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Editors: Jacco van Loon and Albert Zijlstra

Editorial

It is our pleasure to present you with the 107$^{\rm th}$ issue of the AGB Newsletter. Your contributions demonstrate the high productivity of the AGB community, with 29 refereed journal papers, two PhD theses and an announcement of a workshop on White Dwarfs. There is much interest in the Planetary Nebulae formed during post-AGB evolution, in white dwarfs and/or red giants in symbiotic binaries, and in extra-galactic populations of AGB stars and Planetary Nebulae. All of these studies either depend on, or inform us about the structure and evolution of AGB stars. Please also note the advertisement for two tenure-track positions in Brussels.

Without claiming responsibility, given the "Food for Thought" statement of last issue we were both pleased and amused to see the first item to be submitted for the current issue (see the next page). We hope that this month's "Food for Thought" statement will be equally stimulating.

The next issue will be distributed on the 1$^{\rm st}$ of May; the deadline for contributions is the 30$^{\rm th}$ of April.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

In specific circumstances, the core of an AGB star can reach the Chandrasekhar mass limit
(cf. Iben & Renzini 1983, ARA&A, 21, 271)

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

Do all planetary nebulae derive from binaries? I Population synthesis model of the galactic planetary nebula population produced by single stars and binaries

Maxwell Moe[1,2] *and Orsola De Marco*[1,2]

[1]CASA, University of Colorado, USA

[2]American Museum of Natural History, USA

We present a population synthesis calculation to derive the total number of planetary nebulae (PN) in the Galaxy that descend from single stars and stars in binary systems. Using the most recent literature results on galactic and stellar formation as well as stellar evolution, we predict the total number of galactic PNe to be $(6.6 \pm 2.1) \times 10^4$. Our prediction is much higher than the observationally-based estimate of Peimbert: (7200 ± 1800). It will be the subject of the second paper in this series (Paper II) to argue that the number of PN in the Galaxy is better explained if only binaries produce PNe.

The predicted PN formation rate from single stars and binaries is $(8.6 \pm 0.3) \times 10^{-13}$ PN yr^{-1} pc^{-3} in the local neighborhood. This number is lower than the most recent PN birthrate density estimates (2.1×10^{-12} PN yr^{-1} pc^{-3}), which are based on local PN counts and the PN distance scale, suggesting that the adopted PN distance scale should be revised to slightly larger values. Our prediction is however more in line with the white dwarf birthrate densities determined by Liebert et al. ($(1.0 \pm 0.25) \times 10^{-12}$ PN yr^{-1} pc^{-3}), since we expect only a fraction of all WD to have gone through a PN phase. We also predict that only 77% of all post-AGB WDs go through a PN phase which is similar to what is estimated based on WD mass distributions. Revisions of these predictions (in Paper II) based on the assumption that only binaries make PNe are still in line with observations, but will argue for a upward revision of the galactic PN distance scale by a factor of $\sim$2.

Submitted to ApJ

Chemical analysis of carbon stars in the Local Group: I. The Small Magellanic Cloud and the Sagittarius dwarf spheroidal galaxy

P. de Laverny[1]*, C. Abia*[2]*, I. Domínguez*[2]*, B. Plez*[3]*, O. Straniero*[4]*, R. Wahlin*[5]*, K. Eriksson*[5] *and U.G. Jørgensen*[6]

[1]Observatoire de la Côte d'Azur, Dpt. Cassiopée UMR6 202, 06 304 Nice Cedex 4, France

[2]Dpto. Física Teórica y del Cosmos, Universidad de Granada, E-18 071 Granada, Spain

[3]GRAAL, UMR5024, Université de Montpellier II, 34 095 Montpellier cedex 5, France

[4]INAF-Osservatorio di Collurania, 64 100 Teramo, Italy

[5]Department of Astronomy and Space Physics, Box 515, 75120 Uppsala, Sweden

[6]Niels Bohr Institute, Astronomical Observatory, Juliane Maries vej 30, 2 100 Copenhagen, Denmark

We present the first results of our ongoing chemical study of carbon stars in the Local Group of galaxies. We used spectra obtained with UVES at the 8.2 m Kueyen-VLT telescope and a new grid of spherical model atmospheres for cool carbon-rich stars which include polyatomic opacities, to perform a full chemical analysis of one carbon star, BMB-B 30, in the Small Magellanic Cloud (SMC) and two, IGI95-C1 and IGI95-C3, in the Sagittarius Dwarf Spheroidal (Sgr dSph) galaxy. Our main goal is to test the dependence on the stellar metallicity of the s-process nucleosynthesis and mixing mechanism occurring in AGB stars. For these three stars, we find important s-element enhancements with respect to the mean metallicity ([M/H]), namely [s/M]$\approx$+1.0, similar to the figure found in galactic AGB stars of similar metallicity. The abundance ratios derived between elements belonging to the first and second s-process abundance peaks, corresponding to nuclei with a magic number of neutrons $N = 50$ (^{88}Sr, ^{89}Y, ^{90}Zr) and $N = 82$ (^{138}Ba, ^{139}La, ^{140}Ce, ^{141}Pr), agree remarkably well with the theoretical predictions of low mass ($M < 3\,M_\odot$) metal-poor AGB nucleosynthesis models where the main source of neutrons is the $^{13}C(\alpha, n)^{16}O$ reaction activated during the

long interpulse phase, in a small pocket located within the He-rich intershell. The derived C/O and $^{12}C/^{13}C$ ratios are, however, more difficult to reconcile with theoretical expectations. Possible explanations, like the extrinsic origin of the composition of these carbon stars or the operation of a non-standard mixing process during the AGB phase (such as the *cool bottom process*), are discussed on the basis of the collected observational constraints.

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The circumstellar envelope of IRC+10216 from milli-arcsecond to arcmin scales

Leão I.C.[1], *de Laverny P.*[1], *Mékarnia D.*[1], *de Medeiros J. R.*[2] *and Vandame B.*[3]

[1]Observatoire de la Côte d'Azur, Cassiopée, BP 4229, 06304 Nice Cedex 4, France

[2]Departamento de Física, Universidade Federal do Rio Grande do Norte, Natal, Brazil

[3]European Southern Observatory, Garching b. München, Germany

Aims: Analysis of the innermost regions of the carbon-rich star IRC+10216 and of the outer layers of its circumstellar envelope have been performed in order to constrain its mass-loss history.

Methods: High dynamic range near infrared adaptive optics and high angular resolution deep V-band images of its circumstellar envelope collected with VLT/NACO and VLT/FORS1 instruments have been analyzed.

Results: Maps of the sub-arcsecond structures, or clumps, in the innermost regions are derived from the near-infrared observations. The morphology of these clumps is found to strongly vary from J- to L-band. Their relative motion appears to be more complex than proposed in earlier works: they can be weakly accelerated, have a constant velocity, or even be motionless with respect to one another. From V-band imaging, a high spatial resolution map of the shell distribution in the outer layers of IRC+10216 is presented. Shells are well resolved up to a distance of about $90''$ to the core of the nebula and most of them appear to be composed of thinner elongated **shells**. Finally, by combining the NACO and FORS1 images, a global view, showing both the extended layers and the bipolar core of the nebula together with the real size of the inner clumps is presented.

Conclusions: This study confirms the rather complex nature of the IRC+10216 circumstellar environment. In particular, the coexistence at different spatial scales of structures with very different morphologies (clumps, bipolarity and almost spherical external layers) is very puzzling. This confirms that the formation of AGB winds is far more complex than usually assumed in current models.

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First detection of dust clouds around R CrB variable stars

de Laverny P.[1] *and Mékarnia D.*[1]

[1]Observatoire de la Côte d'Azur, Dpt Cassiopée, Nice, France

From VLT/NACO diffraction-limited images of RY Sgr, we report the first direct detection of heterogeneities in the circumstellar envelope of a R Coronae Borealis variable star. Several bright and very large dust clouds are seen in various directions at several hundred stellar radii from RY Sgr, revealing high activity for the ejection of stellar material by R CrB variables. These observations do support the current interpretation that optically thick dust clouds are formed around the surface of this type of variable stars and, when passing between the star and the observer, produce the huge and sudden declines characterizing these objects in visible light. This is the first direct confirmation of a scenario proposed about 70 years ago.

