-collimated bipolar structure. The H_2 emission emanates from the walls of the bipolar outflows and a pair of knots at the tips of these outflows. The H_2 1–0 S(1)/2–1 S(1) line ratio is $\sim$ 7–10 which indicates shock interaction due to both the lateral expansion of the gas in the outflows and the high-velocity knots. The strongest line, H_2 $v = 1$–0 S(1), is also detected in several LISs located at the periphery of the outer shell of the elliptical PN NGC 7662, whereas only four knots are detected in the H_2 $v = 2$–1 S(1) line. These knots have H_2 $v = 1$–0 S(1)/$v = 2$–1 S(1) values between 2 and 3. These data confirm the presence of molecular gas in both highly (K 4-47) and slowly moving LISs (NGC 7662). The H_2 emission in K 4-47 is powered by shocks, whereas in NGC 7662 is due to photo-ionization by the central star. Moreover, a likely correlation is found between the H_2 $v = 1$–0 S(1)/H_2 $v = 2$–1 S(1) and [N II]/Hα line ratios.

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Review Paper

Circumstellar debris and pollution at white dwarf stars

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Circumstellar disks of planetary debris are now known or suspected to closely orbit hundreds of white dwarf stars. To date, both data and theory support disks that are entirely contained within the preceding giant stellar radii, and hence must have been produced during the white dwarf phase. This picture is strengthened by the signature of material falling onto the pristine stellar surfaces; disks are always detected together with atmospheric heavy elements. The physical link between this debris and the white dwarf host abundances enables unique insight into the bulk chemistry of extrasolar planetary systems via their remnants. This review summarizes the body of evidence supporting dynamically active planetary systems at a large fraction of all white dwarfs, the remnants of first generation, main-sequence planetary systems, and hence provide insight into initial conditions as well as long-term dynamics and evolution.

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Announcement

Call for Papers

Special Issue of Geochimica et Cosmochimica Acta for Ernst K. Zinner

Papers are solicited for a new Special Issue of Geochimica et Cosmochimica Acta (GCA) dedicated to the memory of Dr. Ernst K. Zinner organized around the general theme of the astrophysical implications of laboratory studies of extraterrestrial materials. Dr. Zinner (1937–2015) was a pioneer in the use of Secondary Ion Mass Spectrometry in geo- and cosmochemistry. He is best known for the discoveries of deuterium enrichments in interplanetary dust particles and the discovery and detailed characterization of presolar stardust grains in meteorites. The latter discovery opened up important new connections of astrophysics and meteoritical research and this is the overarching theme of the special issue (although papers on other topics that overlap with Dr. Zinner's interests are also encouraged). He was also a mentor, friend, and generous collaborator to legions of scientists. This special issue will present research by those who were inspired by or worked with this distinguished cosmochemist and astrophysicist.

Deadline for first submission: October 1, 2016

See also http://home.dtm.ciw.edu/users/nittler/ZinnerGCA.html