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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 143$^{\rm rd}$ issue of the AGB Newsletter. After a slightly longer interval, it is no surprise to see a whopping 40 items submitted.

Many congratulations to Clio and Timur, for their Ph.D. theses on post-AGB stars. We wish them all the best in their future careers.

Looking for a postdoctoral job working in the exciting field of mass loss and circumstellar matter? Then the opening at the Jodrell Bank Centre for Astrophysics in Manchester, UK, might just be the one for you!

The next issue will be distributed on the 1$^{\rm st}$ of July 2009; the deadline for contributions is the 30$^{\rm th}$ of June.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Can non-radial pulsations on AGB stars cause a tsunami?

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)

Period–Luminosity Relations for Type II Cepheids and their Application

Noriyuki Matsunaga[1], *Michael W. Feast*[2,3] *and John W. Menzies*[3]

[1]Department of Astronomy, Kyoto University, Japan; Research Fellow of the Japan Society for the Promotion of Science

[2]Department of Astronomy, University of Cape Town, South Africa

[3]South African Astronomical Observatory, South Africa

JHK_s magnitudes corrected to mean intensity are estimated for LMC type II Cepheids in the OGLE-III survey. Period–luminosity (PL) relations are derived in JHK_s as well as in a reddening-free VI parameter. Within the uncertainties the BL Her stars ($P < 4$ d) and the W Vir stars ($P = 4$ to 20 d) are co-linear in these PL relations. The slopes of the infrared relations agree with those found previously for type II Cepheids in globular clusters within the uncertainties. Using the pulsation parallaxes of V553 Cen and SW Tau the data lead to an LMC modulus uncorrected for any metallicity effects of 18.46 ± 0.10 mag. The type II Cepheids in the second-parameter globular cluster, NGC 6441, show a PL(VI) relation of the same slope as that in the LMC and this leads to a cluster distance modulus of 15.46 ± 0.11 mag, confirming the hypothesis that the RR Lyrae variables in this cluster are overluminous for their metallicity. It is suggested that the Galactic variable κ Pav is a member of the peculiar W Vir class found by the OGLE-III group in the LMC. Low-resolution spectra of OGLE-III type II Cepheids with $P > 20$ d (RV Tau stars) show that a high proportion have TiO bands; only one has been found showing C_2. The LMC RV Tau stars, as a group, are not co-linear with the shorter-period type II Cepheids in the infrared PL relations in marked contrast to such stars in globular clusters. Other differences between LMC, globular cluster and Galactic field type II Cepheids are noted in period distribution and infrared colours.

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Detection of non-radial pulsation and faint companion in the symbiotic star CH Cyg

E. Pedretti[1], *J.D. Monnier*[2], *S. Lacour*[3], *W.A. Traub*[4], *W.C. Danchi* [5], *P.G. Tuthill*[6], *N.D. Thureau*[1], *R. Millan-Gabet*[7], *J.-P. Berger*[3], *M.G. Lacasse*[8], *P.A. Schuller*[9], *F.P. Schloerb*[10] *and N.P. Carleton*[8]

[1]SUPA, School of Physics and Astronomy, University of St. Andrews, UK

[2]University of Michigan, Astronomy dept., USA

[3]Laboratoire d'Astrophysique de l'Observatoire de Grenoble (LAOG), France

[4]Jet Propulsion Laboratory, California Institute of Technology, USA

[5]NASA Goddard Space Flight Center, USA

[6]School of Physics, Sydney University, Australia

[7]Michelson Science Center, California Institute of Technology, USA

[8]Harvard-Smithsonian Center for Astrophysics, USA

[9]Institut d'Astrophysique Spatiale, Université Paris-Sud, France

[10]University of Massachusetts, Astronomy Department, USA

We have detected asymmetry in the symbiotic star CH Cyg through the measurement of precision closure-phase with the IONIC beam combiner, at the IOTA interferometer. The position of the asymmetry changes with time and is correlated with the phase of the 2.1-yr period found in the radial velocity measurements for this star. We can model the time-dependent asymmetry either as the orbit of a low-mass companion around the M giant or as an asymmetric, 20% change in brightness across the M giant. We do not detect a change in the size of the star during a 3 year monitoring period neither with respect to time nor with respect to wavelength. We find a spherical dust-shell with an

emission size of 2.2 ± 0.1 D$_\star$ FWHM around the M giant star. The star to dust flux ratio is estimated to be 11.63 ± 0.3. While the most likely explanation for the 20% change in brightness is non-radial pulsation we argue that a low-mass companion in close orbit could be the physical cause of the pulsation. The combined effect of pulsation and low-mass companion could explain the behaviour revealed by the radial-velocity curves and the time-dependent asymmetry detected in the closure-phase data. If CH Cyg is a typical long secondary period variable then these variations could be explained by the effect of an orbiting low-mass companion on the primary star.

