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Editorial

Dear Colleagues,

Happy New Year! It is our pleasure to present you the 138$^{\rm th}$ issue of the AGB Newsletter.

Check out the stunning results on the evolution of dusty mass loss, obtained by graduate student Iain McDonald, and a series of results employing water (and silicon monoxide) maser emission, obtained by a Japanese (and Korean) group as well as by others. Several works discuss symbiotic systems, and one paper contemplates the possibility of life to flourish around a red giant. Don't miss the nice treatises on astrochemistry (Hartquist, Van Loo & Falle), and on grain alignment (Lazarian & Thiem).

There are two PhD positions opening in the lively Belgian town of Leuven; please bring these to the attention of any undergraduate students you may know who are particularly passionate about understanding the cosmos.

The next issue will be distributed on the 1$^{\rm st}$ of February; the deadline for contributions is the 31$^{\rm st}$ of January.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Our Sun becomes a red giant — do we have a contingency plan?

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

Refereed Journal Papers

Giants in the globular cluster ω Centauri: dust production, mass loss and distance

Iain McDonald[1], *Jacco Th. van Loon*[1], *Leen Decin*[2], *Martha L. Boyer*[3], *Andrea K. Dupree*[4], *Aneurin Evans*[1], *Robert D. Gehrz*[3] *and Charles E. Woodward*[3]

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We present spectral energy distribution modelling of 6875 stars in ω Centauri, obtaining stellar luminosities and temperatures by fitting literature photometry to state-of-the-art MARCS stellar models. By comparison to four different sets of isochrones, we provide a new distance estimate to the cluster of 4850 ± 200 (random) ± 120 (systematic error) pc, a reddening of $E(B-V) = 0.080 \pm 0.02 \pm 0.02$ mag and a differential reddening of $\Delta[E(B-V)] < 0.02$ mag for an age of 12 Gyr. Several new post-early-AGB candidates are also found. Infra-red excesses of stars were used to measure total mass-loss rates for individual stars down to $\sim 7 \times 10^{-8}$ $M_\odot$ yr^{-1}. We find a total dust mass-loss rate from the cluster of $1.3^{+0.8}_{-0.5} \times 10^{-9}$ $M_\odot$ yr^{-1}, with the total gas mass-loss rate being $> 1.2^{+0.6}_{-0.5} \times 10^{-6}$ $M_\odot$ yr^{-1}. Half of the cluster's dust production and 30% of its gas production comes from the two most extreme stars — V6 and V42 — for which we present new Gemini/T-ReCS mid-infrared spectroscopy, possibly showing that V42 has carbon-rich dust. The cluster's dust temperatures are found to be typically $\gtrsim$550 K. Mass loss apparently does not vary significantly with metallicity within the cluster, but shows some correlation with barium enhancement, which appears to occur in cooler stars, and especially on the anomalous RGB. Limits to outflow velocities, dust-to-gas ratios for the dusty objects and the possibility of short-timescale mass-loss variability are also discussed in the context of mass loss from low-metallicity stars. The ubiquity of dust around stars near the RGB-tip suggests significant dusty mass loss on the RGB; we estimate that typically 0.20–0.25 $M_\odot$ of mass loss occurs on the RGB. From observational limits on intra-cluster material, we suggest the dust is being cleared on a timescale of $\lesssim 10^5$ years.

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Statistical Properties of Stellar H_2O Masers — Results of Three-Year Single-Dish Observations with the VERA Iriki Telescope

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We report on the results of monitoring observations of 242 stellar H_2O masers, which have been made with the Iriki 20 m telescope of the VLBI Exploration of Radio Astrometry (VERA) from 2003 July to 2006 November. The present

paper mainly focuses on 85 stellar H_2O masers that have been tightly observed with a time spacing of typically 1–2 months. In particular, 46 masers out of them have been recognized concerning their periodic flux variation and have light-curve data of stellar visual light. Thus, the present paper shows some statistical views of the observed time variability properties of stellar H_2O masers. We found a good correlation between a time delay of the variation in the H_2O maser flux with respect to that in the stellar visual light and the stellar pulsation period. The corresponding phase lags are mildly scattered, but are mainly concentrated in the range, $0.7 \leq \Delta\phi \leq 1.5$. We also measured line-of-sight velocity drifts of the individual spectral peaks of H_2O maser emission, which indicate radial acceleration of mass-loss outflows from the evolved stars. We discuss possible pulsation-driven shock waves that are enhanced near the stellar surface, and are propagating outwards in the circumstellar envelope.

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H_2O Maser Outflow from the Red Supergiant Star NML Cygni Observed with Japanese VLBI Network

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We present the proper motions of H_2O masers in NML Cygni, observed with the Japanese VLBI Network at three epochs spanning 455 d. We detected about 15 maser features at each epoch. Overall, 13 features that were detected at least twice were tracked by their radial velocities and proper motions. The three-dimensional kinematics of the maser features indicate the presence of an expanding outflow. The major axis of the outflow is estimated to be at a position angle of $\sim 108°$, and an inclination angle of $\sim 8°$ with respect to the line of sight. The H_2O masers are located between an apparent minimum radius of $\sim 9.6 \times 10^{12}$ m (64 AU) and a maximum radius of $\sim 3.0 \times 10^{13}$ m (202 AU), where the expansion velocity increases from 12 to 27 km s^{-1}. A comparison with the distribution of SiO, H_2O, and OH masers suggests that the outflow of NML Cygni is expanding outside a radius of $\sim 1.5 \times 10^{13}$ m (100 AU). This radius corresponds to 6 stellar radii, and is consistent with the radius of the inner boundary for the dust shell.

