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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 123$^{\rm rd}$ issue of the AGB Newsletter. There are 38 refereed journal papers to read, and topics that seem popular include post-AGB objects, chemical abundances in the photospheres and circumstellar envelopes, ultra-metal-poor stars, interacting binaries, and AGB populations and their dust production in the Solar Neighbourhood, Galactic Bulge, and extragalctic environments. We would like to draw attention to the detection of the radio photosphere of Mira (Reid & Menten) which appears comfortably spherical — you may have seen the spectacular wake detected with GALEX as Mira races through the ISM. Another important detection is that of circumstellar material in a Type Ia Supernova (Patat et al.). There is also a "must-read" review on dust alignment in magnetic fields (Lazarian).

We would like to congratulate Kim Clube with her recently awarded PhD, with a thesis on "The Dusty Circumstellar Envelopes of Post0-AGB Stars". If you do not yet have a PhD in astronomy, check out the advertisements for PhD positions in Vienna (Austria) and Monash University (Australia).

The AGB Newsletter currently has well over 500 registrants. A few addresses have bounced, and it is likely that a few of you have registered more than once. If you receive more than one announcement, or you don't receive any, please contact us. The register option on the webpage allows you to update your details — of course you will first have to enter your details as registered previously otherwise the database won't be able to recognise who you are. If you experience problems just send us an e-mail and we'll be happy to sort it out for you.

Last month's *food for Thought* generated lively discussion around at least one coffee table. Please send your reactions or suggestions to us; we won't ignore them!

The next issue will be distributed on the 2$^{\rm nd}$ of October; the deadline for contributions is the 1$^{\rm st}$ of October.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Convection is the least well understood physical phenomenon inside red giants

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)

Stellar population synthesis of post-AGB stars: the *s*-process in MACHO 47.2496.8

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The low-metallicity RV Tauri star MACHO 47.2496.8, recently discovered in the Large Magellanic Cloud, is highly enriched in carbon and heavy elements produced by the *slow* neutron capture process (*s*-process), and is most probably a genuine post-C(N-type) asymptotic giant branch (AGB) star. The intrinsic interpretation of the enrichement is further strengthened by detection of a significant infrared excess. The circumstellar dust is the relic of a recent episode of heavy mass loss. We use the analysis of the abundances of MACHO 47.2496.8 to constrain free parameters in AGB models. We test which values of the free parameters describing uncertain physical mechanisms in AGB stars, namely the third dredge-up and the features of the ^{13}C neutron source, produce models that better match the abundances observed in MACHO 47.2496.8. We carry out stellar population synthesis coupled with *s*-process nucleosynthesis using a synthetic stellar evolution code. The *s*-process ratios observed in MACHO 47.2496.8 can be matched by the same models that explain the *s*-process ratios of Galactic AGB and post-AGB stars of metallicity $> Z_{\odot}/10$, except for the choice of the effectiveness of ^{13}C as a neutron source, which has to be lower by roughly a factor of 3 to 6. The less effective neutron source for lower metallicities is also required when comparing population synthesis results to observations of Galactic halo *s*-enhanced stars, such as Pb stars. The ^{12}C/^{13}C ratio in MACHO 47.2496.8 cannot be matched simultaneously and requires the occurrence of extra-mixing processes. The confirmed trend of the decreased efficiency of the ^{13}C neutron source with metallicity requires an explanation from AGB *s*-process models. The present work is to date the first comparison between theoretical models and the detailed abundances of an extragalactic post-AGB star.

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Available from arXiv:0707.2288

Elemental abundances of Galactic bulge planetary nebulae from optical recombination lines

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Deep long-slit optical spectrophotometric observations are presented for 25 Galactic bulge planetary nebulae (GBPNe) and 6 Galactic disk planetary nebulae (GDPNe). The spectra, combined with archival ultraviolet spectra obtained with the International Ultraviolet Explorer (IUE) and infrared spectra obtained with the Infrared Space Observatory (ISO), have been used to carry out a detailed plasma diagnostic and element abundance analysis utilizing both collisional excited lines (CELs) and optical recombination lines (ORLs).

Comparisons of plasma diagnostic and abundance analysis results obtained from CELs and from ORLs reproduce many of the patterns previously found for GDPNe. In particular we show that the large discrepancies between electron temperatures (Te's) derived from CELs and from ORLs appear to be mainly caused by abnormally low values yielded by recombination lines and/or continua. Similarly, the large discrepancies between heavy element abundances deduced from ORLs and from CELs are largely caused by abnormally high values obtained from ORLs, up to tens of solar in extreme cases. It appears that whatever mechanisms are causing the ubiquitous dichotomy between CELs and ORLs, their main effects are to enhance the emission of ORLs, but hardly affect that of CELs. It seems that heavy element abundances deduced from ORLs may not reflect the bulk composition of the nebula. Rather, our analysis

suggests that ORLs of heavy element ions mainly originate from a previously unseen component of plasma of Te's of just a few hundred Kelvin, which is too cool to excite any optical and UV CELs.
We find that GBPNe are on the average 0.1–0.2 dex more metal-rich than GDPNe but have a mean C/O ratio that is approximately 0.2 dex lower. By comparing the observed relative abundances of heavy elements with recent theoretical predictions, we show that GBPNe probably evolved from a relatively metal-rich environment of initial $Z \sim 0.013$, compared to an initial $Z \leq 0.008$ for GDPNe. In addition, we find that GBPNe tend to have more massive progenitor stars than GDPNe. GBPNe are found to have an average magnesium abundance about 0.13 dex higher than GDPNe. The latter have a mean magnesium abundance almost identical to the solar value. The enhancement of magnesium in GBPNe and the large [α/Fe] ratios of bulge giants suggest that the primary enrichment process in the bulge was Type II SNe. PN observations yield a Ne/O abundance ratio much higher than the solar value, suggesting that the solar neon abundance may have been underestimated by 0.2 dex.

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The spatio-kinematical structure and distance of the pre-planetary nebula IRAS 19134+2131

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Using the VLBA, we have observed H_2O maser emission in the pre-planetary nebula IRAS 19134+2131(I19134), in which the H_2O maser spectrum has two groups of emission features separated in radial velocity by ~ 100 km s^{-1}. We also obtained optical images of I19134 with the HST to locate the bipolar reflection nebula in this source for the first time. The spatio-kinematical structure of the H_2O masers indicates the existence of a fast, collimated (precessing) flow having a projected extent of ~ 140 mas and an expansion rate of ~ 1.9 mas yr^{-1} on the sky plane, which gives a dynamical age of only ~ 40 yr. The two detected optical lobes are also separated by ~ 150 mas in almost the same direction as that of the collimated flow. The good agreement between the extent and orientation of the H_2O maser outflow and optical lobes suggests that the lobes have been recently formed along the collimated fast flow. The positions of all of the detected maser features have been measured with respect to the reference source J1925+2106 over one year. Therefore we analyzed maser feature motions that consist of the combination of an annual parallax, a secular motion following Galactic rotation, and the intrinsic motions within the flow. We obtain an annual-parallax distance to I19134 of $D \sim 8$ kpc kpc and estimate its location in the Galaxy to be $(R, \theta, z) = (7.4\text{kpc}, 62°, 0.65\text{kpc})$. From the mean motion of the blue-shifted and red-shifted clusters of maser features, we estimate the 3-D secular motion of I19134 to be $(V_R, V_\theta, V_z) = (3, 125, 8)$ [km s^{-1}]. From the height from the Galactic plane, z, and the velocity component perpendicular to the Galactic plane, V_z, we estimate a rough upper limit of ~ 9 $M_\odot$ to the stellar mass of I19134's progenitor.

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Spectroscopic analysis of two peculiar emission line stars: RJHA 49 and SS73 21

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Aims: To investigate the spectra and the evolutionary stages of two peculiar emission-line stars: RJHA 49 and SS73 21.