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Planetary nebulae as tracers of galaxy stellar populations

Alberto Buzzoni[1], *Magda Arnaboldi*[2,3] *and Romano L.M. Corradi*[4,5]

[1]INAF - Osservatorio Astronomico di Bologna, Italy
[2]ESO - European Southern Observatory, Garching, Germany
[3]INAF - Osservatorio Astronomico di Torino, Italy
[4]ING - Isaac Newton Group of Telescopes, La Palma, Spain
[5]IAC - Instituto de Astrofísica de Canarias, Tenerife, Spain

We address the general problem of the luminosity-specific planetary nebula (PN) number, better known as the "α" ratio, given by $\alpha = N_{\rm PN}/L_{\rm gal}$, and its relationship with age and metallicity of the parent stellar population. Our analysis relies on population synthesis models, that account for simple stellar populations (SSPs), and more elaborated galaxy models covering the full star-formation range of the different Hubble morphological types. This theoretical framework is compared with the updated census of the PN population in Local Group galaxies and external ellipticals in the Leo group, and the Virgo and Fornax clusters.

The main conclusions of our study can be summarized as follows:

i) according to the Post-AGB stellar core mass, PN lifetime in a SSP is constrained by three relevant regimes, driven by the nuclear ($M_{\rm core}\gtrsim 0.57$ M$_\odot$), dynamical (0.57 M$_\odot$ $\gtrsim M_{\rm core}\gtrsim$0.55 M$_\odot$) and transition (0.55 M$_\odot$ $\gtrsim M_{\rm core}\gtrsim$0.52 M$_\odot$) timescales. The lower limit for $M_{\rm core}$ also sets the minimum mass for stars to reach the AGB thermal-pulsing phase and experience the PN event;

ii) mass loss is the crucial mechanism to constrain the value of α, through the definition of the initial-to-final mass relation (IFMR). The Reimers mass-loss parameterization, calibrated on Pop II stars of Galactic globular clusters, poorly reproduces the observed value of α in late-type galaxies, while a better fit is obtained using the empirical IFMR derived from white-dwarf observations in the Galaxy open clusters;

iii) the inferred PN lifetime for Local Group spirals and irregulars exceeds 10 000 yr, which suggests that $M_{\rm core}\lesssim 0.65$ M$_\odot$ cores dominate, throughout;

iv) the relative PN deficiency in elliptical galaxies, and the observed trend of α with galaxy optical colors support the presence of a prevailing fraction of low-mass cores ($M_{\rm core}\lesssim 0.55$ M$_\odot$) in the PN distribution, and a reduced visibility timescale for the nebulae as a consequence of the increased AGB transition time. The stellar component with $M_{\rm core}\lesssim 0.52$ M$_\odot$, which overrides the PN phase, could provide an enhanced contribution to hotter HB and Post-HB evolution, as directly observed in M 32 and the bulge of M 31. This implies that the most UV-enhanced ellipticals should also display the lowest values of α, as confirmed by the Virgo cluster early-type galaxy population;

v) any blue-straggler population, invoked as progenitor of the $M_{\rm core}\gtrsim 0.7$ M$_\odot$ PNe in order to preserve the constancy of the bright luminosity-function cut-off magnitude in ellipticals, must be confined to a small fraction (few percents at most) of the whole galaxy PN population.

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The origin of the lead-rich stars in Galactic halo: investigation of the model parameters for the s-process

Wenyuan Cui[1,2] *and Bo Zhang*[1,2]

[1]National Astronomical observatories, Chinese Academy of Sciences, Beijing 100012, China
[2]Department of Physics, Hebei Normal University, 113 Yuhua Road, Shijiazhuang, 050016, China

Several stars at the low-metallicity extreme of the Galactic halo show large spreads of [Pb/hs]. Theoretically, a s-process pattern should be obtained from an AGB star with fixed metallicity and initial mass. For the third dredge-up and the s-process model, several important properties depend primarily on the core mass of AGB stars. Zijlstra reported that the initial-final-mass relation steepens at low metallicity, due to low mass-loss efficiency. This perhaps affects the model parameters of the AGB stars, e.g. the overlap factor and the neutron irradiation time, in particular at low metallicity. The calculated results show indeed that the overlap factor and the neutron irradiation time are significantly small at

low metallicities, especially for 3.0 $M_\odot$ AGB stars. The scatter of [Pb/hs] found in low metallicities can therefore be explained naturally when varying the initial mass of the low-mass AGB stars.

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A deep kinematic survey of planetary nebulae in the Andromeda Galaxy using the Planetary Nebula Spectrograph

H. R. Merrett[1], *M. R. Merrifield*[1], *N. G. Douglas*[2], *K. Kuijken*[3,2], *A. J. Romanowsky*[4,1], *N. R. Napolitano*[5,2], *M. Arnaboldi*[6,7], *M. Capaccioli*[8], *K. C. Freeman*[9], *O. Gerhard*[10], *L. Coccato*[2], *D. Carter*[11], *N. W. Evans*[12], *M. I. Wilkinson*[12], *C. Halliday*[13] *and T. J. Bridges*[14]

[1]School of Physics and Astronomy, The University of Nottingham, NG7 2RD, UK
[2]Kapteyn Astronomical Institute, PO Box 800, NL-9700 AV Groningen, The Netherlands
[3]Leiden Observatory, PO Box 9513, NL-2300 RA Leiden, The Netherlands
[4]Departamento de Física, Universidad de Concepción, Casilla 160-C, Concepción, Chile
[5]INAF, Osservatorio di Capodimonte, Via Moiariello 16, Naples 80131, Italy
[6]ESO, Karl-Schwarzschild Str. 2, 85748 Garching bei München, Germany
[7]INAF, Osservatorio Astronomico di Torino, Strada Osservatorio 20, I-10025 Pino Torinese, Italy
[8]Department of Physical Sciences, University of Naples Federico II, via Cinthia, 80126 Napoli, Italy
[9]Research School of Astronomy and Astrophysics, Australian National University, Canberra ACT 2601, Australia
[10]Astronomisches Institut, Universität Basel, Venusstrasse 7, CH 4102 Binningen, Switzerland
[11]Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead CH41 1LD, UK
[12]Institute of Astronomy, Madingley Road, Cambridge CB3 OHA, UK
[13]INAF, Osservatorio Astrofísico di Arcetri, Largo E. Fermi 5, I-50125, Firenze, Italy
[14]Department of Physics, Queen's University, Kingston, Ontario, K7L 3N6, Canada

We present a catalogue of positions, magnitudes and velocities for 3300 emission-line objects found by the Planetary Nebula Spectrograph in a survey of the Andromeda Galaxy, M31. Of these objects, 2615 are found likely to be planetary nebulae (PNe) associated with M31. The survey area covers the whole of M31's disk out to a radius of 1.5°. Beyond this radius, observations have been made along the major and minor axes, and the Northern Spur and Southern Stream regions. The calibrated data have been checked for internal consistency and compared with other catalogues. With the exception of the very central, high surface brightness region of M31, this survey is complete to a magnitude limit of $m_{5007} \sim 23.75$, 3.5 magnitudes into the planetary nebula luminosity function.

We have identified emission-line objects associated with M31's satellites and other background galaxies. We have examined the data from the region tentatively identified as a new satellite galaxy, Andromeda VIII, comparing it to data in the other quadrants of the galaxy. We find that the PNe in this region have velocities that appear to be consistent with membership of M31 itself.

The luminosity function of the surveyed PNe is well matched to the usual smooth monotonic function. The only significant spatial variation in the luminosity function occurs in the vicinity of M31's molecular ring, where the luminosities of PNe on the near side of the galaxy are systematically ~ 0.2 magnitudes fainter than those on the far side. This difference can be explained naturally by a modest amount of obscuration by the ring. The absence of any difference in luminosity function between bulge and disk suggests that the sample of PNe is not strongly populated by objects whose progenitors are more massive stars. This conclusion is reinforced by the excellent agreement between the number counts of PNe and the R-band light.