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A Bipolar Outflow of the M-Type Giant IRC −10 414 Traced by H_2O Maser Emission

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We report on results of five-epoch VLBI observations of H_2O maser emission in the M-type star IRC −10 414, carried out with the VLBI Exploration of Radio Astrometry (VERA). The maser distribution extends over an area of 70 mas × 260 mas and exhibits a bipolar structure. The relative proper motions of 17 maser features were measured during the monitoring observations spanning nine months. The distance to IRC −10 414 was re-estimated on the basis of the statistical treatment of parallax and the model-fitting method, yielding $D = 3.1 \pm 0.4$ kpc and $D = 2.0 \pm 0.2$ kpc, respectively. The estimated distance, D = 2–3 kpc, is much larger than that previously adopted. The stellar luminosity of IRC −10 414 is also re-estimated to be $L_\star \sim 9 \times 10^4 (D/2 \text{ kpc})^2$ $L_\odot$, much brighter by a factor of 10–20 than previously adopted ($L_\star \sim 10,000$ $L_\odot$). The maser motions exhibit not only a spherically expanding flow with a velocity of $\sim 10(D/2 \text{ kpc})$ km s^{-1}, but also a faster bipolar outflow with a major axis in the north–south direction and at a small inclination angle with respect to the celestial sphere. These characteristics of the star and the circumstellar envelope seen in IRC −10 414 are very similar to those in some supergiants exhibiting bipolar stellar mass loss.

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Japanese VLBI Network Observations of SiO Masers in the M-Type Giant IRC −10 414

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We present two-epoch maps of SiO masers ($v = 1$ and $v = 2$, J = 1–0) associated with the M-type star IRC −10 414, which were obtained with the Japanese VLBI Network (JVN). The spatial and Doppler velocity distributions, and the intensity ratio of the $v = 1$ to $v = 2$ (J = 1–0) lines have significantly changed for eight years since our previous Very Long Baseline Array (VLBA) observation. The maser proper motions revealed by these two epoch observations with an interval of one month are quite random and too fast to be explained by ballistic motions of the maser clumps. The maser distributions seen in the present observations cannot be explained by a rotatinginfalling ring model implied in the previous work. We discuss the kinematical relation between the SiO and H_2O masers in IRC −10 414. In the present observations, the scale sizes of SiO $v = 1$ and $v = 2$ masers in IRC −10 414 were roughly equal, as observed in typical Mira variables.

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The spectroscopic orbit and the geometry of R Aqr

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R Aqr is one of the closest symbiotic binaries and the only D-type system with radial velocity data suitable for orbital parameters estimation. The aims of our study are to derive a reliable spectroscopic orbit of the Mira component, and to establish connections between the orbital motion and other phenomena shown by R Aqr. We reanalize velocity data recently published by McIntosh & Rustan complemented by additional velocities. We find an eccentric orbit ($e = 0.25$) with a period 43.6 yr. This solution is in agreement with a resolved VLA observation of this system. We demonstrate that the last 1974–1981 increase of extinction towards the Mira occured during its superior spectroscopic conjunction, and can be due to obscuration by a neutral material in the accreting stream. We also show that jet ejection is not connected with the orbital position.

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On the morphology of the compact dust shell in the symbiotic system HM Sagittae

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The symbiotic system HM Sagittae consists of a Mira star and a secondary White Dwarf component. The dust content of the system was severely affected by the nova outburst in 1975, which is still ongoing. The capabilities of optical interferometry operating in the mid-IR allow us to investigate the current geometry of the dust envelope. We test our previous spectro-interferometric study of this system with new interferometric configurations, increasing the uv coverage and allowing us to ascertain the appearance of the source between 8 and 13 μm. We used the MIDI instrument of the VLTI with the unit telescopes (UTs) and auxiliary telescopes (ATs) providing baselines oriented from $PA = 42°$ to 127°. The data are interpreted by means of an elliptical Gaussian model and the spherical radiative transfer code DUSTY. We demonstrate that the data can be reproduced well by an optically thick dust shell of amorphous silicate, typical of those encountered around Mira stars, whose measured dimension increases from 8 to 13 μm. We confirm that the envelope is more extended in a direction perpendicular to the binary axis. The level of elongation increases with wavelength in contrast to our claim in a previous study. The wider uv coverage allows us to deepen our previous investigations of the close circumstellar structure of this object.