Methods: We used low and high resolution optical data. Line identifications and measurements were performed for several features in their spectra. Results: For each object, we have derived the extinction and the excitation temperature from a set of [Fe II] lines, and the electron density from [N II] lines. For RJHA 49, no detailed spectroscopic study was done so far. Regarding SS73 21, our low resolution spectrum have confirmed the main characteristics found in previous works. On the other side, from our high resolution data, we have found that the Hα line presents a double-peak, in contrast with the suggestion in the literature that it should reveal a P-Cygni profile. Surprisingly, we found a few He I transitions resembling P-Cygni profiles (e.g. He I 5876), directly suggesting that mass loss is active in SS73 21. We also discussed the nature of these two objects based on the data obtained. Although the evolutionary status of SS73 21 seems well established from previous studies (a proto-planetary nebula), the situation for RJHA 49 is not so clear mainly due to its unknown distance. However, from the strength of [N II] 5754 relative to [O I] 6300, the possibility of RJHA 49 being a LBV object is reduced, and a B[e]-supergiant or a proto-planetary nebula status is more plausible.

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PPN as Explosions: Bullets vs Jets and Nebular Shaping

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Many proto-planetary nebulae (PPN) appear as narrow collimated structures sometimes showing multiple, roughly aligned lobes. In addition, many PPN flows have been shown to have short acceleration times. In this paper we explore whether jet or "bullet" (a massive clump) models fit the observations of individual collimated lobes adequately by comparing simulations of both radiatively cooled (stable) jets and bullets. We find that the clump model is somewhat favored over jets because (1) it leads to greater collimation of outflows (2) it accounts better and more naturally for ring-like structures observed in the PPN CRL 618, and (3) it is more successful in reproducing the Hubble-flow character of observed kinematics in some PPN. In addition, bullets naturally account for observed multipolar flows, since the likely MHD launch mechanisms required to drive outflows make multiple non-aligned jets unlikely. Thus we argue that PPN outflows may be driven by explosive MHD launch mechanisms such as those discussed in the context of supernovae (SNe) and gamma-ray bursts(GRB).

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SiS in circumstellar envelopes around AGB stars

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New SiS multi-transition (sub-)millimetre line observations of a sample of AGB stars with varying photospheric C/O-ratios and mass-loss rates are presented. Given their photospheric origin and refractive nature, SiS molecules can provide important constraints on the relative roles of dust condensation and non-equilibrium processes in regulating the chemistry in circumstellar envelopes around evolved stars. A combination of low- and high-energy lines are important in constraining the circumstellar distribution of SiS molecules. A detailed radiative transfer modelling of the observed SiS line emission is performed, including the effect of thermal dust grains in the excitation analysis. We find that the circumstellar fractional abundance of SiS in these environments has a strong dependence on the photospheric C/O-ratio as expected from chemical models. The carbon stars (C/O > 1) have a mean fractional abundance of 3.1×10^{-6}, about

an order of magnitude higher than found for the M-type AGB stars (C/O < 1) where the mean value is 2.7×10^{-7}. These numbers are in reasonable agreement with photospheric LTE chemical models. SiS appears to behave similar to SiO in terms of photodissociation in the outer part of the circumstellar envelope. In contrast to previous results for the related molecule SiO, there is no strong correlation of the fractional abundance with density in the CSE, as would be the case if freeze-out onto dust grains were important. However, possible time-variability of the line emission in the lower J transitions and the sensitivity of the line emission to abundance gradients in the inner part of the CSE may mask a correlation with the density of the wind. There are indications that the SiS fractional abundance could be significantly higher closer to the star which, at least in the case of M-type AGB stars, would require non-equilibrium chemical processes.

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A Spitzer IRAC Census of the Asymptotic Giant Branch Populations in Local Group Dwarfs. II. IC 1613

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We present Spitzer Space Telescope IRAC photometry of the Local Group dwarf irregular galaxy IC 1613. We compare our 3.6, 4.5, 5.8, and 8.0 μm photometry with broadband optical photometry and find that the optical data do not detect 43% and misidentify an additional 11% of the total AGB population, likely because of extinction caused by circumstellar material. Further, we find that a narrowband optical carbon star study of IC 1613 detects 50% of the total AGB population and only considers 18% of this population in calculating the carbon to M-type AGB ratio. We derive an integrated mass-loss rate from the AGB stars of $0.2 - 1.0 \times 10^{-3}$ $M_\odot$ yr^{-1} and find that the distribution of bolometric luminosities and mass-loss rates are consistent with those for other nearby metal-poor galaxies. Both the optical completeness fractions and mass-loss rates in IC 1613 are very similar to those in the Local Group dwarf irregular, WLM, which is expected given their similar characteristics and evolutionary histories.

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A Spitzer Study of the Mass Loss Histories of Three Bipolar Pre-Planetary Nebulae

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We present the results of far-infrared imaging of extended regions around three bipolar pre-planetary nebulae, AFGL 2688, OH 231.8+4.2, and IRAS 16342−3814, at 70 and 160 μm with the MIPS instrument on the Spitzer Space Telescope. After a careful subtraction of the point spread function of the central star from these images, we place constraints on the existence of extended shells and thus on the mass outflow rates as a function of radial distance from these stars. We find no apparent extended emission in AFGL 2688 and OH 231.8+4.2 beyond 100″ from the central source. In the case of AFGL 2688, this result is inconsistent with a previous report of two extended dust shells made on the basis of ISO observations. We derive an upper limit of 2.1×10^{-7} $M_\odot$ yr^{-1} and 1.0×10^{-7} $M_\odot$ yr^{-1} for the dust mass loss rate of AFGL 2688 and OH 231.8, respectively, at 200″ from each source. In contrast to these two sources, IRAS 16342−3814 does show extended emission at both wavelengths, which can be interpreted as a very large dust shell with a radius of ∼ 400″ and a thickness of ∼ 100″, corresponding to 4 pc and 1 pc, respectively, at a distance of 2 kpc. However, this enhanced emission may also be galactic cirrus; better azimuthal coverage is necessary for confirmation of a shell. If the extended emission is a shell, it can be modeled, with some assumptions about its

dust properties, as enhanced mass outflow at a dust mass outflow rate of 1.5×10^{-6} $M_\odot$ yr^{-1} superimposed on a steady outflow with a dust mass outflow rate of 1.5×10^{-7} $M_\odot$ yr^{-1}. Because of the size of the possible shell, it is likely that this shell has swept up a substantial mass of interstellar gas during its expansion, so these estimates are upper limits to the stellar mass loss rate. We find a constant color temperature of 32 K throughout the circumstellar envelope of IRAS 16342−3814, which is consistent with heating by the interstellar radiation field.

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Chemical Abundances of Luminous Cool Stars in the Galactic Center from High-Resolution Infrared Spectroscopy

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We present chemical abundances in a sample of luminous cool stars located within 30 pc of the Galactic Center. Abundances of carbon, nitrogen, oxygen, calcium, and iron were derived from high-resolution infrared spectra in the H- and K-bands. The abundance results indicate that both [O/Fe] and [Ca/Fe] are enhanced respectively by averages of +0.2 and +0.3 dex, relative to either the Sun or the Milky Way disk at near solar Fe abundances. The Galactic Center stars show a nearly uniform and nearly solar iron abundance. The mean value of A(Fe) = 7.59 ± 0.06 agrees well with previous work. The total range in Fe abundance among Galactic Center stars, 0.16 dex, is significantly narrower than the iron abundance distributions found in the literature for the older bulge population. Our snapshot of the current-day Fe abundance within 30 pc of the Galactic Center samples stars with an age less than 1 Gyr; a larger sample in time (or space) may find a wider spread in abundances.

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Detection of circumstellar material in a normal Type Ia Supernova

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Type Ia supernovae are thought to be thermonuclear explosions of accreting white dwarfs that reach a critical mass

limit. Despite their importance as cosmological distance indicators, the nature of their progenitors has remained controversial. Here we report the detection of circumstellar material in a normal Type Ia supernova. The expansion velocities, densities and dimensions of the circumstellar envelope indicate that this material was ejected from the progenitor system. The relatively low expansion velocities appear to favor a progenitor system where a white dwarf accretes material from a companion star which is in the red-giant phase at the time of explosion.