The number counts of kinematically-selected PNe also allow us to probe the stellar distribution in M31 down to very faint limits. There is no indication of a cut-off in M31's disk out to beyond four scale-lengths, and no signs of a spheroidal halo population in excess of the bulge out to 10 effective bulge radii.

We have also carried out a preliminary analysis of the kinematics of the surveyed PNe. The mean streaming velocity of the M31 disk PNe is found to show a significant asymmetric drift out to large radii. Their velocity dispersion, although initially declining with radius, flattens out to a constant value in the outer parts of the galaxy. There are no indications that the disk velocity dispersion varies with PN luminosity, once again implying that the progenitors

of PNe of all magnitudes form a relatively homogeneous old population. The dispersion profile and asymmetric drift results are shown to be mutually consistent, but require that the disk flares with radius if the shape of its velocity ellipsoid remains invariant.

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On the nitrogen abundance of FLIERs: the outer knots of the planetary nebula NGC 7009

Denise R. Gonçalves[1,3], *Barbara Ercolano*[2], *Aurelio Carnero*[2], *Antonio Mampaso*[3] *and Romano L. M. Corradi*[4]

[1]IAG - Universidade de São Paulo
[2]Department of Physics and Astronomy - University College London
[3]Instituto de Astrofísica de Canarias
[4]Isaac Newton Group of Telescopes

We have constructed a 3D photoionization model of a planetary nebula (PN) similar in structure to NGC 7009 with its outer pair of knots (also known as FLIERs fast, low-ionization emission regions). The work is motivated by the fact that the strong [N II]λ6583 line emission from FLIERs in many PNe has been attributed to a significant local overabundance of nitrogen. We explore the possibility that the apparent enhanced nitrogen abundance previously reported in the FLIERs may be due to ionization effects. The model is constrained by the results obtained by Gonçalves et al. from the analysis of both Hubble Space Telescope (HST) [O III] and [N II] images, and long-slit spectra of NGC 7009. Our model is indeed able to reproduce the main spectroscopic and imaging characteristics of the bright inner rim of NGC 7009 and its outer pairs of knots, assuming homogeneous elemental abundances throughout the nebula, for nitrogen as well as all the other elements included in the model.

We also study the effects of a narrow slit on our non-spherically symmetric density distribution, via the convolution of the model results with the profile of the long slit used to obtain the spectroscopic observations that constrained our model. This effect significantly enhances the [N II]/Hα emission, more in the FLIERs than in the inner rim.

Because of the fact that the $(N^+/N)/(O^+/O)$ ratio predicted by our models is 0.60 for the rim and is 0.72 for the knots, so clearly in disagreement with the $N^+/N = O^+/O$ assumption of the ionization correction factor (icf) method, the icfs will be underestimated by the empirical scheme, in both components, rim and knots, but more so in the knots. This effect is partly responsible for the apparent inhomogeneous N abundance empirically derived. The differences in the above ratio in these two components of the nebula may be due to a number of effects including charge exchange as pointed out previously by other authors and the difference in the ionization potentials of the relevant species which makes this ratio extremely sensitive to the shape of the local radiation field. Because of the latter, a realistic density distribution is essential to the modelling of a non-spherical object, if useful information is to be extracted from spatially resolved observations, as in the case of NGC 7009.

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The dust envelope of the pre-planetary nebula IRAS19475+3119

Geetanjali Sarkar [1] *and Raghvendra Sahai*[2]

[1]Department of Physics, Indian Institute of Technology, Kanpur-208016, U.P., India
[2]Jet Propulsion Laboratory, MS 183-900, 4800 Oak Grove Drive, Pasadena, CA 91109, U.S.A.

We present the spectral energy distribution (SED) of the pre-planetary nebula, IRAS 19475+3119 (I 19475), from the optical to the far-infrared. We identify emission features due to crystalline silicates in the ISO SWS spectra of the

star. We have fitted the SED of I 19475 using a 1-D radiative transfer code, and find that a shell with inner and outer radii of 8.8×10^{16} and 4.4 $\times10^{17}$ cm, and dust temperatures ranging from about 94 K to 46 K provide the best fit. The mass of this shell is $\gtrsim1\,[34\ \mathrm{cm^2\ g^{-1}}/\kappa(100\mu\mathrm{m})][\delta/200]\ \mathrm{M_\odot}$, where $\kappa(100\mu\mathrm{m})$ is the 100μm dust mass absorption coefficient (per unit dust mass), and δ is the gas-to-dust ratio. In agreement with results from optical imaging and millimeter-wave observations of CO emission of I 19475, our model fits support an $\mathrm{r^{-3}}$ density law for its dust shell, with important implications for the interaction process between the fast collimated post-AGB winds and the dense AGB envelopes which results in the observed shapes of PPNs and PNs. We find that the observed JCMT flux at sub-millimeter wavelengths (850 μm) is a factor $\sim$2 larger than our model flux, suggesting the presence of large dust grains in the dust shell of I 19475 which are not accounted for by our adopted standard MRN grain size distribution.

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High resolution optical spectroscopy of IRAS 09425−6040 (=GLMP 260)

D. A. García-Hernández[1], *C. Abia*[2], *A. Manchado*[3,4] *and P. García-Lario*[1]

[1]ISO Data Centre, European Space Astronomy Centre (ESAC), ESA. Villafranca del Castillo. P.O. Box - Apdo. 50727. E-28080 Madrid. Spain

[2]Departamento de Física Teórica y del Cosmos, Universidad de Granada, E-18071 Granada, Spain.

[3]Instituto de Astrofísica de Canarias, E-38200 La Laguna, Spain.

[4]Consejo Superior de Investigaciones Científicas, Spain.

We present high resolution optical spectroscopic observations of IRAS 09425−6040, a peculiar, extremely red, C-rich AGB star showing prominent O-rich dust features in its ISO infrared spectrum attributed to crystalline silicates. Our analysis shows that IRAS 09425−6040 is indeed a C-rich star slightly enriched in lithium (log (Li/H) + 12 $\sim$ 0.7) with a low $^{12}\mathrm{C}/^{13}\mathrm{C}$ = 15±6 ratio. We also found some evidence that it may be enriched in s-elements. Combining our results with other observational data taken from the literature we conclude that the star is possibly an intermediate-mass TP-AGB star ($\mathrm{M}\gtrsim3\ \mathrm{M_\odot}$) close to the end of its AGB evolution which may have only very recently experienced a radical change in its chemistry, turning into a carbon-rich AGB star.

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Chemical abundances for Hf 2-2, a planetary nebula with the strongest known heavy element recombination lines

Liu X.-W.[1], *Barlow M. J.*[2], *Zhang Y.*[1], *Bastin R.*[2] *and Storey P. J.*[2]

[1]Department of Astronomy, Peking University, Beijing 100871, P. R. China

[2]Department of Physics and Astronomy, University College London, London WC1E 6BT, UK

We present high quality optical spectroscopic observations of the planetary nebula (PN) Hf 2-2. The spectrum exhibits many prominent optical recombination lines (ORLs) from heavy element ions. Analysis of the H I and He I recombination spectrum yields an electron temperature of $\sim$ 900 K, a factor of ten lower than given by the collisionally excited [O III] forbidden lines. The ionic abundances of heavy elements relative to hydrogen derived from ORLs are about a factor of 70 higher than those deduced from collisionally excited lines (CELs) from the same ions, the largest abundance discrepancy factor (adf) ever measured for a PN. By comparing the observed O II λ4089/λ4649 ORL ratio to theoretical value as a function of electron temperature, we show that the O II ORLs arise from ionized regions with an electron temperature of only $\sim$ 630 K. The current observations thus provide the strongest evidence that the nebula contains another previously unknown component of cold, high metallicity gas, which is too cool to excite

any significant optical or UV CELs and is thus invisible via such lines. The existence of such a plasma component in PNe provides a natural solution to the long-standing dichotomy between nebular plasma diagnostics and abundance determinations using CELs on the one hand and ORLs on the other.