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Light element abundances in carbon-enhanced metal-poor stars

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We model the evolution of the abundances of light elements in carbon-enhanced metal-poor (CEMP) stars, under the assumption that such stars are formed by mass transfer in a binary system. We have modelled the accretion of material ejected by an asymptotic giant branch star on to the surface of a companion star. We then examine three different scenarios: one in which the material is mixed only by convective processes, one in which thermohaline mixing is present and a third in which both thermohaline mixing and gravitational settling are taken in to account. The results of these runs are compared to light element abundance measurements in CEMP stars (primarily CEMP-s

stars, which are rich in s-processes elements and likely to have formed by mass transfer from an AGB star), focusing on the elements Li, F, Na and Mg. None of the elements is able to provide a conclusive picture of the extent of mixing of accreted material. We confirm that lithium can only be preserved if little mixing takes place. The bulk of the sodium observations suggest that accreted material is effectively mixed but there are also several highly Na and Mg-rich objects that can only be explained if the accreted material is unmixed. We suggest that the available sodium data may hint that extra mixing is taking place on the giant branch, though we caution that the data is sparse.

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Dissociation of the benzene molecule by UV and soft X-rays in circumstellar environment

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Benzene molecules, present in the proto-planetary nebula CRL 618, are ionized and dissociated by UV and X-ray photons originated from the hot central star and by its fast wind. Ionic species and free radicals produced by these processes can lead to the formation of new organic molecules. The aim of this work is to study the photoionization and photodissociation processes of the benzene molecule, using synchrotron radiation and time of flight mass spectrometry. Mass spectra were recorded at different energies corresponding to the vacuum ultraviolet (21.21 eV) and soft X-ray (282–310 eV) spectral regions. The production of ions from the benzene dissociative photoionization is here quantified, indicating that C_6H_6 is more efficiently fragmented by soft X-ray than UV radiation, where 50% of the ionized benzene molecules survive to UV dissociation while only about 4% resist to X-rays. Partial ion yields of H^+ and small hydrocarbons such as $C_2H_2^+$, $C_3H_3^+$ and $C_4H_2^+$ are determined as a function of photon energy. Absolute photoionization and dissociative photoionization cross sections have also been determined. From these values, half-life of benzene molecule due to UV and X-ray photon fluxes in CRL 618 were obtained.

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Abundances in the Galactic bulge: results from planetary nebulae and giant stars

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Our understanding of the chemical evolution of the Galactic bulge requires the determination of abundances in large samples of giant stars and planetary nebulae (PNe). We discuss PNe abundances in the Galactic bulge and compare these results with those presented in the literature for giant stars. We present the largest, high-quality data-set available for PNe in the direction of the Galactic bulge (inner-disk/bulge). For comparison purposes, we also consider a sample of PNe in the Large Magellanic Cloud (LMC). We derive the element abundances in a consistent way for all the PNe studied. By comparing the abundances for the bulge, inner-disk, and LMC, we identify elements that have not been modified during the evolution of the PN progenitor and can be used to trace the bulge chemical enrichment history.

We then compare the PN abundances with abundances of bulge field giant. At the metallicity of the bulge, we find that the abundances of O and Ne are close to the values for the interstellar medium at the time of the PN progenitor formation, and hence these elements can be used as tracers of the bulge chemical evolution, in the same way as S and Ar, which are not expected to be affected by nucleosynthetic processes during the evolution of the PN progenitors. The PN oxygen abundance distribution is shifted to lower values by 0.3 dex with respect to the distribution given by giants. A similar shift appears to occur for Ne and S. We discuss possible reasons for this PNe-giant discrepancy and conclude that this is probably due to systematic errors in the abundance derivations in either giants or PNe (or both). We issue an important warning concerning the use of absolute abundances in chemical evolution studies.

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Faint recombination lines in Galactic PNe with [WC] nucleus

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We present spatially resolved high-resolution spectrophotometric data for the planetary nebulae PB 8, NGC 2867, and PB 6. We have analyzed two knots in NGC 2867 and PB 6 and one in PB 8. The three nebulae are ionized by [WC] type nuclei: early [WO] for PB 6 and NGC 2867 and [WC 5–6] in the case of PB 8. Our aim is to study the behavior of the abundance discrepancy problem (ADF) in this type of PNe. We measured a large number of optical recombination (ORL) and collisionally excited lines (CEL), from different ionization stages (many more than in any previous work), thus, we were able to derive physical conditions from many different diagnostic procedures. We determined ionic abundances from the available collisionally excited lines and recombination lines. Based on both sets of ionic abundances, we derived total chemical abundances in the nebulae using suitable ionization correction factors. From CELs, we have found abundances typical of Galactic disk planetary nebulae. Moderate ADF(O^{++}) were found for PB 8 (2.57) and NGC 2867 (1.63). For NGC 2867, abundances from ORLs are higher but still consistent with Galactic disk planetary nebulae. On the contrary, PB 8 presents a very high O/H ratio from ORLs. A high C/O was obtained from ORLs for NGC 2867; this ratio is similar to C/O obtained from CELs and with the chemical composition of the wind of the central star, indicating that there was no further C-enrichment in the star, relative to O, after the nebular material ejection. On the contrary, we found $C/O < 1$ in PB 8. Interestingly, we obtain $(C/O)_{\rm ORLs}/(C/O)_{\rm CELs} < 1$ in PB 8 and NGC 2867; this added to the similarity between the heliocentric velocities measured in [O III] and O II lines for our three objects, argue against the presence of H-deficient metal-rich knots coming from a late thermal pulse event.