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HE 0557−4840 — Ultra-Metal-Poor and Carbon-Rich

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We report the discovery and high-resolution, high S/N, spectroscopic analysis of the ultra-metal-poor red giant HE 0557−4840, which is the third most heavy-element deficient star currently known. Its atmospheric parameters are $T_{\rm eff}$ = 4900 K, $\log g = 2.2$, and [Fe/H]= −4.75. This brings the number of stars with [Fe/H]< −4.0 to three, and the discovery of HE 0557−4840 suggests that the metallicity distribution function of the Galactic halo does not have a "gap" between [Fe/H]= −4.0, where several stars are known, and the two most metal-poor stars, at [Fe/H]∼ −5.3. HE 0557-4840 is carbon rich — [C/Fe]= +1.6 — a property shared by all three objects with [Fe/H]< −4.0, suggesting that the well-known increase of carbon relative to iron with decreasing [Fe/H] reaches its logical conclusion — ubiquitous carbon richness — at lowest abundance. We also present abundances (nine) and limits (nine) for a further 18 elements. For species having well-measured abundances or strong upper limits, HE 0557−4840 is "normal" in comparison with the bulk of the stellar population at [Fe/H]∼ −4.0 — with the possible exception of Co. We discuss the implications of these results for chemical enrichment at the earliest times, in the context of single ("mixing and fallback") and two-component enrichment models. While neither offers a clear solution, the latter appears closer to the mark. Further data are required to determine the oxygen abundance and improve that of Co, and hence more strongly constrain the origin of this object.

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Excited-state OH Mainline Masers in AU Geminorum and NML Cygni

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Excited-state OH maser emission has previously been reported in the circumstellar envelopes of only two evolved stars: the Mira star AU Geminorum and the hypergiant NML Cygni. We present Very Large Array (VLA) observations of the 1665, 1667, and excited-state 4750 MHz mainline OH transitions in AU Gem and Expanded Very Large Array (EVLA) observations of the excited-state 6030 and 6035 MHz OH mainline transitions in NML Cyg. We detect masers in both mainline transitions in AU Gem but no excited-state emission in either star. We conclude that the excited-state OH emission in AU Gem is either a transient phenomenon (such as for NML Cyg outlined below), or possibly an artifact in

the data, and that the excited state OH emission in NML Cyg was generated by an episode of enhanced shock between the stellar mass-loss and an outflow of the Cyg OB2 association. With these single exceptions, it therefore appears that excited-state OH emission indeed should not be predicted nor observable in evolved stars as part of their normal structure or evolution.

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On the fraction of intermediate-mass close binaries that explode as type-Ia supernovae

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Type-Ia supernovae (SNe-Ia) are thought to result from a thermonuclear runaway in white dwarfs (WDs) that approach the Chandrasekhar limit, either through accretion from a companion or a merger with another WD. I compile observational estimates of the fraction eta of intermediate-mass stars that eventually explode as SNe-Ia, supplement them with several new estimates, and compare them self-consistently. The estimates are based on five different methods, each utilising some observable related to the SN-Ia rate, combined with assumptions regarding the IMF: the ratio of SN-Ia to core-collapse rates in star-forming galaxies; the SN-Ia rate per unit star-formation rate; the SN-Ia rate per unit stellar mass; the iron to stellar mass ratio in galaxy clusters; and the abundance ratios in galaxy clusters. The five methods indicate that a fraction in the range $\eta \sim 2 - 40\%$ of all stars with initial masses of 3-8 $M_\odot$ (the generally assumed SN-Ia progenitors) explode as SNe-Ia. A fraction of $\eta \sim 15\%$ is consistent with all five methods for a range of plausible IMFs. Considering also the binarity fraction among such stars, the mass ratio distribution, the separation distribution, and duplicity (every binary can produce only one SN-Ia explosion), this implies that nearly every intermediate mass close binary ends up as a SN-Ia, or possibly more SNe-Ia than progenitor systems. Theoretically expected fractions are generally one to two orders of magnitude lower. The problem could be solved: if all the observational estimates are in error; or with a "middle-heavy" IMF; or by some mechanism that strongly enhances the efficiency of binary evolution toward SN-Ia explosion; or by a non-binary origin for SNe-Ia.

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On the abundance discrepancy problem in H II regions

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The origin of the abundance discrepancy is one of the key problems in the physics of photoionized nebula. In this work, we analize and discuss data for a sample of Galactic and extragalactic H II regions where this abundance discrepancy has been determined. We find that the abundance discrepancy factor (ADF) is fairly constant and of the order of 2 in all the available sample of H II regions. This is a rather different behaviour than that observed in planetary nebulae, where the ADF shows a much wider range of values. We do not find correlations between the ADF and the O/H, O^{++}/H^+ ratios, the ionization degree, T_e(High), T_e(Low)/ T_e(High), FWHM, and the effective temperature of the main ionizing stars within the observational uncertainties. These results indicate that whatever mechanism is producing the abundance discrepancy in H II regions it does not substantially depend on those nebular parameters. On the contrary, the ADF seems to be slightly dependent on the excitation energy, a fact that is consistent with the predictions of the classical temperature fluctuations paradigm. Finally, we obtain that Te values obtained from O II recombination lines in H II regions are in agreement with those obtained from collisionally excited line ratios, a behaviour that is again different from that observed in planetary nebulae. These similar temperature determinations are in contradiction with the predictions of the model based on the presence of chemically inhomogeneous clumps

but are consistent with the temperature fluctuations paradigm. We conclude that all the indications suggest that the physical mechanism responsible of the abundance discrepancy in H II regions and planetary nebulae are different.

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Evolution of interstellar dust and stardust in the solar neighbourhood

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The abundance evolution of interstellar dust species originating from stellar sources and from condensation in molecular clouds in the local interstellar medium of the Milky Way is studied and the input of dust material to the Solar System is determined. A one-zone chemical evolution model of the Milky Way for the elemental composition of the disk combined with an evolution model for its interstellar dust component similar to that of Dwek (1998) is developed. The dust model considers dust-mass return from AGB stars as calculated from synthetic AGB models combined with models for dust condensation in stellar outflows. Supernova dust formation is included in a simple parameterized form which is gauged by observed abundances of presolar dust grains with supernova origin. For dust growth in the ISM a simple method is developed for coupling this with disk and dust evolution models. The time evolution of the abundance of the following dust species is followed in the model: silicate, carbon, silicon carbide, and iron dust from AGB stars and from SNe as well as silicate, carbon, and iron dust grown in molecular clouds. It is shown that the interstellar dust population is dominated by dust accreted in molecular clouds; most of the dust material entering the Solar System at its formation does not show isotopic abundance anomalies of the refractory elements, i.e., inconspicuous isotopic abundances do not point to a Solar System origin of dust grains. The observed abundance ratios of presolar dust grains formed in SN ejecta and in AGB star outflows requires that for the ejecta from SNe the fraction of refractory elements condensed into dust is 0.15 for carbon dust and is quite small ($\sim 10^{-4}$) for other dust species.

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Spitzer IRAC observations of newly-discovered planetary nebulae from the Macquarie-AAO-Strasbourg Hα Planetary Nebula Project

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We compare Hα, radio continuum, and *Spitzer* Space Telescope (SST) images of 58 planetary nebulae (PNe) recently

discovered by the Macquarie-AAO-Strasbourg Hα PN Project (MASH) of the SuperCOSMOS Hα Survey. Using InfraRed Array Camera (IRAC) data we define the IR colors of PNe and demonstrate good isolation between these colors and those of many other types of astronomical object. The only substantive contamination of PNe in the color-color plane we illustrate is due to YSOs. However, this ambiguity is readily resolved by the unique optical characteristics of PNe and their environs. We also examine the relationships between optical and MIR morphologies from 3.6 to 8.0 μm, and explore the ratio of mid-infrared (MIR) to radio nebular fluxes, which is a valuable discriminant between thermal and nonthermal emission. MASH emphasizes late evolutionary stages of PNe compared with previous catalogs, enabling study of the changes in MIR and radio flux that attend the aging process. Spatially integrated MIR energy distributions were constructed for all MASH PNe observed by the GLIMPSE Legacy Project, using the Hα morphologies to establish the dimensions for the calculations of the Midcourse Space Experiment (MSX), IRAC, and radio continuum (from the Molonglo Observatory Synthesis Telescope and the Very Large Array) flux densities. The ratio of IRAC 8.0-μm to MSX 8.3-μm flux densities provides a measure of the absolute diffuse calibration of IRAC at 8.0 μm. We independently confirm the aperture correction factor to be applied to IRAC at 8.0 μm to align it with the diffuse calibration of MSX. The result is in accord with the recommendations of the *Spitzer* Science Center, and with our results from a parallel study of H II regions in the MIR and radio. However, these PNe probe the diffuse calibration of IRAC on a spatial scale of $9'' - 77''$, as opposed to the many arcmin scale from the study of H II regions.