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The Origins and Evolutionary Status of B Stars Found Far From the Galactic Plane II: Kinematics and Full Sample Analysis

J.C. Martin[1]

[1]Warner & Swasey Observatory, Case Western Reserve Univesity

This paper continues the analysis of faint high latitude B stars from Martin (2004). Here we analyze the kinematics of the stars and combine them with the abundance information from the first paper to classify each one. The sample contains 31 Population I runaways, fifteen old evolved stars (including five BHB stars, three post-HB stars, a pulsating helium dwarf, and six stars of ambiguous classification), one F-dwarf, and two stars which do not easily fit in one of the other categories. No star in the sample unambiguously shows the characteristics of a young massive star formed in situ in the halo. The two unclassified stars are probably extreme Population I runaways. The low binary frequency and rotational velocity distribution of the Population I runaways imply that most were ejected from dense star clusters by DES (dynamic ejection scenario). However we remain puzzled by the lack of runaway Be stars. We also confirm that PB 166 and HIP 41979 are both nearby solar-metallicity BHB stars.

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Astromineralogy of the 13 μm Feature in the Spectra of Oxygen-Rich AGB Stars - Part I: Corundum & Spinel

K. DePew[1]*, A. K. Speck*[1] *and C. Dijkstra*[1]

[1]University of Missouri-Columbia

Asymptotic Giant Branch (AGB) Stars have several interesting infrared spectral features. Approximately half the oxygen-rich AGB stars to be investigated spectroscopically exhibit a feature at ∼13 μm. The carrier of this feature has not yet been unequivocally identified, but has been attributed to various dust species, including corundum (α-Al_2O_3), spinel ($MgAl_2O_4$) and silica (SiO_2). In order to constrain the carrier of the 13 μm feature, we have used 1-d radiative transfer code DUSTY to model the effects of composition and optical depth on the shape and strength of the emerging 13 μm feature from corundum and spinel grains. We have modeled various corundum, spinel, corundum-silicate and spinel-silicate mixtures in dust shells surrounding O-rich AGB stars. These models demonstrate that 1) if corundum is present in these circumstellar dust shells, even at very low relative abundances, a ∼13 μm feature should be observed; 2) corundum's feature at ∼21 μm is not observable in models where the 13 μm feature is found at relative strengths similar to those found in the observed spectra, suggesting that the absence of the 21 μm feature in the observed spectra should not rule out corundum as a carrier species; 3) even at low relative abundances, spinel exhibits a feature at 16.8 μm that is not found in observations; and 4) the grains must be spherical. Other grain shapes (spheroids, ellipsoids, hollow spheres) shift the features to longer wavelengths for both spinel and corundum. Our models show that spinel is unlikely to be the carrier of the 13 μm feature. The case for corundum as the carrier is strengthened but not yet proven.

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M-type giants as optical counterparts of X-ray sources 4U 1700+24 and 4U 1954+319

Nicola Masetti[1], *Mauro Orlandini*[1], *Eliana Palazzi*[1], *Lorenzo Amati*[1] *and Filippo Frontera*[1,2]

[1]INAF/IASF, Bologna, Italy

[2]Dip. Fisica, Univ. Ferrara, Italy

We observed with Chandra two peculiar galactic X-ray sources, 4U 1700+24 and 4U 1954+319, which are suspected to have a M-type giant star as optical counterpart, in order to get an high-precision astrometric position for both of them. The peculiarity of these sources lies in the fact that these are the only two cases among low-mass X-ray binaries (LMXBs), besides the confirmed case of GX 1+4, for which the companion can possibly be a M-type giant. We found that in both cases the field M-type giant star is indeed the counterpart of these X-ray sources. We also determined the distance to 4U 1954+319 to be about 1.7 kpc. This result suggests that a number of faint (L_X around 10^{32}–10^{34} erg s^{-1}) Galactic X-ray sources are 'symbiotic X-ray binaries', that is, wide-orbit LMXBs composed of a compact object, most likely a neutron star, accreting from the wind of a M-type giant.

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The effect of dust obscuration in RR Tel on optical and IR long-term photometry and Fe II emission lines

D. Kotnik-Karuza[1], *M. Friedjung*[2], *P. A. Whitelock*[3], *F. Marang*[3], *K. Exter*[4], *F.P. Keenan*[5] *and D.L. Pollacco*[5]

[1]Physics Department, Faculty of Arts and Sciences, Omladinska 14, HR-51000 Rijeka, Croatia

[2]Institut d'Astrophysique de Paris UMR7075 CNRS, Université Pierre & Marie Curie, 98 bis Boulevard Arago, 75014 Paris, France

[3]South African Astronomical Observatory, Observatory, South Africa and national Astrophysics and Space Science Programme, University of Cape Town, 7701 Rondebosch, South Africa

[4]Instituto de Astrofisica de Canarias, La Laguna (Tenerife), Espana

[5]Dept. of pure and applied physics, Queens University, Belfast, Northern Ireland

Infrared and optical photometric and spectroscopic observations of the symbiotic nova RR Tel are used to study the effects and properties of dust in symbiotic binaries containing a cool Mira component, as well as showing "obscuration events" of increased absorption, which are typical for such Miras. A set of photometric observations of the symbiotic nova RR Tel in different wavelength bands - visual from 1949 to 2002 and near-infrared (JHKL) from 1975 to 2002 - are presented. The variability due to the normal Mira pulsation was removed from the JHKL data, which were then compared with the AAVSO visual light curve. The changes of the Fe II emission line fluxes during the 1996-2000 obscuration episode were studied in the optical spectra taken with the Anglo-Australian telescope. We discuss the three periods during which the Mira component was heavily obscured by dust as observed in the different wavelength bands. A change in the correlations of J with other infrared magnitudes was observed with the colour becoming redder after JD2446000. Generally, J-K was comparable, while K-L was larger than typical values for single Miras. A distance estimate of 2.5 kpc, based on the IR data, is given. A larger flux decrease for the permitted than for the forbidden Fe II lines, during the obscuration episode studied, has been found. There is no evidence for other correlations with line properties, in particular with wavelength, which suggests obscuration due to separate optically thick clouds in the outer layers.

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Radio observations of the planetary nebula around the OH/IR Star OH354.88-0.54 (V1018 Sco)

Martin Cohen[1], *Jessica M. Chapman*[2], *Rachel M. Deacon*[3], *Robert J. Sault*[4], *Quentin A. Parke*[5,6] *and Anne J. Green*[3]

[1]Radio Astronomy Laboratory, UC-Berkeley, USA

[2]Australia Telescope National Facility, Epping, Australia

[3]School of Physics, University of Sydney, Australia

[4]Australia Telescope National Facility, Narrabri, Australia

[5]Department of Physics, Macquarie University, Sydney, Australia

[6]Anglo-Australian Observatory, Epping, Australia

We present radio observations of the unique, recently formed, planetary nebula (PN) associated with a very long-period OH/IR variable star V1018 Sco that is unequivocally still in its asymptoticgiant branch phase. Two regions within the optical nebula are clearly detected in nonthermal radio continuum emission, with radio spectral indices comparable to those seen in colliding-wind Wolf-Rayet binaries. We suggest that these represent shocked interactions between the hot, fast stellar wind and the cold nebular shell that represents the PN's slow wind moving away from the central star. This same interface produces both synchrotron radio continuum and the optical PN emission. The fast wind is neither spherical in geometry nor aligned withany obvious optical or radio axis. We also report the detection of transient H2O maser emission in this nebula.