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Habitability of Super-Earth Planets around Other Suns: Models including Red Giant Branch Evolution

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The unexpected diversity of exoplanets includes a growing number of super-Earth planets, i.e., exoplanets with masses of up to several Earth masses and a similar chemical and mineralogical composition as Earth. We present a thermal evolution model for a 10 Earth mass planet orbiting a star like the Sun. Our model is based on the integrated system approach, which describes the photosynthetic biomass production taking into account a variety of climatological,

biogeochemical, and geodynamical processes. This allows us to identify a so-called photosynthesis-sustaining habitable zone (pHZ) determined by the limits of biological productivity on the planetary surface. Our model considers the solar evolution during the main-sequence stage and along the Red Giant Branch as described by the most recent solar model. We obtain a large set of solutions consistent with the principal possibility of life. The highest likelihood of habitability is found for "water worlds". Only mass-rich water worlds are able to realize pHZ-type habitability beyond the stellar main-sequence on the Red Giant Branch.

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High velocity water maser emission from the Post-AGB star OH 009.1−0.4

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Observations of water masers towards the post-AGB star and water fountain source OH 009.1−0.4 were made as part of HOPS (The H_2O southern galactic Plane Survey), with the Mopra radiotelescope. Together with followup observations using the Australia Telescope Compact Array (ATCA), we have identified water maser emission over a velocity spread of nearly 400 km s^{-1} (−109 to +289 km s^{-1}). This velocity spread appears to be the largest of any known maser source in our Galaxy. High resolution observations with the ATCA indicate the maser emission is confined to a region $0.3'' \times 0.3''$ and shows weak evidence for a separation of the red- and blueshifted maser spots. We are unable to determine if the water fountain is projected along the line of sight, or is inclined, but either way OH 009.1−0.4 is an interesting source, worthy of followup observations.

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AGB Stars in the Fornax Dwarf Spheroidal Galaxy

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We report on a multi-epoch study of the Fornax dwarf spheroidal galaxy, made with the Infrared Survey Facility, over an area of about $42' \times 42'$. The colour-magnitude diagram shows a broad well-populated giant branch with a tip that slopes down-wards from red to blue, as might be expected given Fornax's known range of age and metallicity. The extensive AGB includes seven Mira variables and ten periodic semi-regular variables. Five of the seven Miras are known to be carbon rich. Their pulsation periods range from 215 to 470 days, indicating a range of initial masses. Three of the Fornax Miras are redder than typical LMC Miras of similar period, probably indicating particularly heavy mass-loss rates. Many, but not all, of the characteristics of the AGB are reproduced by isochrones from Marigo et al.

for a 2 Gyr population with a metallicity of $Z = 0.0025$.
An application of the Mira period–luminosity relation to these stars yields a distance modulus for Fornax of 20.69 ±0.04 (internal), ±0.08 (total) (on a scale that puts the LMC at 18.39 mag) in good agreement with other determinations. Various estimates of the distance to Fornax are reviewed.

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The Red Rectangle: Its Shaping Mechanism and its Source of Ultraviolet Photons

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The proto-planetary Red Rectangle nebula is powered by HD 44179, a spectroscopic binary ($P = 318$ d), in which a luminous post-AGB component is the primary source of both luminosity and current mass loss. Here, we present the results of a seven-year, eight-orbit spectroscopic monitoring program of HD 44179, designed to uncover new information about the source of the Lyman/far-ultraviolet continuum in the system as well as the driving mechanism for the bipolar outflow producing the current nebula. Our observations of the Hα line profile around the orbital phase of superior conjunction reveal the secondary component to be the origin of the fast (max. $v \sim 560$ km s^{-1}) bipolar outflow in the Red Rectangle. The outflow was previously inferred on the basis of a single, broad Hα emission line profile. The variation of total Hα flux from the central H II region with orbital phase also identifies the secondary or its surroundings as the source of the far-ultraviolet ionizing radiation in the system. The estimated mass of the secondary (~ 0.94 M$_\odot$) and the speed of the outflow suggest that this component is a main sequence star and not a white dwarf, as previously suggested. We identify the source of the Lyman/far-ultraviolet continuum in the system as the hot, inner region ($T_{\rm max} \geq 17,000$ K) of an accretion disk surrounding the secondary, fed by Roche lobe overflow from the post-AGB primary at a rate of about 2–5 $\times 10^{-5}$ M$_\odot$ yr^{-1}. The speed of the accretion-driven, bipolar outflow was found to be strongly modulated by the inter-component separation in the highly eccentric ($e = 0.37$) orbit, with maximum speeds occurring near periastron and minimum speeds found around apastron. The total luminosity of the accretion disk around the secondary is estimated to be at least 300 L$_\odot$, about 5% of the luminosity of the entire system.