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Carbon-Enhanced Hyper-metal-poor Stars and the Stellar IMF at Low Metallicity

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The two known "hyper-metal-poor" (HMP) stars, HE 0107−5240 and HE 1327−2326, have extremely high enhancements of the light elements C, N, and O relative to Fe and appear to represent a statistically significant excess population relative to the halo metallicity distribution extrapolated from [Fe/H]> -3. This study weighs the available evidence for and against three hypothetical origins for these stars: (1) that they formed from gas enriched by a primordial "faint supernova", (2) that they formed from gas enriched by core-collapse supernovae and C-rich gas ejected in rotation-driven winds from massive stars, and (3) that they formed as the low-mass secondaries in binary systems at $Z \sim 10^{-5.5}$ Z$_\odot$ and acquired their light-element enhancements from an intermediate-mass companion as it passed through an AGB phase. The observations interpreted here, especially the depletion of lithium seen in HE 1327−2326, favor the binary mass-transfer hypothesis. If HE 0107−5240 and HE 1327−2326 formed in binary systems, the statistically significant absence of isolated and/or C-normal stars at similar [Fe/H] implies that low-mass stars could form at that metallicity, but that masses $M \lesssim 1.4$ M$_\odot$ were disfavored in the IMF. This result is also explained if the abundance-derived top-heavy IMF for primordial stars persists to [Fe/H]~ -5.5. This finding indicates that low-mass star formation was possible at extremely low metallicity, and that the typical stellar mass may have had a complex dependence on metallicity rather than a sharp transition driven solely by gas cooling.

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Carbon-Enhanced Metal-Poor Stars, the Cosmic Microwave Background, and the Stellar IMF in the Early Universe

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The characteristic mass of stars at early times may have been higher than today owing to the cosmic microwave

background (CMB). This study proposes that (1) the testable predictions of this "CMB-IMF" hypothesis are an increase in the fraction of carbon-enhanced metal-poor (CEMP) stars with declining metallicity and an increase from younger to older populations at a single metallicity (e.g. disk to halo), and (2) these signatures are already seen in recent samples of CEMP stars and can be better tested with anticipated data. The expected spatial variation may explain discrepancies of CEMP frequency among published surveys. The ubiquity and time dependence of the CMB will substantially alter the reconstruction of star formation histories in the Local Group and early Universe.

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Spitzer/IRS spectroscopy of high mass precursors to planetary nebulae

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We present Spitzer/IRS observations of a small sample of heavily obscured IRAS sources displaying both the infrared and OH maser emission characteristic of OH/IR stars on the asymptotic giant branch (AGB), but also radio continuum emission typical of ionized planetary nebulae (PNe), the so-called *OHPNe*. Our observations show that their mid-infrared spectra are dominated by the simultaneous presence of strong and broad amorphous silicate absorption features together with crystalline silicate features, originated in their O-rich circumstellar shells. Out of the five sources observed, three of them are clearly non-variable at infrared wavelengths, confirming their post-AGB status, while the remaining two still show strong photometric fluctuations, and may still have not yet departed from the AGB. One of the non-variable sources in the sample, IRAS 17393−2727, displays a strong [Ne II] nebular emission at 12.8 μm, indicating that the ionization of its central region has already started. This suggests a rapid evolution from the AGB to the PN stage. We propose that these heavily obscured OHPNe represent the population of high mass precursors to PNe in our Galaxy.

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Submillimeter Array Observation of the Proto-Planetary Nebula CRL 618 in the CO $J = 6-5$ Line

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We report on the results of a Submillimeter Array interferometric observation of the proto-planetary nebula CRL 618 in the ^{12}CO $J = 6-5$ line. With the new capability of SMA enabling us to use two receivers at a time, we also observed simultaneously in the ^{12}CO $J = 2-1$ and ^{13}CO $J = 2-1$ lines. The ^{12}CO $J = 6-5$ and ^{13}CO $J = 2-1$ lines were first interferometrically observed toward CRL 618. The flux of the high velocity component of the ^{12}CO $J = 6-5$ line is almost fully recovered, while roughly 80% of the flux of the low velocity component is resolved out. The low

recovery rate suggests that the emission region of the low velocity component of the ^{12}CO $J = 6-5$ line is largely extended. Continuum emission is detected both at 230 and 690 GHz. The flux of the 690 GHz continuum emission seems to be partially resolved out, suggesting dust emission partly contaminates the 690 GHz continuum flux. The cavity structure, which has been confirmed in a previous observation in the ^{12}CO $J = 2-1$ line, is not clearly detected in the ^{12}CO $J = 6-5$ line, and only the south wall of the cavity is detected. This result suggests that the physical condition of the molecular envelope of CRL 618 is not exactly axial symmetric.

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Outer Jet X-Ray and Radio Emission in R Aquarii: 1999.8 to 2004.0

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Chandra and VLA observations of the symbiotic star R Aqr in 2004 reveal significant changes over the 3-4 year interval between these observations and previous observations taken in with the VLA in 1999 and with Chandra in 2000. This paper reports on the evolution of the outer thermal X-ray lobe jets and radio jets. The emission from the outer X-ray lobe jets lies farther away from the central binary than the outer radio jets and comes from material interpreted as being shock-heated to ~ 106 K, a likely result of collision between high-speed material ejected from the central binary and regions of enhanced gas density. Between 2000 and 2004, the northeast (NE) outer X-ray lobe jet moved out, away from the central binary, with an apparent projected motion of ~ 580 km s^{-1}. The southwest (SW) outer X-ray lobe jet almost disappeared between 2000 and 2004, presumably due to adiabatic expansion and cooling. The NE radio-bright spot also moved away from the central binary between 2000 and 2004, but with a smaller apparent velocity than the NE X-ray bright spot. The SW outer lobe jet was not detected in the radio in either 1999 or 2004. The density and mass of the X-ray emitting material is estimated. Cooling times, shock speeds, pressure, and confinement are discussed.

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Fluorine in a Carbon-Enhanced Metal-Poor Star

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The fluorine abundance of the Carbon-Enhanced Metal-Poor (CEMP) star HE 1305+0132 has been derived by analysis of the molecular HF (1-0) R9 line at 2.3357 μm in a high-resolution ($R = 50,000$) spectrum obtained with the Phoenix spectrometer and Gemini-South telescope. Our abundance analysis makes use of a CNO-enhanced ATLAS12 model atmosphere characterized by a metallicity and CNO enhancements determined utilizing medium-resolution ($R = 3,000$) optical and near-IR spectra. The effective iron abundance is found to be [Fe/H]$= -2.5$, making HE 1305+0132 the most Fe-deficient star, by more than an order of magnitude, for which the abundance of fluorine has been measured. Using spectral synthesis, we derive a super-solar fluorine abundance of $A(^{19}\mathrm{F}) = 4.96 \pm 0.21$, corresponding to a relative abundance of [F/Fe] $= 2.90$. A single line of the Phillips C_2 system is identified in our Phoenix spectrum, and along with multiple lines of the first-overtone vibration-rotation CO (3-1) band head, C and O abundances of $A(^{12}\mathrm{C}) = 8.57 \pm 0.11$ and $A(^{16}\mathrm{O}) = 7.04 \pm 0.14$ are derived. We consider the striking fluorine overabundance in the framework of the nucleosynthetic processes thought to be responsible for the C-enhancement of CEMP stars and

conclude that the atmosphere of HE 1305+0132 was polluted via mass transfer by a primary companion during its asymptotic giant branch phase. This is the first study of fluorine in a CEMP star, and it demonstrates that this rare nuclide can be a key diagnostic of nucleosynthetic processes in the early Galaxy.