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Rubidium and Lead Abundances in Giant Stars of the Globular Clusters M13 and NGC 6752

D. Yong[1], *W. Aoki*[2], *D. L. Lambert*[3] *and D. B. Paulson*[4]

[1]University of North Carolina, USA

[2]National Astronomical Observatory, Japan

[3]University of Texas, USA

[4]NASA Goddard Space Flight Center, USA

We present measurements of the neutron-capture elements Rb and Pb in five giant stars of the globular cluster NGC 6752 and Pb measurements in four giants of the globular cluster M13. The abundances were derived by comparing synthetic spectra with high-resolution, high signal-to-noise ratio spectra obtained using HDS on the Subaru telescope and MIKE on the Magellan telescope. The program stars span the range of the O-Al abundance variation. In NGC 6752, the mean abundances are [Rb/Fe]= -0.17 ± 0.06 (σ=0.14), [Rb/Zr]= -0.12 ± 0.06 (σ=0.13), and [Pb/Fe]= -0.17 ± 0.04 (σ=0.08). In M13 the mean abundance is [Pb/Fe]= -0.28 ± 0.03 (σ=0.06). Within the measurement uncertainties, we find no evidence for star-to-star variation for either Rb or Pb within these clusters. None of the abundance ratios [Rb/Fe], [Rb/Zr], or [Pb/Fe] are correlated with the Al abundance. NGC 6752 may have slightly lower abundances of [Rb/Fe] and [Rb/Zr] compared to the small sample of field stars at the same metallicity. For M13 and NGC 6752 the Pb abundances are in accord with predictions from a Galactic chemical evolution model. If metal-poor intermediate-mass asymptotic giant branch stars did produce the globular cluster abundance anomalies, then such stars do not synthesize significant quantities of Rb or Pb. Alternatively, if such stars do synthesize large amounts of Rb or Pb, then they are not responsible for the abundance anomalies seen in globular clusters.

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New Praesepe white dwarfs and the initial mass-final mass relation

Paul Dobbie[1], *Ralf Napiwotzki*[2], *Matt Burleigh*[1], *Martin Barstow*[1], *David Boyce*[1], *Sarah Casewell*[1], *Richard Jameson*[1], *Ivan Hubeny*[3] *and Gilles Fontaine*[4]

[1]University of Leicester, UK

[2]University of Hertfordshire, UK

[3]Steward Observatory and Department of Astronomy, University of Arizona, USA

[4]Departement de Physique, Université de Montreal, Canada

We report the spectroscopic confirmation of four further white dwarf members of Praesepe. This brings the total number of confirmed white dwarf members to eleven making this the second largest collection of these objects in an open cluster identified to date. This number is consistent with the high mass end of the initial mass function of Praesepe being Salpeter in form. Furthermore, it suggests that the bulk of Praesepe white dwarfs did not gain a substantial recoil kick velocity from possible asymmetries in their loss of mass during the asymptotic giant branch phase of evolution. By comparing our estimates of the effective temperatures and the surface gravities of WD0833+194, WD0840+190, WD0840+205 and WD0843+184 to modern theoretical evolutionary tracks we have derived their masses to be in the range 0.72-0.76 $M_\odot$ and their cooling ages ∼300 Myrs. For an assumed cluster age of 625 ± 50 Myrs the infered progenitor masses are between 3.3-3.5 $M_\odot$. Examining these new data in the context of the initial mass-final mass relation we find that it can be adequately represented by a linear function ($a_0 = 0.289 \pm 0.051$, $a_1 = 0.133 \pm 0.015$) over the initial mass range 2.7 $M_\odot$ to 6 $M_\odot$. Assuming an extrapolation of this relation to larger initial masses is valid and adopting a maximum white dwarf mass of 1.3 $M_\odot$, our results support a minimum mass for core-collapse supernovae progenitors in the range ∼6.8-8.6 $M_\odot$.

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The Planetary Nebula population of the Sagittarius Dwarf Spheroidal Galaxy

Albert Zijlstra[1], *K. Gesicki*[2], *J.R. Walsh*[3], *D. Pequignot*[4], *P.A.M. van Hoof*[5] *and D. Minniti*[6]

[1]University of Manchester, UK

[2]Centrum Astronomii UMK, Torun, Poland

[3]European Coordinating Facility, ESO, Garching, Germany

[4]Observatoire de Paris-Meudon, France

[5]Royal Observatory of Belgium, Brussels, Belgium

[6]Universidad Catolica, Santiago, Chile

The identification of two new Planetary Nebulae in the Sagittarius Dwarf Spheroidal Galaxy (Sgr) is presented. This brings the total number to four. Both new PNe were previously classified as Galactic objects. The first, StWr 2-21, belongs to the main body of Sgr, from its velocity and location. The second, the halo PN BoBn 1, has a location, distance and velocity in agreement with the leading tidal tail of Sgr. We estimate that 10 per cent of the Galactic halo consists of Sgr debris. The specific frequency of PNe indicates a total luminosity of Sgr, including its tidal tails, of $M_V = -14.1$. StWr 2-21 shows a high abundance of $[O/H] = -0.23$, which confirms the high-metallicity population in Sgr uncovered by Bonaficio et al. (2004). The steep metallicity–age gradient in Sgr is due to ISM removal during the Galactic plane passages, ISM reformation due to stellar mass loss, and possibly accretion of metal-enriched gas from our Galaxy. The ISM re-formation rate of Sgr, from stellar mass loss, is $5 \times 10^{-4}\,M_\odot\,yr^{-1}$, amounting to $\sim 10^6\,M_\odot$ per orbital period.

HST images of three of the PNe reveal well-developed bipolar morphologies, and provide clear detections of the central stars. All three stars with deep spectra show WR-lines, suggesting that the progenitor mass and metallicity determines whether a PN central star develops a WR spectrum. One Sgr PN belongs to the class of IR-[WC] stars. Expansion velocities are determined for three nebulae. Comparison with hydrodynamical models indicates an initial density profile of $\rho \propto r^{-3}$. This is evidence for increasing mass-loss rates on the AGB. Peak mass-loss rates are indicated of $\sim 10^{-4}\,M_\odot\,yr^{-1}$.

The IR-[WC] PN, He 2-436, provides the sole direct detection of dust in a dwarf spheroidal galaxy, to date.

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An estimate of the time variation of the abundance gradient from planetary nebulae: III. O, S, Ar, and Ne: A comparison of PN samples

W. J. Maciel[1], *L . G. Lago*[1] *and R. D. D. Costa*[1]

[1]IAG/USP, São Paulo, Brazil

The time behaviour of the radial abundance gradients in the galactic disk is investigated on the basis of four different samples of planetary nebulae, comprising both smaller, homogeneous sets of data, and larger, albeit non-homogeneous samples. Four different chemical elements are considered, namely, oxygen, sulphur, argon and neon. Our analysis support our earlier conclusions that, on the average, the radial abundance gradients have flattened out in the last 6 to 8 Gyr.

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Near-Infrared Photometry of Carbon Stars

Patricia A. Whitelock[1,2,3], *Michael W. Feast*[2], *Freddy Marang*[1] *and M.A.T. Groenewegen*[4]

[1]SA Astronomical Observatory, S Africa

[2]Dept of Astronomy, University of Cape Town, S Africa

[3]National Astrophysics and Space Science Programme, Dept of Mathematics, UCT, S Africa

[4]Instituut voor Sterrenkunde, KU Leuven, Belgium

Near-infrared, JHKL, photometry of 239 Galactic carbon-rich variable stars is presented and discussed. From these and published data the stars were classified as Mira or non-Mira variables and amplitudes and pulsation periods, ranging from 222 to 948 days for the Miras, were determined for most of them. A comparison of the colour and period relations with those of similar stars in the Large Magellanic Cloud indicates minor differences, which may be the consequence of sample selection effects. Apparent bolometric magnitudes were determined by combining the mean JHKL fluxes with mid-infrared photometry from IRAS and MSX. Then, using the Mira period luminosity relation to set the absolute magnitudes, distances were determined – to greater accuracy than has hitherto been possible for this type of star. Bolometric corrections to the K magnitude were calculated and prescriptions derived for calculating these from various colours. Mass-loss rates were also calculated and compared to values in the literature.