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Fluorine in AGB Carbon Stars Revisited

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A reanalysis of the fluorine abundance in three Galactic AGB carbon stars (TX Psc, AQ Sgr and R Scl) has been performed from the molecular HF (1–0) R9 line at 2.3358 μm. High-resolution ($R \sim 50,000$) and high signal to noise spectra obtained with the CRIRES spectrograph and the VLT telescope or from the NOAO archive (for TX Psc) have been used. Our abundance analysis uses the latest generation of MARCS model atmospheres for cool carbon rich stars. Using spectral synthesis in LTE we derive for these stars fluorine abundances that are systematically lower by ~ 0.8 dex in average with respect to the sole previous estimates by Jorissen, Smith & Lambert (1992). The possible reasons

of this discrepancy are explored. We conclude that the difference may rely on the blending with C-bearing molecules (CN and C_2) that were not properly taken into account in the former study. The new F abundances are in better agreement with th prediction of full network stellar models of low mass AGB stars. These models also reproduce the s-process elements distribution in the sampled stars. This result, if confirmed in a larger sample of AGB stars, might alleviate the current difficulty to explain the largest [F/O] ratios found by Jorissen et al. In particular, it may not be necessary to search for alternative nuclear chains affecting the production of F in AGB stars.

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Scattering polarization due to light source anisotropy II. Envelope of arbitrary shape

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We consider the polarization arising from scattering in an envelope illuminated by a central anisotropic source. Spherical harmonics are used to describe both the light source anisotropy and the envelope density distribution functions of the scattering particles. This framework demonstrates how the net resultant polarization arises from a superposition of three basic "shape" functions: the distribution of source illumination, the distribution of envelope scatterers, and the phase function for dipole scattering. Specific expressions for the Stokes parameters and scattered flux are derived for the case of an ellipsoidal light source inside an ellipsoidal envelope, with principal axes that are generally not aligned. Two illustrative examples are considered: (a) axisymmetric mass loss from a rapidly rotating star, such as may apply to some Luminous Blue Variables, and (b) a Roche-lobe filling star in a binary system with a circumstellar envelope. As a general conclusion, the combination of source anisotropy with distorted scattering envelopes leads to more complex polarimetric behavior such that the source characteristics should be carefully considered when interpreting polarimetric data.

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The Iron abundance in Galactic Planetary Nebulae

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We constrain the iron abundance in a sample of 33 low-ionization Galactic planetary nebulae (PNe) using [Fe III] lines and correcting for the contribution of higher ionization states with ionization correction factors (ICFs) that take into account uncertainties in the atomic data. We find very low iron abundances in all the objects, suggesting that more than 90% of their iron atoms are condensed onto dust grains. This number is based on the solar iron abundance and implies a lower limit on the dust-to-gas mass ratio, due solely to iron, of $M_{\rm dust}/M_{\rm gas} > 1.3 \times 10^{-3}$ for our sample. The depletion factors of different PNe cover about two orders of magnitude, probably reflecting differences in the formation, growth, or destruction of their dust grains. However, we do not find any systematic difference between the gaseous iron abundances calculated for C-rich and O-rich PNe, suggesting similar iron depletion efficiencies in both environments. The iron abundances of our sample PNe are similar to those derived following the same procedure for a group of 10 Galactic H II regions. These high depletion factors argue for high depletion efficiencies of refractory elements onto dust grains both in molecular clouds and AGB stars, and low dust destruction efficiencies both in interstellar and circumstellar ionized gas.

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Post Common Envelope Binaries from SDSS. V: Four eclipsing white dwarf main sequence binaries

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We identify SDSS 011009.09+132616.1, SDSS 030308.35+005444.1, SDSS 143547.87+373338.5 and SDSS 154846.00+405728.8 as four eclipsing white dwarf plus main sequence (WDMS) binaries from the Sloan Digital Sky Survey, and report on follow-up observations of these systems. SDSS 0110+1326, SDSS 1435+3733 and SDSS 1548+4057 contain DA white dwarfs, while SDSS 0303+0054 contains a cool DC white dwarf. Orbital periods and ephemerides have been established from multi-season photometry. SDSS 1435+3733, with $P_{\rm orb} = 3$ h has the shortest orbital period of all known eclipsing WDMS binaries. As for the other systems, SDSS 0110+1326 has $P_{\rm orb} = 8$ h, SDSS 0303+0054 has $P_{\rm orb} = 3.2$ h and SDSS 1548+4057 has $P_{\rm orb} = 4.4$ h. Time-resolved spectroscopic observations have been obtained and the Hα and Ca II triplet emission lines, as well as the Na I absorption doublet were used to measure the radial velocities of the secondary stars in all four systems. A spectral decomposition/fitting technique was then employed to isolate the contribution of each of the components to the total spectrum, and to determine the white dwarf effective temperatures and surface gravities, as well as the spectral types of the companion stars. We used a light curve modelling code for close binary systems to fit the eclipse profiles and the ellipsoidal modulation/reflection effect in the light curves, to further constrain the masses and radii of the components in all systems. All three DA white dwarfs have masses of $M_{\rm wd} \sim 0.4$–0.6 M$_\odot$, in line with the expectations from close binary evolution. The DC white dwarf in SDSS 0303+0054 has a mass of $M_{\rm wd} \gtrsim 0.85$ M$_\odot$, making it unusually massive for a post-common envelope system. The companion stars in all four systems are M-dwarfs of spectral type M4 and later. Our new additions raise the number of known eclipsing WDMS binaries to fourteen, and we find that the average white dwarf mass in this sample is $\langle M_{\rm wd} \rangle = 0.57 \pm 0.16$ M$_\odot$, only slightly lower than the average mass of single white dwarfs. The majority of all eclipsing WDMS binaries contain low-mass (< 0.6 M$_\odot$) secondary stars, and will eventually provide valuable observational input for the calibration of the mass–radius relations of low-mass main sequence stars and of white dwarfs.