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Raman Scattered O VIλ6825 and the Accretion Disk Emission Model in the Symbiotic Stars V1016 Cygni and HM Sagittae

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We present the high resolution spectra of the D type symbiotic stars V1016 Cygni and HM Sagittae obtained with the Bohyunsan Optical Echelle Spectrograph (BOES), and investigate the double-peaked asymmetric profiles of the Raman scattered O VI 6825. This feature is formed through Raman scattering of O VI 1032 by atomic hydrogen with small scattering cross section of $\sim 10^{-23}$ cm^2, requiring a specific condition of coexistence of a highly ionized emission nebula and a thick neutral region. By adopting a wind accretion disk model, we assume that the O VI emission region is described by a Keplerian thin disk. The Raman scattering occurs in a neutral region near the giant, taking in the form of a slow stellar wind, part of which is ionized by the strong UV radiation from the hot white dwarf. Using a Monte Carlo technique, we compute the line profiles that are modulated by the slow spherical stellar wind from the giant component with the ionization front approximated by a hyperboloid. In order to account for the asymmetry and the existence of a central dip in the profiles, we add an O VI resonance scattering region between the hot white dwarf and the giant star which hinders the incidence of slightly blue O VI photons upon the H I region. Overall good fits to the observed data are obtained from our model, which lends support to the accretion disk emission model in these objects. The best fitting parameters for V1016 Cyg are $v_o = 30$ km s^{-1}, $v_\infty = 11$ km s^{-1}, and $v_c = 10$ km s^{-1}, where v_o, v_∞ and v_c are the velocity of the outer disk rim, the terminal velocity of the giant wind, and the velocity component of the resonance scattering O VI region along the binary axis, respectively. Similar fitting parameters $v_o = 27$ km s^{-1}, $v_\infty = 10$ km s^{-1} and $v_c = 9$ km s^{-1} are obtained for HM Sge. We also investigate the effect of a hot spot in a disk that is well known in accretion disks in cataclysmic variables. However, the introduction of a hot spot in our Keplerian disk model failed to improve the overall profile fitting quality significantly. Brief discussions about our profile analysis in relation to bipolar morphology and accretion processes are presented.

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Spitzer Observations of V4332 Sagittarii: Detection of Alumina Dust

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We present broad-band 24, 70 and 160 μm photometry, 5-35 μm and 55-90 μm spectra of the eruptive variable V4332 Sgr from Spitzer observations. The distinguishing feature of the 5-35 μm spectrum is an unusually broad absorption feature near 10 μm at the position generally associated with silicate-rich dust. Through radiative transfer modeling, we show that this broad feature cannot arise from silicates alone but requires the inclusion of alumina (Al_2O_3) as a dust condensate. The case for including Al_2O_3 is strengthened further by the presence of the AlO radical, a potentially important molecule in forming Al_2O_3. The present detection indicates that porous alumina manifests itself through a broadening of the 9.7 μm silicate feature and additionally displays, on the shoulder of the silicate feature, a component at ~ 11.5 μm. We discuss how further observations of V4332 Sgr may have the potential

of verifying some general predictions of the dust condensation process.

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The distribution of $H^{13}CN$ in the circumstellar envelope around IRC +10216

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$H^{13}CN$ $J = 8 \rightarrow 7$ sub-millimetre line emission produced in the circumstellar envelope around the extreme carbon star IRC +10216 has been imaged at sub-arcsecond angular resolution using the SMA. Supplemented by a detailed excitation analysis the average fractional abundance of $H^{13}CN$ in the inner wind ($\lesssim 5 \times 10^{15}$ cm) is estimated to be about 4×10^{-7}, translating into a total HCN fractional abundance of 2×10^{-5} using the isotopic ratio $^{12}C/^{13}C = 50$. Multi-transitional single-dish observations further requires the $H^{13}CN$ fractional abundance to remain more or less constant in the envelope out to a radius of $\approx 4 \times 10^{16}$ cm, where the HCN molecules are effectively destroyed, most probably, by photodissociation. The large amount of HCN present in the inner wind provides effective line cooling that can dominate over that generated from CO line emission. It is also shown that great care needs to be taken in the radiative transfer modelling where non-local, and non-LTE, effects are important and where the radiation field from thermal dust grains plays a major role in exciting the HCN molecules. The amount of HCN present in the circumstellar envelope around IRC +10216 is consistent with predicted photospheric values based on equilibrium chemical models and indicates that any non-equilibrium chemistry occurring in the extended pulsating atmosphere has no drastic net effect on the fractional abundance of HCN molecules that enters the outer envelope. It further suggests that few HCN molecules are incorporated into dust grains.

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Ruthenium and hafnium abundances in giant and dwarf barium stars

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We present abundances for Ru and Hf, compare them to abundances of other heavy elements, and discuss the problems found in determining Ru and Hf abundances with laboratory gf-values in the spectra of barium stars. We determined Ru and Hf abundances in a sample of giant and dwarf barium stars, by the spectral synthesis of two RuI (4080.574 Å and 4757.856 Å) and two HfII (4080.437 Å and 4093.155 Å) transitions. The stellar spectra were observed with FEROS/ESO, and the stellar atmospheric parameters lie in the range $4300 < T_{\rm eff}/{\rm K} < 6500$, $-1.2 < {\rm [Fe/H]} < 0$ and $1.4 \leq \log g < 4.6$. The HfII 4080 and the RuI 4758 observed transitions result in a unreasonably high solar abundance, given certain known uncertainties, when fitted with laboratory gf-values. For these two transitions we determined empirical gf-values by fitting the observed line profiles of the spectra of the Sun and Arcturus. For the sample stars, this procedure resulted in a good agreement of Ru and Hf abundances given by the two available lines. The resulting Ru and Hf abundances were compared to those of Y, Nd, Sm and Eu. In the solar system Ru, Sm and Eu are dominated by the r-process and Hf, Nd and Y by the s-process, and all of these elements are enhanced in barium stars since they lie inside the s-process path. Ru abundances show large scatter when compared to other heavy elements,

whereas Hf abundances show less scatter and closely follow the abundances of Sm and Nd, in good agreement with theoretical expectations. We also suggest a possible, unexpected, correlation of Ru and Sm abundances. The observed behaviour in abundances is probably due to variations in the ^{13}C pocket efficiency in AGB stars, and, though masked by high uncertainties, hint at a more complex scenario than proposed by theory.

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CAL 87 — an evolved wind-driven supersoft X-ray binary

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Compact binary supersoft X-ray sources (CBSS) are explained as being associated with hydrostatic nuclear burning on the surface of a white dwarf with high accretion rate. This high mass transfer rate has been suggested to be caused by dynamical instability, expected when the donor star is more massive than the accreting object. When the orbital period is smaller than ∼6 hours, this mechanism does not work and the CBSS with such periods are believed to be fed by a distinct mechanism: the wind-driven accretion. Such a mechanism has been proposed to explain the properties of objects like SMC 13, T Pyx and V617 Sgr. One observational property that offers a critical test for discriminating between the above two possibilities is the orbital period change. As systems with wind-driven accretion evolve with increasing periods, some of them may reach quite long orbital periods. The above critical test may, therefore, also be applied to orbital periods longer than 6 hours. CAL 87 is an eclipsing system in the LMC with an orbital period of 10.6 hours that could provide the opportunity for testing the hypothesis of the system being powered by wind-driven accretion. We obtained eclipse timings for this system and show that its orbital period increases with a rate of $P/\dot{P} = +7.2(\pm1.3) \times 10^6$ years. Contrary to the common belief, we conclude that CAL 87 is the first confirmed case of a wind-driven CBSS with an orbital period longer than 6 hours. The system is probably an evolved object that had an initial secondary mass of $M_{2i} = 0.63$ M$_\odot$ but is currently reduced to about $M_2 = 0.34$ M$_\odot$. We discuss evidence that other CBSS, like CAL 83 and V Sge stars, like WX Cen, are probably also wind-driven systems. This may in fact be the rule, and systems with inverted mass ratio, the exception.

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Imaging the Radio Photospheres of Mira Variables

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We have used the VLA at 43 GHz to image the radio continuum emission from *o* Ceti, R Leo, and W Hya and to precisely locate their SiO maser emission with respect to the star. The radio continuum emission region for all three stars has a diameter close to 5.6 AU. These diameters are similar to those measured at infrared wavelengths in bands containing strong molecular opacity and about twice those measured in line-free regions of the infrared spectrum. Thus, the radio photosphere and the infrared molecular layer appear to be coextensive. The 43 GHz continuum emission is consistent with temperatures near 1600 K and opacity from H^- free-free interactions. While the continuum image of *o* Ceti appears nearly circular, both R Leo and W Hya display significant elongations. The SiO masers for all three stars show partial rings with diameters close to 8 AU.