Approximately one third of the C-rich Miras and an unknown fraction of the non-Miras exhibit apparently random obscuration events that are reminiscent of the phenomena exhibited by the hydrogen deficient RCB stars. The underlying cause of this is unclear, but it may be that mass loss, and consequently dust formation, is very easily triggered from these very extended atmospheres.

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Carbon-Rich Mira Variables: Radial Velocities and Distances

John W. Menzies[1], *Michael W. Feast*[2] *and Patricia A. Whitelock*[1,2,3]

[1]SA Astronomical Observatory, S Africa

[2]Dept of Astronomy, University of Cape Town, S Africa

[3]National Astrophysics and Space Science Programme, Dept of Mathematics, UCT, S Africa

Optical radial velocities have been measured for 38 C-type Mira variables. These data together with others in the literature are used to study the differences between optical and CO mm observations for C-Miras and the necessary corrections to the optical velocities are derived in order to obtain the true radial velocities of the variables. The difference between absorption and emission line velocities is also examined. A particularly large difference (+30 km s^{-1}) is found in the case of the H-alpha emission line. A catalogue is given of 177 C-Miras with estimated distances and radial velocities. The distances are based on bolometric magnitudes derived in Paper I using SAAO observations or (for 60 of the stars) using non-SAAO photometry. In the latter case the necessary transformations to the SAAO system are derived. These data will be used in paper III to study the kinematics of the C-Miras.

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Carbon-Rich Mira Variables: Kinematics and Absolute Magnitudes

Michael W. Feast[1], *Patricia A. Whitelock*[1,2,3] *and John W. Menzies*[2]

[1]Dept of Astronomy, University of Cape Town, S Africa

[2]SA Astronomical Observatory, S Africa

[3]National Astrophysics and Space Science Programme, Dept of Mathematics, UCT, S Africa

The kinematics of galactic C-Miras are discussed on the basis of the bolometric magnitudes and radial velocities of Papers I and II of this series. Differential galactic rotation is used to derive a zero-point for the bolometric period-luminosity relation which is in satisfactory agreement with that inferred from the LMC C-Miras. We find for the galactic Miras, $M_{\rm bol} = -2.54 \log P + 2.06(\pm 0.24)$, where the slope is taken from the LMC. The mean velocity dispersion, together with the data of Nordstroem et al. and the Padova models, leads to a mean age for our sample of C-Miras of 1.8 ± 0.4 Gyr and a mean initial mass of 1.8 ± 0.2 solar masses. Evidence for a variation of velocity dispersion with period is found, indicating a dependence of period on age and initial mass, the longer period stars being younger. We discuss the relation between the O- and C-Miras and also their relative numbers in different systems.

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Deep CFHT Photometric Survey of the Entire M33 Galaxy I: Catalogue of 36000 Variable Point Sources

J.D.Hartman[1], *D.Bersier*[2], *K.Z.Stanek*[3], *J.-P.Beaulieu*[4], *J.Kaluzny*[5], *J.-B.Marquette*[4] *and P.B.Stetson*[6]

[1]Harvard-Smithsonian CfA

[2]Liverpool John Moores University

[3]The Ohio State University

[4]Université Pierre & Marie Curie

[5]Nicolaus Copernicus Astronomical Center

[6]Dominion Astrophysical Observatory

We have conducted a variability survey of the local group galaxy M33 using g', r', and i' observations from 27 nights spanning 17 months made with the MegaPrime/MegaCam instrument on the 3.6 m CFHT telescope. We identify

more than 36000 variable sources with $g', r', i' \leq 24$ out of approximately 2 million point sources in a one square degree field of view. This increases the number of known variables in this galaxy by more than a factor of 20. In this paper we provide a brief description of the data and a general overview of the variable star population which includes more than 800 candidate variable blue and red supergiant stars, more than 2000 Cepheids, and more than 19000 long period variable AGB and RGB stars.

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Radio continuum monitoring of the extreme carbon star IRC+10216

K. M. Menten[1], *M.J. Reid*[2], *E. Kruegel*[1], *M.J. Claussen*[3] *and R. Sahai*[4]

[1]MPIfR, Germany
[2]CfA, USA
[3]NRAO, USA
[4]JPL, USA

We describe Very Large Array observations of the extreme carbon star IRC+10216 at 8.4, 14.9, and 22.5 GHz made over a two year period. We find possible variability correlated with the infrared phase and a cm- to sub-millimeter wavelength spectral index very close to 2. The variability, observed flux densities, and upper limit on the size are consistent with the emission arising from the stellar photosphere or a slightly larger radio photosphere.

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Mid-infrared spectroscopy of carbon stars in the Small Magellanic Cloud

Sloan, G.C.[1], *Kraemer, K.E.*[2], *Matsuura, M.*[3,4], *Wood, P.R.*[5], *Price, S.D.*[2] *and Egan, M.P.*[2]

[1]Cornell University
[2]Air Force Research Laboratory
[3]University of Manchester
[4]Queen's University of Belfast
[5]Australian National University

We have observed a sample of 36 objects in the Small Magellanic Cloud (SMC) with the Infrared Spectrometer on the *Spitzer Space Telescope*. Nineteen of these sources are carbon stars. An examination of the near- and mid-infrared photometry shows that the carbon-rich and oxygen-rich dust sources follow two easily separated sequences. A comparison of the spectra of the 19 carbon stars in the SMC to spectra from the *Infrared Space Observatory* (*ISO*) of carbon stars in the Galaxy reveals significant differences. The absorption bands at 7.5 μm and 13.7 μm due to C_2H_2 are stronger in the SMC sample, and the SiC dust emission feature at 11.3 μm is weaker. Our measurements of the MgS dust emission feature at 26–30 μm are less conclusive, but this feature appears to be weaker in the SMC sample as well. All of these results are consistent with the lower metallicity in the SMC. The lower abundance of SiC grains in the SMC may result in less efficient carbon-rich dust production, which could explain the excess C_2H_2 gas seen in the spectra. The sources in the SMC with the strongest SiC dust emission tend to have redder infrared colors than the other sources in the sample, which implies more amorphous carbon, and they also tend to show stronger MgS dust emission. The weakest SiC emission features tend to be shifted to the blue; these spectra may arise from low-density shells with large SiC grains.

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Structure of the hot object in the symbiotic prototype Z And during its 2000-03 active phase

A. Skopal[1], *A. A. Vittone*[2], *L. Errico*[2], *M. Otsuka*[3], *S. Tamura*[4], *M. Wolf*[5] *and V. G. Elkin*[6]

[1]Astronomical Institute, Slovak Academy of Sciences, 059 60 Tatranská Lomnica, Slovakia

[2]INAF Osservatorio Astronomico di Capodimonte, via Moiariello 16, I-80 131 Napoli, Italy

[3]Okayama Astrophysical Observatory, NAOJ, Kamogata, Okayama 719-0232, Japan

[4]Astronomical Institute, Tohoku University, Sendai 980-8578, Japan

[5]Astronomical Institute, Charles University Prague, CZ-18000 Praha 8, V Holešovičkách 2, Czech Republic

[6]Centre for Astrophysics, University of Central Lancashire, Preston PR1 2HE, United Kingdom

Aims: To investigate structure of the hot object in the symbiotic prototype Z And during its major 2000-03 active phase. Methods: Analysis of the far ultraviolet, optical low- and high-resolution spectroscopy and $UBVR$ photometry. Reconstruction of the spectral energy distribution (SED) during the outburst. The Raman scattering process. Results: At the initial stages of the outburst the hot object was characterized by the two-temperature spectrum (a warm stellar radiation and a strong nebular emission) with signatures of a mass-outflow at moderate ($\sim 100 \div 200$ km/s) and very high ($\approx 1000 \div 2000$ km/s) velocities. The corresponding structure of the hot object consists of an optically thick, slowly-expanding disk-like material encompassing the accretor at the orbital plane and a fast optically thin wind over the remainder of the star. The disk-like shell persisted around the central star until 2002 August as was indicated by the eclipse effect. Then a significant dilution of the optically thick material and evolution of a fast wind from the hot star, concentrated more at the orbital plane, were detected. A striking similarity of [Fe VII] λ6087 and Raman λ6825 profiles at/after the dilution of the disk suggested their origin within the interaction zone where the winds from the binary components collide.