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The ^{13}C Pocket In Low Mass AGB Stars

O. Straniero[1]*, S. Cristallo*[1] *and R. Gallino*[2]

[1]INAF — Osservatorio Astronomico di Teramo, via Maggini, 64100 Teramo, Italy
[2]Università di Torino — Dip. Fisica Generale, via Giuria 1, 10100 Torino, Italy

It is well known that thermally pulsing Asymptotic Giant Branch stars with low mass play a relevant role in the chemical evolution. They have synthesized about 30% of the galactic carbon and provide an important contribution to the nucleosynthesis of heavy elements ($A > 80$). The relevant nucleosynthesis site is the He-rich intermediate zone (less than 10^{-2} M$_\odot$), where $\alpha(2\alpha,\gamma)^{12}$C reactions and slow neutron captures on seed nuclei (essentially iron) take place. A key ingredient is the interplay between nuclear processes and convective mixing. It is the partial overlap of internal and external convective zones that allows the dredge-up of the material enriched in C and heavy elements. We review the progresses made in the last 50 years in the comprehension of the s process in AGB stars, with special attention to the identification of the main neutron sources and to the particular physical conditions allowing this important nucleosynthesis.

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Asymptotic Giant Branch models at very low metallicity

S. Cristallo[1]*, L. Piersanti*[1]*, O. Straniero*[1]*, R. Gallino*[2]*, I. Domínguez* [3] *and F. Kappeler*[4]

[1]INAF — Osservatorio Astronomico di Teramo, Teramo, Italy
[2]Università di Torino — Dip. Fisica Generale, Torino, Italy
[3]Universisad de Granada — Dep.to de Física Teórica y del Cosmos, Granada, Spain
[4]Forschungszentrum Karlsruhe, Institut für Kernphysik, Karlsruhe, Germany

In this paper we present the evolution of a low mass model (initial mass $M = 1.5$ M$_\odot$) with a very low metal content ($Z = 5 \times 10^{-5}$, equivalent to [Fe/H]$= -2.44$). We find that, at the beginning of the AGB phase, protons are ingested from the envelope in the underlying convective shell generated by the first fully developed thermal pulse. This peculiar phase is followed by a deep third dredge up episode, which carries to the surface the freshly synthesized ^{13}C, ^{14}N and ^{7}Li. A standard TP-AGB evolution, then, follows. During the proton ingestion phase, a very high neutron density is attained and the s-process is efficiently activated. We therefore adopt a nuclear network of about 700 isotopes, linked by more than 1200 reactions, and we couple it with the physical evolution of the model. We discuss in detail the evolution of the surface chemical composition, starting from the proton ingestion up to the end of the TP-AGB phase.

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Planetary nebulae and the chemical evolution of the Magellanic Clouds

W.J. Maciel[1]*, R.D.D. Costa*[1] *and T.E.P. Idiart*[1]

[1]University of São Paulo, Brazil

The determination of accurate chemical abundances of planetary nebulae (PN) in different galaxies allows us to obtain important constraints of chemical evolution models for these systems. We have a long term program to derive abundances in the galaxies of the Local Group, particularly the Large and Small Magellanic Clouds. In this work, we present our new results on these objects and discuss their implications in view of recent abundance determinations the literature. In particular, we obtain distance-independent correlations involving He, N, O, Ne, S, and Ar, and compare the results with data from our own Galaxy and other galaxies in the Local Group. As a result of our observational program, we have a large database of PN in the Galaxy and the Magellanic Clouds, so that we can obtain reliable constraints to the nucleosynthesis processes in the progenitor stars in galaxies of different metallicities.

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

Scaling for the intensity of radiation in spherical and aspherical planetary nebulae

Lorenzo Zaninetti[1]

[1]Dipartimento di Fisica Generale di Torino, Italy

The image of planetary nebulae is made by three different physical processes. The first process is the expansion of the shell that can be modeled by the canonical laws of motion in the spherical case and by the momentum conservation when gradients of density are present in the interstellar medium. The second process is the diffusion of particles that radiate from the advancing layer. The 3D diffusion from a sphere as well as the 1D diffusion with drift are analyzed. The third process is the composition of the image through an integral operation along the line of sight. The developed framework is applied to A 39 , to the Ring nebula and to the etched hourglass nebula MyCn 18.