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Integral-Field Spectroscopy of the Post Red Supergiant IRC +10420: evidence for an axi-symmetric wind

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We present NAOMI/OASIS adaptive-optics assisted integral-field spectroscopy of the transitional massive hypergiant IRC +10420, an extreme mass-losing star apparently in the process of evolving from a Red Supergiant toward the Wolf-Rayet phase. To investigate the present-day mass-loss geometry of the star, we study the appearance of the line-emission from the inner wind as viewed when reflected off the surrounding nebula. We find that, contrary to previous work, there is strong evidence for wind axi-symmetry, based on the equivalent-width and velocity variations of Hα and Fe II λ6516. We attribute this behaviour to the appearance of the complex line-profiles when viewed from different angles. We also speculate that the Ti II emission originates in the outer nebula in a region analogous to the Strontium Filament of η Carinae, based on the morphology of the line-emission. Finally, we suggest that the present-day axisymmetric wind of IRC +10420, combined with its continued blueward evolution, is evidence that the star is evolving toward the B[e] supergiant phase.

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Variability and evolution in various classes of post-AGB stars

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We aim to compare properties of early-type post asymptotic giant-branch (post-AGB) stars, including normal first-time Btype post-AGB stars, and extreme helium stars (EHes). Hipparcos photometry for 12 post-AGB stars and 7 EHe stars has been analyzed; 5 post-AGB stars are clearly variable. The Hipparcos data are not sufficiently sensitive to detect variability in any of the EHes.

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The evolutionary stage of the semiregular variable QY Sge = IRAS 20056+1834

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Repeated spectral observations made with the 6-m telescope of SAO RAS yielded new data on the radial velocity variability of the peculiar yellow supergiant QY Sge. The strongest and most peculiar feature in its spectrum is the complex profile of Na I D lines, which contains a narrow and a very wide emissions. The wide emission can be seen to extend from −170 to +120 km s^{-1}, and at its central part it is cut by an absorption feature, which, in turn, is split into two subcomponents by a narrow (16 km s^{-1} at r=2.5) emission. An analysis of all the V_r values leads us to adopt for the star a systemic velocity of V_r=−21.1 km s^{-1}, which corresponds to the position of the narrow emission component of Na I. The locations of emission features of Na I D lines are invariable, which point to their formation in regions that are external to the supergiant's photosphere. Differential line shifts of about 10 km s^{-1} are revealed. Emission in the Hα line is weaker than in Na I D lines, it fills the photospheric absorption almost completely. The absorption lines in the spectrum of QY Sge have a substantial width of $FWHM \approx 45$ km s^{-1}. The method of model atmospheres is used to determine the following parameters: the effective temperature $T_{\rm eff}$=6250±150 K, surface gravity $\log g$=2.0±0.2,

and microturbulence velocity ξ_t=4.5±0.5 km s^{-1}. The chemical composition of the atmosphere differs only slightly from the solar composition: the metallicity is found to be somewhat higher than the solar metallicity with an average overabundance of iron-peak elements of [Met/H]$_\odot$=+0.20. The star is found to be slightly overabundant in carbon and nitrogen, [C/Fe]=+0.25, [N/Fe]=+0.27. The α-process elements Mg, Si, Ca are slightly overabundant, on the average by [α/H]$_\odot$=+0.12, and sulfur overabundance is higher, [S/α]=+0.29. The strong overabundance of sodium, [Na/Fe]=+0.75, is likely to be due to the dredge-up of the matter processed in the NeNa cycle. Heavy elements of the *s*-process are underabundant relative to the Sun. On the whole, the observed properties of QY Sge do not give grounds for including this star into the group of R CrB or RV Tau-type objects.

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Structure and clumping in the fast of NGC 6543

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Far-UV spectroscopy from the FUSE satellite is analysed to uniquely probe spatial structure and clumping in the fast wind of the central star of the H-rich planetary nebula NGC 6543 (HD 164963). Time-series data of the unsaturated P V 1118, 1128 resonance line P Cygni profiles provide a very sensitive diagnostic of variable wind conditions in the outflow. We report on the discovery of episodic and recurrent optical depth enhancements in the P V absorption troughs, with some evidence for a 0.17-day modulation time-scale. SEI line-synthesis modelling is used to derive physical properties, including the optical depth evolution of individual 'events'. The characteristics of these features are essentially identical to the 'discrete absorption components' (DACs) commonly seen in the UV lines of massive OB stars. We have also employed the unified model atmosphere code CMFGEN to explore spectroscopic signatures of clumping, and report in particular on the clear sensitivity of the P V lines to the clump volume filling factor. The results presented here have implications for the downward revision of mass-loss rates in PN central stars. We conclude that the temporal structures seen in the P V lines of NGC 6543 likely have a physical origin that is similar to that operating in massive, luminous stars, and may be related to near-surface perturbations caused by stellar pulsation and/or magnetic fields.

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The 3D structure of a radiative, cosmic bullet flow

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We have carried out an axisymmetric and a 3D numerical simulation of a radiative, interstellar bullet flow with the same physical and numerical setup. We find that while some of the main features of the axisymmetric flow are reproduced in the 3D simulation (e.g., the production of the "vortex shedding events" and the fragmentation of the head of the bullet flow), strong deviations from axisymmetry occur in the 3D flow. The main difference between the axisymmetric and the 3D flows is that the on-axis, high velocity condensation that is characteristic of the axisymmetric flow does not appear in the 3D bullet flow.

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A centimetre-wave excess over free-free emission in planetary nebulae

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We report a centimetre-wave (cm-wave, 5–31 GHz) excess over free-free emission in PNe. Accurate 31 and 250 GHz measurements show that the 31 GHz flux densities in our sample are systematically higher than the level of optically thin free-free continuum extrapolated from 250 GHz. The 31 GHz excess is observed, within one standard deviation, in all 18 PNe with reliable 31 and 250 GHz data, and is significant in 9 PNe. The only exception is the peculiar object M 2-9, whose radio spectrum is that of an optically thick stellar wind. On average the fraction of non-free-free emission represents 51% of the total flux density at 31 GHz, with a scatter of 11%. The average 31–250 GHz spectral index of our sample is $\langle \alpha_{31}^{250} \rangle = -0.43 \pm 0.03$ (in flux density, with a scatter of 0.14). The 31–250 GHz drop is reminiscent of the anomalous foreground observed in the diffuse ISM by CMB anisotropy experiments. The 5–31 GHz spectral indices are consistent with both flat spectra and spinning dust emissivities, given the 10% calibration uncertainty of the comparison 5 GHz data. But a detailed study of the objects with the largest cm-excess, including the low frequency data available in the literature, shows that present spinning dust models cannot alone explain the cm-excess in PNe. Although we have no definitive interpretation of our data, the least implausible explanation involves a synchrotron component absorbed by a cold nebular screen. We give flux densities for 37 objects at 31 GHz, and for 26 objects at 250 GHz.

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The assessment of the near infrared identification of carbon stars. I. The Local Group galaxies WLM, IC 10 and NGC 6822

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The selection of AGB C and M stars from NIR colours has been done in recent years using adjustable criteria that are in needs of standardization if one wants to compare, in a coherent manner, properties of various populations. We intend to assess the NIR colour technique to identify C and M stars. We compare the NIR colours of several C stars previously identified from spectroscopy or narrow band techniques in WLM, IC 10 and NGC 6822. We demonstrate that very few M stars have $(J-K)_0 > 1.4$ but a non negligible number of C stars are bluer than this limit. Thus, counts of M and C stars based on such limit do not produce pure samples. C/M ratios determined from NIR colours must be regarded as underestimates mainly because the M numbers include many warm C stars and also K stars if no blue limit is considered.