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Modelling Chromospheric Line Profiles in NGC2808: Evidence of Mass Loss from RGB Stars

P.J.D. Mauas[1], *C. Cacciari* [2] *and L. Pasquini*[3]

[1]Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

[2]INAF, Osservatorio Astronomico di Bologna, Italy

[3]European Southern Observatory, Garching b. München, Germany

In this study we test the possibility that the asymmetry in the profiles of the H-alpha and Ca II K lines in red giant stars is due to the presence of an active chromosphere rather than to mass loss. To this end, we compare line profiles computed using relevant model chromospheres to profiles of the H-alpha and Ca II K lines observed in five red giant stars of the globular cluster NGC 2808. The spectra were taken with FLAMES during Science Verification, using the UVES mode at high resolution (R=43,000) for the H-alpha line, and GIRAFFE in MEDUSA mode (R=20,000) for the Ca II K line. We find that the observed profiles are better described if a negative (outward) velocity field is included in the model chromospheres. This leads to mass loss rates of a few 10^{-9} solar masses per year, very close to the requirements of the stellar evolution theory.

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White Dwarf - Red Dwarf Systems Resolved with the Hubble Space Telescope: I. First Results

J. Farihi[1,2], *D.W. Hoard*[3,4] *and S. Wachter*[3]

[1]Gemini Observatory, Northern Operations, 670 North A'ohoku Place, Hilo, HI 96720
[2]Department of Physics & Astronomy, University of California, 430 Portola Plaza, Los Angeles, CA 90095
[3]Spitzer Science Center, California Institute of Technology, MS 220-6, Pasadena, CA 91125
[4]Department of Physics & Astronomy, Pomona College, 610 North College Plaza, Claremont, CA 91711

First results are presented for a Hubble Space Telescope Advanced Camera for Surveys snapshot study of white dwarfs with likely red dwarf companions. Of 48 targets observed and analyzed so far, 27 are totally or partially resolved into two or more components, while an additional 15 systems are almost certainly unresolved binaries. These results provide the first direct empirical evidence for a bimodal distribution of orbital separations among binary systems containing at least one white dwarf.

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Conference Papers

AGB star intershell abundances inferred from analyses of extremely hot H-deficient post-AGB stars

K. Werner[1], D. Jahn[1], T. Rauch[1], E. Reiff[1], F. Herwig[2] and J.W. Kruk[3]

[1]Institut für Astronomie und Astrophysik, Universität Tübingen
[2]Alamos National Laboratory, Theoretical Astrophysics Group T-6
[3]Department of Physics and Astronomy, Johns Hopkins University

The hydrogen-deficiency in extremely hot post-AGB stars of spectral class PG1159 is probably caused by a (very) late helium-shell flash or a AGB final thermal pulse that consumes the hydrogen envelope, exposing the usually-hidden intershell region. Thus, the photospheric element abundances of these stars allow to draw conclusions about details of nuclear burning and mixing processes in the precursor AGB stars. We compare predicted element abundances to those determined by quantitative spectral analyses performed with advanced non-LTE model atmospheres. A good qualitative and quantitative agreement is found for many species (He, C, N, O, Ne, F, Si) but discrepancies for others (P, S, Fe) point at shortcomings in stellar evolution models for AGB stars.

Oral contribution, published in The VIII Torino Workshop on Nucleosynthesis in AGB stars: Constraints on AGB Nucleosynthesis from Observations, edited by C. Abia and I. Domínguez
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Spitzer IRS spectra of Luminous 8 μm Sources in the Large Magellanic Cloud

Catherine L. Buchanan[1], Joel H. Kastner[1], William J. Forrest[2], Bruce J. Hrivnak[3], Raghvendra Sahai[4], Michael Egan[5], Adam Frank[2] and Cecilia Barnbaum[6]

[1]Center for Imaging Science, Rochester Institute of Technology
[2]Department of Physics & Astronomy, University of Rochester
[3]Department of Physics and Astronomy, Valparaiso University
[4]NASA/JPL
[5]Air Force Research Laboratory; OASD (NII) Space Programs
[6]Valdosta University

We have produced an atlas of *Spitzer* Infrared Spectrograph (IRS) spectra of mass-losing, evolved stars in the Large

Magellanic Cloud. These stars were selected to have high mass-loss rates and so contribute significantly to the return of processed materials to the ISM. Our high-quality spectra enable the determination of the chemistry of the circumstellar envelope from the mid-IR spectral features and continuum. We have classified the spectral types of the stars and show that the spectral types separate clearly in infrared color-color diagrams constructed from 2MASS data and synthetic IRAC/MIPS fluxes derived from our IRS spectra. We present diagnostics to identify and classify evolved stars in nearby galaxies with high confidence levels using Spitzer and 2MASS photometry. Comparison of the spectral classes determined using IRS data with the IR types assigned based on NIR colors also revealed a significant number of misclassifications and enabled us to refine the NIR color criteria resulting in more accurate NIR color classifications of dust-enshrouded objects.

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Synthetic Super AGB Stars

Robert G. Izzard[1,2] *and Arend Jan T. Poelarends*[1]

[1]Sterrenkundig Instituut, Universiteit Utrecht

[2]The Carolune Institute for Quality Astronomy

We describe our first attempt at modelling nucleosynthesis in massive AGB stars which have undergone core carbon burning, the super-AGB stars. We fit a synthetic model to detailed stellar evolution models in the mass range $9 \leq M/\mathrm{M}_\odot \leq 11.5$ (Z=0.02), and extrapolate these fits to the end of the AGB. We determine the number of thermal pulses and AGB lifetime as a function of mass and mass-loss prescription. Our preliminary nucleosynthesis calculations show that, for a reasonable mass-loss rate, the effect of hot-bottom burning in super-AGB stars on the integrated yield of a stellar population is not large. There are many uncertainties, such as mass-loss and convective overshooting, which prevent accurate yield calculations. However, as potential progenitors of electron-capture supernovae, these stars may contribute 7% of non-type-Ia supernovae.

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Population synthesis of s-process element enhanced stars: Constraining the ^{13}C efficiency

A. Bonačić Marinović[1]*, R.G. Izzard*[1]*, M. Lugaro*[1] *and O.R. Pols*[1]

[1]Sterrenkundig Instituut Utrecht (SIU), Universiteit Utrecht, P.O. Box 80000, NL-3508 TA Utrecht, The Netherlands.

We study s-process element abundance ratios in stars by carrying out stellar population synthesis, using a rapid synthetic stellar evolution code which includes an up-to-date treatment of AGB nucleosynthesis and evolution. In contrast to other studies, we find that a large spread in the ^{13}C efficiency parameter ($^{13}\mathrm{C}_{\mathrm{eff}}$) is not needed to explain the observed spread in the ratios of heavy s-process to light s-process elements ([hs/ls]), but this comes naturally from the range of different initial stellar masses and their time evolution. As a result, the ^{13}C efficiency needed for fitting most stars in the galactic disk is constrained to $1 < {}^{13}\mathrm{C}_{\mathrm{eff}} < 2.5$. In the same fashion we also study the [Pb/Ce] ratios of lead stars and find out that for low metallicities $^{13}\mathrm{C}_{\mathrm{eff}}$ is approximately 0.5.

Oral contribution, published in 8^{th} Torino Workshop, Granada, Spain, February, 2006
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Are There Radical Cyanogen Abundance Differences Between Galactic Globular Cluster RGB and AGB Stars?

S. W. Campbell[1], *J. C. Lattanzio*[1] *and L. M. Elliott*[1]

[1]Centre for Stellar and Planetary Astrophysics, Monash University, Melbourne, Australia

Abridged

Norris et al. (1981) found that there was a distinct lack of cyanogen-strong (CN-strong) stars in their sample of AGB stars in NGC 6752, as compared to their sample of RGB stars (which had roughly equal numbers of CN-normal and CN-strong stars). Similar features have been discovered in the AGB populations of other clusters. Unfortunately all of these studies suffer from low AGB star counts so the conclusions are not necessarily robust – larger, statistically signifcant, sample sizes are needed.