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Imaging the Cool Hypergiant NML Cygni's Dusty Circumstellar Envelope with Adaptive Optics

M.T. Schuster[1]*, M. Marengo*[1]*, J.L. Hora*[1]*, G.G. Fazio*[1]*, R.M. Humphreys*[2]*, R.D. Gehrz*[2]*, P.M. Hinz*[3]*, M.A. Kenworthy*[3] *and W.F. Hoffmann*[3]

[1]Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
[2]University of Minnesota, School of Physics and Astronomy, Minneapolis, MN 55455, USA
[3]Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

We present sub-arcsec angular resolution, high-Strehl ratio mid-IR adaptive optics images of the powerful OH/IR source and cool hypergiant NML Cyg at 8.8, 9.8 and 11.7 μm. These images reveal once more the complexity in the dusty envelope surrounding this star. We spatially resolve the physical structures (radius $\sim 0.14''$, ~ 240 AU adopting a distance of 1.74 kpc) responsible for NML Cyg's deep 10 μm silicate dust absorption feature. We also detect an asymmetric excess, at separations of $\sim 0.3''$ to $0.5''$ (~ 520 to 870 AU), NW from the star. The colors of this excess are consistent with thermal emission of hot, optically thin dust. This excess is oriented in the direction of the Cyg OB2 stellar association, and is likely due to the disruption of NML Cyg's dusty wind with the near-UV radiation flux from the massive hot stars within Cyg OB2. This interaction was predicted in our previous paper (Schuster et al. 2006), to explain the geometry of an inverted photo-dissociation region observed at optical wavelengths.

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X-ray and Infrared Observations of Two Externally-Polluted White Dwarfs

M. Jura[1], *M.P. Muno*[2], *J. Farihi*[3] *and B. Zuckerman*[1]

[1]UCLA, USA
[2]Caltech, USA
[3]Leicester, UK

With *XMM-Newton* and the *Spitzer Space Telescope*, we obtain upper bounds to the X-ray fluxes from G 29-38 and GD 362, and the 70-μm flux from G 29-38. These data provide indirect evidence that G 29-38 is accreting from a tidally disrupted asteroid: it is neither accreting large amounts of hydrogen and helium nor is its surrounding dusty disk being replenished from a reservoir of cold grains experiencing Poynting-Robertson drag. The upper bound to the X-ray flux from GD 362 is consistent with the estimated rate of mass accretion required to explain its pollution by elements heavier than helium. GD 362 also possesses 0.01 Earth masses of hydrogen, an anomalously large amount for a white dwarf with a helium-dominated atmosphere. One possibility is that before the current disk was formed, this hydrogen was accreted from either about 100 Ceres-like asteroids or one large object. An alternative scenario which simultaneously explains all of GD 362's distinctive properties is that we are witnessing the consequences of the tidal-destruction of a single parent body that had internal water and was at least as massive as Callisto and probably as massive as Mars.

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Expansion parallax of the planetary nebula IC 418

Lizette Guzmán[1], *Laurent Loinard*[1], *Yolanda Gómez*[1] *and Christophe Morisset*[2]

[1]Centro de Radioastronomía y Astrofísica, UNAM
[2]Instituto de Astronomía, UNAM, México

In this paper, we present radio continuum observations of the planetary nebula IC 418 obtained at two epochs separated by more than 20 years. These data allow us to show that the angular expansion rate of the ionization front in IC 418 is 5.8 ± 1.5 mas yr^{-1}. If the expansion velocity of the ionization front is equal to the expansion velocity of the gas along the line of sight as measured by optical spectroscopy, then the distance to IC 418 must be 1.1 ± 0.3 kpc. Recent theoretical predictions appropriate for the case of IC 418, however, suggest that the ionization front may be expanding about 20% faster than the material. Under this assumption, the distance to IC 418 would increase to 1.3 ± 0.4 kpc.