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Hipparcos astrometric orbit and evolutionary status of HR 6046

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The previously known, 6-yr spectroscopic binary HR 6046 has been speculated in the past to contain a compact object as the secondary. A recent study has re-determined the orbit with great accuracy, and shown that the companion is an evolved but otherwise normal star of nearly identical mass as the primary, which is also a giant. The binary motion was detected by the Hipparcos mission but was not properly accounted for in the published astrometric solution. Here we use the Hipparcos intermediate data in combination with the spectroscopic results to revise that solution and establish the orbital inclination angle for the first time, and with it the absolute masses $M_{\rm A} = 1.38^{+0.09}_{-0.03}$ M$_\odot$ and $M_{\rm B} = 1.36^{+0.07}_{-0.02}$ M$_\odot$. Aided by other constraints, we investigate the evolutionary status and confirm that the primary star is approaching the tip of the red-giant branch, while the secondary is beginning its first ascent.

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High mass-loss AGB stars detected by MSX in the "intermediate" and "outer" Galactic bulge

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We present a study of MSX point sources in the Galactic bulge ($|l| < 3^\circ$, $1^\circ < |b| < 5^\circ$), observed at A, C, D and E-band (8 to 21 μm), with a total area $\sim$ 48 deg^2 and more than 7000 detected sources in the MSX D-band (15 μm). We discuss the nature of the MSX sources (mostly AGB stars), their luminosities, the interstellar extinction, the mass-loss rate distribution and the total mass-loss rate in the bulge. The mid-infrared data of MSX point sources have been combined with the near-infrared (J, H and K$_{\rm s}$) data of 2MASS survey. The cross-identification was restricted to K$_{\rm s}$-band detected sources with $K_{\rm s} \leq 11$ mag. However, for those bright MSX D-band sources ([D] < 4.0 mag), which do not satisfy this criteria, we have set no K$_{\rm s}$-band magnitude cut off. The bolometric magnitudes and the corresponding luminosities of the MSX sources were derived by fitting blackbody curves. The relation between $\dot{\rm M}$ and $({\rm K_s} - [15])_0$ was used to derive the mass-loss rate of each MSX source in the bulge fields. Except for very few post-AGB stars, planetary nebulae and OH/IR stars, a large fraction of the detected sources at 15 μm (MSX D-band) are AGB stars well above the RGB tip. A number of them show an excess in $([{\rm A}]\text{-}[{\rm D}])_0$ and $({\rm K_s}\text{-}[{\rm D}])_0$ colours, characteristic of mass-loss. These colours, especially $({\rm K_s}\text{-}[{\rm D}])_0$, enable estimation of the mass-loss rates ($\dot{\rm M}$) of the sources in the bulge fields which range from 10^{-7} to 10^{-4} M$_\odot$ yr^{-1}. Taking into consideration the completeness of the mass-loss rate bins, we find that the contribution to the integrated mass-loss is probably dominated by mass-loss rates larger than 3×10^{-7} M$_\odot$ yr^{-1} and is about 1.96×10^{-4} M$_\odot$ yr^{-1} deg^{-2} in the "intermediate" and "outer" bulge fields of sources with mass-loss rates, $\dot{M} > 3 \times 10^{-7}$ M$_\odot$ yr^{-1}. The corresponding integrated mass-loss rate per unit stellar mass is 0.48×10^{-11} yr^{-1}. Apart from this, the various mid- and near-infrared colour-colour and colour-magnitude diagrams are discussed in the paper to study the nature of the stellar population in the MSX bulge fields.

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and from http://www.tifr.res.in/∼ojha/bulge_mass-loss.pdf

Infrared point source variability between the Spitzer and MSX surveys of the Galactic mid-plane

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We present a list of 552 sources with suspected variability, based on a comparison of mid-infrared photometry from the GLIMPSE I and MSX surveys, which were carried out nearly a decade apart. We were careful to address issues such as the difference in resolution and sensitivity between the two surveys, as well as the differences in the spectral responses of the instruments. We selected only sources where the IRAC 8.0μm and MSX 8.28μm fluxes differ by more than a factor of two, in order to minimize contamination from sources where the difference in fluxes at 8μm is due to a strong 10μm silicate feature. We present a subset of 40 sources for which additional evidence suggests variability, using 2MASS and MIPSGAL data. Based on a comparison with the variability flags in the IRAS and MSX Point-Source Catalogs we estimate that at least a quarter of the 552 sources, and at least half of the 40 sources are truly variable. In addition, we tentatively confirm the variability of one source using multi-epoch IRAS LRS spectra. We suggest that most of the sources in our list are likely to be Asymptotic Giant Branch stars.

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Conference Papers

UV excess and AGB evolution in elliptical-galaxy stellar populations

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The puzzling origin of the "UV-upturn" phenomenon, observed in some elliptical galaxies, has recently been settled by identifying hot HB stars as main contributors to galaxy ultraviolet luminosity excess. While a blue HB morphology seems a natural characteristic of metal-poor stellar populations, its appearence in metal-rich systems, often coupled with a poorer rate of planetary nebulae per unit galaxy luminosity, might be calling for an intimate connection between UV excess and AGB properties in early-type galaxies. In this work, we want to briefly assess this issue, relying on infrared surface brightness fluctuactions as a powerful tool to trace AGB properties in external galaxies with unresolved stellar populations.

Oral contribution, published in Ultraviolet properties of evolved stellar populations, eds. M. Chavez, E. Bertone, D. Rosa-González, & L.H. Rodriguez-Merino, Astrophysics & Space Science Proceedings (Dordrecht:Springer)
Available from arXiv:0708.0193

A Large-Scale Survey of Neutron-Capture Element Abundances in Planetary Nebulae

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We present results from the first large-scale survey of neutron(n)-capture element abundances in planetary nebulae (PNe). This survey was motivated by the fact that a PN may be enriched in n-capture elements if its progenitor star experienced s-process nucleosynthesis during the thermally-pulsing asymptotic giant branch (AGB) phase. We have measured emission from Se and Kr in over 100 PNe, and use literature data to expand our sample to 120 objects. [Kr III] 2.199 and/or [Se IV] 2.287 μm were detected in 81 PNe, for a detection rate of nearly 70%. We derive Se and Kr abundances or upper limits using ionization correction factors derived from photoionization models. A significant range is found in the Se and Kr abundances, from near solar (no enrichment), to enriched by a factor of ten. Overall, 41 of the 94 PNe with derived Se and/or Kr abundances or meaningful upper limits exhibit s-process enrichments. Our survey has increased the number of PNe with known n-capture element abundances by an order of magnitude, enabling us to explore correlations between s-process enrichments and other nebular and central star properties. In particular, the Se and Kr enrichments display a positive correlation with nebular C/O ratios, as theoretically expected. Peimbert Type I PNe and bipolar PNe, whose progenitors are believed to be intermediate-mass stars ($>$ 3–4 $M_\odot$), exhibit little or no s-process enrichment. Interestingly, PNe with H-deficient [WC] central stars do not exhibit systematically larger s-process enrichments than other PNe, despite the fact that their central stars are enriched in C and probably n-capture elements. Finally, the few PNe in our sample with known or probable binary central star systems exhibit little s-process enrichment, which may be explained if binary interactions truncated their AGB phases. We also briefly discuss a new observational program to detect optical emission lines of n-capture elements, and new atomic data calculations that will greatly improve the accuracy of n-capture element abundance determinations in PNe.

Oral contribution, published in Asymmetrical Planetary Nebulae IV, eds. R.L.M. Corradi, A. Manchado & N. Soker

Available from arXiv:0708.1323

Charging of fractal dust agglomerates in a plasma environment

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The charge on micron-sized dust grains plays a crucial role in the structure and evolution of forming aggregates within the dust population during the coagulation process. The manner in which the charge is arranged on developing irregular structures can affect the fractal dimension of aggregates formed during collisions, which in turn influences the coagulation rate and size evolution of the dust cloud. Preliminary models for the charge evolution on fractal aggregates immersed in a plasma environment calculated using a modification to the orbital-motion-limited (OML) theory are presented in this paper.

The model calculates currents to each point on the aggregate surface using a line-of-sight (LOS) approximation: only those electron or ion trajectories which are not blocked by another grain within the aggregate contribute to the charging current. Both the total charge and the dipole moment are calculated for the dust aggregate. While most coagulation theories assume that it is difficult for like-charged grains to coagulate, the OML_LOS approximation indicates that the electric potentials of aggregate structures are often reduced enough to allow significant coagulation.