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Tracing the asymmetry in the envelope around the carbon star CIT 6

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We present high angular resolution observations of HC_3N J=5–4 line and 7 mm continumm emission from the extreme carbon star CIT 6. We find that the 7 mm continuum emission is unresolved and has a flux consistent with black-body thermal radiation from the central star. The HC_3N J=5–4 line emission originates from an asymmetric and clumpy expanding envelope comprising two separate shells of HC_3N J=5–4 emission: (i) a faint outer shell that is nearly spherical which has a radius of 8″; and (ii) a thick and incomplete inner shell that resembles a one-arm spiral starting at or close to the central star and extending out to a radius of about 5″. Our observations therefore suggest that the mass loss from CIT 6 is strongly modulated with time and highly anisotropic. Furthermore, a comparison between the data and our excitation modelling results suggests an unusually high abundance of HC_3N in its envelope. We discuss the possibility that the envelope might be shaped by the presence of a previously suggested possible binary companion. The abundance of HC_3N may be enhanced in spiral shocks produced by the interaction between the circumstellar envelope of CIT 6 and its companion star.

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The shaping effect of collimated fast outflows in the Egg nebula

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We present high angular resolution observations of the HC_3N J=5–4 line from the Egg nebula, which is the archetype of protoplanetary nebulae. We find that the HC_3N emission in the approaching and receding portion of the envelope traces a clumpy hollow shell, similar to that seen in normal carbon rich envelopes. Near the systemic velocity, the hollow shell is fragmented into several large blobs or arcs with missing portions correspond spatially to locations of previously reported high-velocity outlows in the Egg nebula. This provides direct evidence for the disruption of the slowly-expanding envelope ejected during the AGB phase by the collimated fast outflows initiated during the transition to the protoplanetary nebula phase. We also find that the intersection of fast molecular outflows previously suggested as the location of the central post-AGB star is significantly offset from the center of the hollow shell. From modelling the HC_3N distribution we could reproduce qualitatively the spatial kinematics of the HC_3N J=5–4 emission using a HC_3N shell with two pairs of cavities cleared by the collimated high velocity outflows along the polar direction and in the equatorial plane. We infer a relatively high abundance of $HC_3N/H_2 \sim 3 \times 10^{-6}$ for an estimated mass–loss rate of 3×10^{-5} $M_\odot$ yr^{-1} in the HC_3N shell. The high abundance of HC_3N and the presence of some weaker J=5–4 emission in the vicinity of the central post-AGB star suggest an unusually efficient formation of this molecule in the Egg nebula.

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Conference Papers

The Ages, Masses, Evolution and Kinematics of Mira Variables

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Evidence om the ages and masses of Mira variables is reviewed. Period increases with increasing initial mass. Miras of $\log P \sim 3.0$ have initial masses near 4 $M_\odot$. It is suggested that the apparent gap in the LMC Mira PL relation at about this period may be due to the onset of hot bottom burning and that this adds about 15 to 20 percent to the stellar energy production. Shorter period HBB stars are probably overtone pulsators. T Lep may be an example of cool bottom processing.

Oral contribution, published in "AGB stars and related phenomena", Tokyo, Nov. 2008
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Improved Neutron-Capture Element Abundances in Planetary Nebulae

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Spectroscopy of planetary nebulae (PNe) provides the means to investigate s-process enrichments of neutron(n)-capture elements that cannot be detected in asymptotic giant branch (AGB) stars. However, accurate abundance

determinations of these elements present a challenge. Corrections for unobserved ions can be large and uncertain, since in many PNe only one ion of a given n-capture element has been detected. Furthermore, the atomic data governing the ionization balance of these species are not well-determined, inhibiting the derivation of accurate ionization corrections. We present initial results of a program that addresses these challenges. Deep high resolution optical spectroscopy of ∼20 PNe has been performed to detect emission lines from trans-iron species including Se, Br, Kr, Rb, and Xe. The optical spectral region provides access to multiple ions of these elements, which reduces the magnitude and importance of uncertainties in the ionization corrections. In addition, experimental and theoretical efforts are providing determinations of the photoionization cross-sections and recombination rate coefficients of Se, Kr, and Xe ions. These new atomic data will make it possible to derive robust ionization corrections for these elements. Together, our observational and atomic data results will enable n-capture element abundances to be determined with unprecedented accuracy in ionized nebulae.