We outline the results of a literature search for relevant CN observations and describe our observing proposal to test the suggestion that there are substantial abundance differences between the AGB and RGB in galactic globular clusters. The literature search revealed that the AGB star counts for all studies (which are not, in general, studies about AGB stars in particular) are low, usually being $\lesssim$10. The search also revealed that the picture may not be consistent between clusters. Although most clusters appear to have CN-weak AGBs, at least two seem to have CN-strong AGBs (M5 & 47 Tuc). To further complicate the picture, clusters often appear to have a combination of both CN-strong and CN-weak stars on their AGBs – although one population tends to dominate. Again, all these assertions are however based on small sample sizes.We aim to increase the sample sizes by an order of magnitude using existing high quality photometry in which the AGB and RGB can be reliably separated. For the observations we will use a wide-field, low- to mid-resolution multi-object spectroscope. With the new information we hope to ascertain whether significant abundance differences really exist.

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Theses

Study of the transition phase between AGB stars and PNe

D. A. García-Hernández[1]

[1]Instituto de Astrofísica de Canarias, E-38200 La Laguna, Spain.

This thesis addresses several topics in the study of the still poorly-known transition phase between the AGB ('Asymptotic Giant Branch') and the Planetary Nebula (PN) stage. In order to better understand this short evolutionary phase, we analysed various types of objects in this phase, including AGB/post-AGB stars and proto-planetary nebulae (PPNe), using a variety of observational data.

First, we analysed near-infrared spectroscopic data in a representative sample of transition objects which cover the entire post-AGB evolution. The sample includes late-AGB stars, post-AGB stars with different spectral types, as well as some of the youngest known PNe. This study has been centered on the detection of H_2 emission in post-AGB stars and has explored the correlations between the presence and the nature of the H_2 emission observed and the evolutionary stage and/or morphology of the sources under analysis.

Second, the distribution of the dust around the multipolar proto-PN IRAS 16594−4656 and the young elliptical planetary nebula IRAS 07027−7934 was studied with the help of diffraction-limited mid-IR images (at $\sim$10 μm). We interpreted the observed morphology based on the available ISO spectroscopy. In addition, we discussed the evolutionary status of both objects.

Finally, we analysed a large sample of galactic O-rich AGB stars using high resolution optical spectroscopy (R$\sim$40,000-50,000) in order to study their lithium abundances and/or possible s-process element enrichment. The

complete sample was studied taking into account certain observational properties such as their position in the IRAS two colour-diagram ([12]−[25] *vs* [25]−[60]), galactic distribution, expansion velocity (derived from the OH maser emision), and period of variability. We then performed a chemical analysis by combining classical hidrostatic model atmospheres for cool stars and synthetic spectroscopy with extensive line lists. From this chemical analysis, we derived the lithium and zirconium (taken as representative for the s-process enrichment) abundances and discussed the results obtained in the framework of "Hot Bottom Burning" (HBB) and nucleosynthesis models, which predict a chemical segregation in the AGB phase as a function of the initial mass of the progenitor star. A comparison of our results with similar studies carried out in the Magellanic Clouds is also included. The discrepancies observed are explained as a consequence of different metallicities. We also compared the results obtained with the data available in the literature for galactic post-AGB stars and PNe.

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Available from http://www.iso.vilspa.esa.es/science/theses/thesis_dagh.pdf

Mass loss from dust-enshrouded Asymptotic Giant Branch stars and red supergiants in the Large Magellanic Cloud

Jonathan Marshall[1]

[1]Astrophysics Group, School of Physical & Geographical Sciences, Keele University, Staffordshire ST5 5BG, UK. jrm@astro.keele.ac.uk

The process of mass-loss from evolved stars is the single largest contributor of matter back into the ISM. Intense mass-loss during the AGB phase of low-intermediate mass stars via a radiatively-driven wind can lead the stars to become enshrouded in an optically-thick layer of dust which condenses out of an extended molecular atmosphere. This thesis attempts to gain further insights into the mass-loss process that is presently poorly understood.

We used the Parkes radio telescope to observe dust-enshrouded AGB stars and supergiants in the LMC and SMC, deriving the speed of the superwind from the double-peaked OH maser profiles. Out of 8 targets in the LMC we detected 5, of which 3 are new detections. Our results confirm the simple theory for radiatively driven winds, this verifies the scaling relations we use in determining mass-loss rates and allows us to speculate on the chemical enrichment at different metallicities.

From investigating mass-loss from clusters in the Magellanic Clouds we find that the mass-loss rate increases with larger progenitor mass, possibly due to a dependence on the initial metallicity or the stellar luminosity. We investigate the dust-enshrouded carbon star LI-LMC 1813 in more depth and derive an accurate mass-loss rate and the stellar parameters, mass and metallicity. It is now one of the few AGB stars currently undergoing the superwind phase for which values for the fundamental astrophysical parameters are known.

With the ESO Very Large Telescope we obtained 3–4 μm spectra of IR stars in the LMC. 28 of 30 targets are identified as carbon stars, significantly adding to the known population of optically invisible carbon stars in the LMC. We find evidence for a high abundance of C_2H_2, suggestive of high carbon-to-oxygen abundance ratios at the low metallicity which would explain the large population of carbon stars.

Defended on 14th December 2005. Thesis supervisor: Dr. Jacco Th. van Loon (Keele University, UK)

Job Advert

Royal Observatory of Belgium Research position in astrophysics

Two tenure-track research positions in astrophysics are vacant at the Royal Observatory of Belgium (ROB), situated in Brussels.

Applicants should have a Master degree in sciences, a degree in civil engineering or a PhD in (applied) sciences. Candidates must be citizens of a country of the European Economic Area.

The successful candidates are expected to conduct active research in stellar astrophysics. The main topics studied at the Royal Observatory are: massive stars and stellar winds, post-AGB stars and planetary nebulae, variable stars and asteroseismology, binary stars and stellar groups (including astrometry).

Please note that linguistic constraints exist which must also be fulfilled (see below: selection criteria).

The deadline for receipt of applications is May 3, 2006.

For detailed information about the application and the selection criteria, see:
http://www.ejustice.just.fgov.be/cgi/article_body.pl?language=nl&caller=summary&pub_date=2006-03-24&numac=2006021042 (in Dutch)
http://www.ejustice.just.fgov.be/cgi/article_body.pl?language=fr&caller=summary&pub_date=2006-03-24&numac=2006021042 (in French)
http://www.belspo.be/belspo/home/jobs/pages/KSB240306_2.pdf (in Dutch/French)
http://www.belspo.be/belspo/home/jobs/pages/KSB240306sel_2.pdf (in Dutch/French)
or, contact the Director of the ROB (e-mail: ronald.vanderlinden@oma.be).

Announcement

15^{th} European Workshop on White Dwarfs

The 15^{th} European Workshop on White Dwarfs will be held at the University of Leicester from August 7-11^{th} 2006.

A tentative list of session topics is:
White Dwarf structure and evolution
Progenitors and Planetary Nebulae
White Dwarfs in binaries: CV, double degenerates, brown dwarfs etc.
White dwarfs, dust disks and planetary systems
Atmospheres, chemical composition, magnetic fields
Variable White Dwarfs
White Dwarfs in stellar clusters and the halo
White Dwarfs as SNIa progenitors

IMPORTANT: The registration deadline will be May 2, 2006.

Further details of the 15th European Workshops on White Dwarfs are available from the website (http://www.star.le.ac.uk/∼eurowd06).

Contact email address: eurowd06@star.le.ac.uk.

Chair of the Scientific Organizing Committee: Ralf Napiwotzki, Centre for Astrophysics Research, University of Hertfordshire, UK
Chair of the Local Organizing Committee: Dr. Matt Burleigh, University of Hertfordshire, UK

See also http://www.star.le.ac.uk/∼eurowd06/