Poster contribution, published in 2007 IEEE Pulsed Power and Plasma Science Conference; 34$^{\rm th}$ Annual ICOPS

Available from arXiv:0707.3816

Clumping in the winds of O-type CSPNs

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Recent studies of massive O-type stars present clear evidences of inhomogeneous and clumped winds. O-type (H-rich) central stars of planetary nebulae (CSPNs) are in some ways the low mass–low luminosity analogous of those massive stars. In this contribution, we present preliminary results of our on-going multi-wavelength (FUV, UV and optical) study of the winds of Galactic CSPNs. Particular emphasis will be given to the clumping factors derived by means of optical lines (Hα and He II 4686) and "classic" FUV (and UV) lines.

Oral contribution, published in "Clumping in Hot Star Winds", eds. W.-R. Hamann, A. Feldmeier & L. Oskinova

Available from arXiv:0708.1176

The 3D structure of the Ring Nebula

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The Ringnebula (M 57) is one of the closest and best observed planetary nebulae. Still, its structure remains controversial. Based on detailed spectroscopic observations of the kinematics we present a solution generated with SHAPE to the 3D structure of the [N II] emission. Assuming that the inner halo is the result from enhanced illumination from the central star through the "holes" of the inner nebula, we solve the geometry of the nebula.

Poster contribution, published in Asymmetrical Planetary Nebulae IV

Available from http://www.astrosen.unam.mx/shape/publications/2007_steffen_apn4.pdf

Near-infrared VLT adaptive optics imaging of evolved stars

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The high angular resolution and dynamic range achieved by the NACO adaptive optics system on the VLT is an excellent tool to study the morphology of Planetary Nebulae (PNe). We observed four stars in different evolutionary stages from the AGB to the PNe phase. The images of the inner parts of the PN Hen 2-113 reveal the presence of a dusty torus tilted with respect to all the other structures of the nebula and the present of hot dust close to the hot central star. The NACO observations of Roberts 22 reveal an amazingly complex nebular morphology with a S-shape that can be interpreted in terms of the 'warped disc' scenario of Icke (2003). Combined NACO and MIDI (the VLTI mid-infrared interferometer) observations of the nebula OH 231.8+4.2 have enabled us to resolve a very compact (diameter of 30-40 mas , corresponding to 40-50 a.u.) dusty structure in the core of the nebula. Finally, recent observations of the AGB star V Hydrae show that this star present a departure from spherical symmetry in its inner shell and is probably on its way to become an asymmetrical planetary nebula. These observations show that NACO is a great instrument for the discovery and study of small structures in circumstellar envelopes and PNe and a good complement to interferometric devices.

Oral contribution, published in Asymmetrical Planetary Nebulae IV

Available from arXiv:0708.3112

Review Paper

Tracing magnetic fields with aligned grains

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Magnetic fields play a crucial role in various astrophysical processes, including star formation, accretion of matter, transport processes (e.g., transport of heat), and cosmic rays. One of the easiest ways to determine the magnetic field direction is via polarization of radiation resulting from extinction or/and emission by aligned dust grains. Reliability of interpretation of the polarization maps in terms of magnetic fields depends on how well we understand the grain-alignment theory. Explaining what makes grains aligned has been one of the big issues of the modern astronomy. Numerous exciting physical effects have been discovered in the course of research undertaken in this field. As both the theory and observations matured, it became clear that the grain-alignment phenomenon is inherent not only in diffuse interstellar medium or molecular clouds but also is a generic property of the dust in circumstellar regions, interplanetary space and cometary comae. Currently the grain-alignment theory is a predictive one, and its results nicely match observations. Among its predictions is a subtle phenomenon of radiative torques. This phenomenon, after having stayed in oblivion for many years after its discovery, is currently viewed as the most powerful means of alignment. In this article, I shall review the basic physical processes involved in grain alignment, and the currently known mechanisms of alignment. I shall also discuss possible niches for different alignment mechanisms. I shall dwell on the importance of the concept of grain helicity for understanding of many properties of grain alignment, and shall demonstrate that rather arbitrarily shaped grains exhibit helicity when they interact with gaseous and radiative flows.

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Thesis

The Dusty Circumstellar Envelopes of Post-AGB Stars

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Post-AGB stars are transition objects between the Asymptotic Giant Branch (AGB) and Planetary Nebula (PN) stages of stellar evolution. This is a relatively short (10^3-10^4 years) phase during which the star is surrounded by an expanding dusty shell. One of the questions raised about this stage of stellar evolution is why do nearly all PN have asymmetric structures, usually axisymmetric, while outflows from AGB stars are largely spherically symmetric? When does this shaping first occur and what causes it? Studies of individual stars in this transitional phase of their evolution will help to answer these questions, and a small sample of objects in this transitional phase has been imaged with the mid-infrared camera, OSCIR, mounted on the 8.1 m Gemini North Telescope. The sample includes both O- and C-rich stars. The spectral energy distribution (SED) from UV to sub-mm wavelengths is fitted, for each object, using a 2-D dust radiation transport code. The code also produces model images which are fitted to the OSCIR images to determine the degree of axisymmetry in the dust shell.

Each of the objects studied here shows axisymmetric structure. The mid-IR images of IRAS 22223+4327 show two peaks, which are probably the limb brightened peaks of a dust torus. The images suggest that there is more dust in one of the peaks. The modelling suggests that this object is at least 2.8 kpc away. IRAS 19500−1709 is shown to be at least 4 kpc away by the modelling. This object is C-rich, like IRAS 22223+4327, and the dust shells of both of these objects are fitted with a dust grain model composed of amorphous carbon, silicon carbide and magnesium sulphide.

IRAS 19475+3119 is the O-rich object in this sample and the SED is fitted with a dust grain model composed of amorphous silicates, crystalline silicates and crystalline water ice coated silicates.

Each of the objects in this sample shows evidence of a brightness asymmetry. The cause of this is uncertain but it is likely to be due to the presence of a binary companion or planet, and comparison is made with other similar objects. Long term monitoring of the radial velocities of these objects is needed to confirm the presence of any companion.

Detailed radiative transfer modelling of the circumstellar envelopes, along with well resolved mid-IR images, is shown to be a highly effective way of determining the morphology and properties of the dust surrounding post-AGB stars.

This work was carried out under the supervision of Dr. Tim Gledhill. Awarded July 2007.

208 pages available upon request from K.L.1.Clube@herts.ac.uk
http://star.herts.ac.uk/∼kclube/thesis.pdf

Job Adverts

Institute of Astronomy, University of Vienna doctoral position

The working group on Asymptotic Giant Branch Stars at the Institute of Astronomy, University of Vienna, is inviting applications for one doctoral position to work with Dr. Lebzelter on long period variables within Coordination Unit 7 (variable stars) of the Gaia space mission. The student shall significantly contribute to the development of various tools for allowing to handle LPVs within the Gaia data analysis pipeline and to ongoing work on the P-L-relations of these variables.

The position is funded for two years with a possible extension for another six months. Net salary is about 17.000 EUR per year. University fees are waived.

A masters degree in Astronomy or Physics (with a focus on Astrophysics) is required. Interest in AGB star research and the Gaia space mission is expected. Basic knowledge of light curve analysis and/or synthetic spectra of cool stars as well as programming skills (Eclipse, UML) are a plus. If the applicant has no experience in programming, the readiness to acquire the required basic skills is expected.

Application proceeds by sending a letter of interest, a CV, a summary of the master thesis, the university diplomas and a list of marks, publication list, and at least one letter of reference to the address given below. All applications received prior to September 25 2007 are assured full consideration, however the position is open until filled.

Material should be sent to:
Doz.Dr. Thomas Lebzelter
Institute of Astronomy
University of Vienna
Türkenschanzstraße 17
A-1180 Vienna
AUSTRIA
Fax number: +43-1-4277-9518
Questions about the position may be directed to lebzelter@astro.univie.ac.at

See also http://homepage.univie.ac.at/thomas.lebzelter/job_announcement.pdf

Monash University, Melbourne, Australia PhD positions

The centre for Stellar and Planetary Astrophysics CSPA is pleased to offer PhD scholarships for suitably qualified candidates.

See also http://www.maths.monash.edu.au/∼johnl/PhD2008/