Oral contribution, published in "The Origin of the Elements Heavier than Fe", Sep. 25–27, 2008, Turin, Italy, PASA, eds. John C. Lattanzio and M. Lugaro
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How Interstellar Chemistry (and Astrochemistry More Generally) Became Useful

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In 1986 Alex Dalgarno published a paper entitled "Is Interstellar Chemistry Useful?" By the middle 1970s, and perhaps even earlier, Alex had hoped that astronomical molecules would prove to: possess significant diagnostic utility; control many of the environments in which they exist; stimulate a wide variety of physicists and chemists who are at least as fascinated by the mechanisms forming and removing the molecules as by astronomy. His own research efforts have contributed greatly to the realization of that hope. This paper contains a few examples of: how molecules are used to diagnose large-scale dynamics in astronomical sources including star forming regions and supernovae; the ways in which molecular processes control the evolution of astronomical objects such as dense cores destined to become stars and very evolved giant stars; theoretical and laboratory investigations that elucidate the processes producing and removing astronomical molecules and allow their detection.

Oral contribution, published in Dalgarno Celebratory Symposium: "Contributions to Atomic, Molecular, and Optical Physics, Astrophysics and Atmospheric Physics"
Available from arXiv:0812.3265

Magnetic Fields in Paradigms of Planetary Nebulae and Related MHD Frontiers

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Many, if not all, post AGB stellar systems swiftly transition from a spherical to a powerful aspherical pre-planetary nebula (pPNE) outflow phase before waning into a PNe. The pPNe outflows require engine rotational energy and a mechanism to extract this energy into collimated outflows. Just radiation and rotation are insufficient but a symbiosis between rotation, differential rotation and large scale magnetic fields remains promising. Present observational evidence for magnetic fields in evolved stars is suggestive of dynamically important magnetic fields, but both theory and observation are rife with research opportunity. I discuss how magnetohydrodynamic outflows might arise in pPNe and PNe and distinguish different between approaches that address shaping vs. those that address both launch and shaping. Scenarios involving dynamos in single stars, binary driven dynamos, or accretion engines cannot be ruled out.

One appealing paradigm involves accretion onto the primary post-AGB white dwarf core from a low mass companion whose decaying accretion supply rate owers first the pPNe and then the lower luminosity PNe. Determining observational signatures of different MHD engines is a work in progress. Accretion disk theory and large scale dynamos pose many of their own fundamental challenges, some of which I discuss in a broader context.

Oral contribution, published in IAU Symposium 259: "Cosmic Magnetic Fields:from Planets, to Stars and Galaxies," edited by K.G. Strassmeier, A.G. Kosovichev & J. Beckmann
Available from arXiv:0812.2525

Review Paper

Alignment of Dust by Radiative Torque: Recent Developments

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Alignment of dust by radiative torques (RATs) has proven to be the most promising mechanism to explain alignment in various astrophysical environments, from comet atmospheres to circumstellar accretion disks, molecular clouds, and diffuse interstellar gas. Recent years have been marked by intensive attempts to provide proper theoretical treatment of the alignment process. We discuss some of the major advances, which include, first of all, formulating of the analytical model of RATs. This model was shown to reproduce well the torques acting on actual irregular dust grains and allowed studies of the parameter space for which the alignment happens with long axes perpendicular and parallel to the magnetic field. Such a study resulted in an important conclusion that, without any paramagnetic relaxation, the RAT alignment always happens for interstellar grains with long axes perpendicular to the magnetic field. Incidentally, this conclusion is not true for the alignment of large (i.e. $a > 10^{-4}$ cm) grains that are present, e.g., in accretion disks, as these grains can demonstrate both the alignment with long axes parallel and perpendicular to the magnetic field, although the alignment with long grain axes perpendicular to the magnetic field is preferential in many cases, which can also be identified with the analytical model. Additional recent advances include the description of effects of gaseous bombardment and pinwheel torques on grains aligned by RATs. Very counterintuitively, the gaseous bombardment was shown in some cases to increase the degree of alignment by knocking out grains from the positions of imperfect alignment when the grains rotate slowly to more stable positions of perfect alignment where grains rotate fast. In terms of pinwheel torques, important revisions have been made in the Lazarian & Draine model of grain flipping and thermal trapping. Those, however, do not change the major conclusion that very small grains (i.e. $a < 3 \times 10^{-6}$ cm) should be marginally aligned. Recent work made the RAT alignment a predictive theory which is ready for quantitative modeling of astrophysical polarization. The right timing of this work is not only due to renewed efforts in terms of astrophysical polarimetry, but also due to the interest to the polarized foreground arising from the attempts to measure CMB polarization. In particular, we predict that the microwave emission from the Zodiacal dust presents an important contaminant, which should be included into foreground polarization templates.

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Job Adverts

Instituut voor Sterrenkunde, KU Leuven, Belgium
Post-doc position for 2+2 years on: Post-AGB binaries in evolutionary perspective

The Instituut voor Sterrenkunde (IvS) of Leuven University is a young and active research group of some 50 scientists, engineers and administrative staff (http://www.ster.kuleuven.be). The institute is involved in several international

networks and research projects which rely on data gathered with telescopes at international observatories and with space missions. The IvS operates the modern 1.2m Mercator telescope at Roque de los Muchachos observatory which is equipped with a CCD camera and an efficient high-resolution fiber-fed spectrograph (HERMES). The institute is also responsible for the organization of the Master in Astronomy & Astrophysics of the Faculty of Science at Leuven University.

With this vacancy, we are looking for a motivated postdoctoral researcher to join the IvS to pursue a research program aiming at unraveling the evolutionary connections between the many different types of evolved stars in binary systems.

Short project description:

The project is embedded in a larger theoretical and observational effort at the IvS, to study in detail the final evolution of stars of low and intermediate initial mass. In recent years, the IvS team focused on the characteristics of wide binaries with a post-AGB component, and started an extensive multi-wavelength program, including radial velocity monitoring, high spectral resolution optical studies, infrared spectral investigation of the circumstellar dust, submillimetre bolometric observations and high spatial resolution interferometric studies. The global picture that emerged is that a binary star evolved in a system that is too short to accommodate a full-grown AGB star. During a still badly understood phase of strong interaction, a circumbinary dusty disk was formed, but the binary system did not suffer a dramatic spiral in. The bound dusty disk plays a lead role in the evolution of the system.

The goal of this project is to build further on the current program and to expand these results in the global context of stellar binary evolution. Different sample of wide binaries with a WD companion or a Red Giant companion exist (e.g., Ba stars, CH stars, silicate J-type carbon stars) and there is growing evidence that binary interaction channels are compulsory routes to explain the wide variety of morphological and kinematical properties of PNe.

With this program, we want to unravel evolutionary connections (or the lack of them) between these classes and to progress in our understanding of the final evolutionary stages of low and intermediate mass binaries.

The project is embedded into the science goals of the own high-resolution HERMES spectrograph, in the GTO program of Belgium on the VLT interferometer, and in the GTO program of Belgium of the Hershel satellite. Within the team and depending on the expertise, the successful candidate will pursue a research programme on the quantified analyses of the multi-wavelength data.

Profile:

The candidate
- holds a PhD in Astrophysics
- has an excellent track record of peer-reviewed publications on themes related to final stages of stellar evolution
- has good knowledge of tools to interpret binary star data
- has a proven expertise on observational stellar astrophysics
- good knowledge of echelle data reduction techniques and/or interferometric data reduction and interpretation is a strong asset

Tasks:

The successful candidate will spend most of the time on research in the context of the program and will:
- contribute to the main science goals of the whole program by quantified analyses of the different GTO programs.
- develop complementary observational experiments using international facilities.
- co-develop and survey the observational monitoring programs at the Mercator telescope and develop efficient tools to streamline the data-flow and the scientific interpretation of the HERMES spectra.
- assist the project leader in the writing of and reporting for research grants (5- perform at least one observing run of two weeks per year for the pooled IvS programmes at the observatories of La Palma or La Silla.
- take up a teaching task and/or research classes in Bachelor of Physics or the Master in Astronomy and Astrophysics with a maximum of 4 hours/week.

The successful candidate shall have the opportunity to act as supervisor for master thesis research, as well as co-supervisor of PhD students.

Contract:

- Following the usual procedure at Leuven University, the initial contract runs over two years and will be prolonged after positive evaluation with another 2 years. The position is to be taken up as soon as possible. Applicants are requested to indicate their availability in their application (not later than 1 August 2009).

- Salary is according to the university regulations for postdoctoral researchers and depends on age and work experience.

Applications:

Send curriculum vitae and a 1-page motivation letter, in PDF format, to

Hans Van Winckel
Hans.VanWinckel@ster.kuleuven.be

The candidates also must arrange for three letters of recommendation to be sent electronically to the same email address.

The application and recommendation letter deadline is 1 February 2009. Only complete applications will be considered.

See also http://www.ster.kuleuven.be/vacancies/index_en.html

Instituut voor Sterrenkunde, University of Leuven, Belgium vacancy for a 4-year PhD position, entitled "The circumstellar environment of evolved stars as traced by molecules"

The project is embedded in a larger theoretical and observational effort at the IvS to study in detail the late stages of evolution of low and intermediate mass stars.

Evolved stars are important sources for the enrichment of the interstellar medium due to their dense outflows. These outflows are variable on many timescales and their physics and chemistry are not well understood. Presently, the IvS is at the unique position to use guaranteed time observations of both the HIFI and PACS instrument onboard the Herschel Space Observatory to study the role of different molecules in the stellar winds of evolved Asymptotic Giant Branch (AGB) stars with unprecedented detail. HERSCHEL will, e.g., for the first time give a full inventory of water both in the gas phase and in the form of solid water ice. Water plays a pivotal role in the physics and chemistry of the molecular envelopes that surround AGB stars. The goal of the present PhD project is to study the role of different molecules (H_2O, CO, HCN, ...) in the chemical and thermodynamical structure of the envelopes of stars with a wide range in stellar wind properties. Depending on the interest of the successful candidate, this PhD project can either have a more theoretical or a more observational accent.

The Herschel HIFI and PACS data will be complemented with already obtained ground-based high-resolution sub-millimeter single-dish and interferometric data of several molecules excited in the stellar wind of AGB stars. This PhD project will be performed in close collaboration with colleagues from the University of Amsterdam.

See also http://www.ster.kuleuven.be/vacancies/index_en.html