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The modulation of SiO maser polarization by Jovian planets

Helmut W. Wiesemeyer[1,2]

[1]Institut de RadioAstronomie Millimétrique, Grenoble, France
[2]Instituto de RadioAstronomía Milimétrica, Granada, Spain

Searching for planets in the atmosphere of AGB stars is difficult, due to confusion with the stellar wind and pulsations. The aim here is to provide a complementary strategy for planet searches in such a dense environment.
The polarization properties of SiO masers, especially their circular polarization, are, under certain conditions, good tracers of rapid magnetospheric events. A Jovian planet with a magnetosphere whose dipole axis is misaligned with its rotation axis naturally provides such conditions. Here I present several models showing that the polarization will be periodically modulated.
The linear and circular polarization of an SiO maser in a planetary magnetosphere is modulated by the precessing dipole

component of the latter. The effect is measurable in saturated masers, while unsaturated masers only exhibit weak changes, because of dilution effects, and because the circular polarization there stems from the Zeeman effect making it as weak as for thermal radiation. The situation would change if anisotropic pump- and loss-rates were included, which would increase the fractional linear and, via magnetorotation, the circular polarization of the modulation.
Single-dish monitoring with a dense enough time sampling and a carefully calibrated polarimeter, in combination with VLBI observations, are suited to detecting and locating a periodic modulation of the circular maser polarization due to a precessing Jovian magnetosphere. The phenomenon will be rare, because a favorable arrangement of maser and magnetosphere is needed. Otherwise the polarization may be below the detection threshold, especially if the maser is unsaturated. Though exhibiting a qualitatively similar modulation, linear polarization is likely to suffer more from confusion due to dilution of the magnetosphere within the maser cross section, even in VLBI observations.

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Direct Observation of the Extended Molecular Atmosphere of *o* Cet by Differential Spectral Imaging with an Adaptive Optics System

Hideki Takami[1], *Miwa Goto*[2], *Wolfgang Gässler*[2], *Yutaka Hayano*[1], *Masanori Iye*[3], *Yukiko Kamata*[3], *Tomio Kanzawa*[3], *Naoto Kobayashi*[4], *Yosuke Minowa*[1], *Shin Oya*[1], *Tae-Soo Pyo*[1], *David Saint-Jacques*[5], *Naruhisa Takato*[1], *Hiroshi Terada*[1], *Alan T. Tokunaga*[6] *and Takashi Tsuji*[4]

[1]Subaru Telescope, National Astronomical Observatory of Japan, Japan
[2]Max-Planck-Institut für Astronomie, Germany
[3]National Astronomical Observatory of Japan, Japan
[4]Institute of Astronomy, University of Tokyo, Japan
[5]Groupe d'astrophysique, Université de Montréal, Canada
[6]Institute for Astronomy, University of Hawaii, USA

We present new measurements of the diameter of *o* Cet (Mira) as a function of wavelength in the 2.2-μm atmospheric window using the adaptive optics system and the infrared camera and spectrograph mounted on the Subaru Telescope. We found that the angular size of the star at the wavelengths of CO and H_2O absorption lines were up to twice as large as the continuum photosphere. This size difference is attributable to the optically thick CO and H_2O molecular layers surrounding the photosphere. This measurement is the first direct differential spectroscopic imaging of stellar extension that resolves individual molecular lines with high spectral-resolution observations. This observation technique is extremely sensitive to differences in spatial profiles at different wavelengths; we show that a difference in diameter much smaller than the point spread function can be measured.

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Stellar mass-loss, rotation and the chemical enrichment of early type galaxies

Antonio Pipino[1], *Cristina Chiappini*[2], *Genevieve Graves*[3] *and Francesca Matteucci*[4]

[1]University of Southern California, USA
[2]Observatoire de Genève, Switzerland
[3]UCO/Lick Observatory, USA
[4]Università di Trieste, Italy

We present a comparison between the [Ca,C,N/Fe]-mass relations observed in local spheroids and the results of a chemical evolution model which already successfully reproduces the [Mg/Fe]-mass and the [Fe/H]-mass relations in these systems. We find that the [Ca/Fe]-mass relation is naturally explained by such a model without any additional

assumption. In particular, the observed under-abundance of Ca with respect to Mg can be attributed to the different contributions from supernovae Type Ia and supernovae Type II to the nucleosynthesis of these two elements. For C and N, we consider new stellar yields that take into account stellar mass loss and rotation. These yields have been shown to successfully reproduce the C and N abundances in Milky Way metal-poor stars. The use of these new stellar yields produces a good agreement between the chemical evolution model predictions and the integrated stellar population observations for C. In the case of N, the inclusion of fast rotators and stellar mass-loss nucleosynthesis prescriptions improves our predictions for the slope of the [N/Fe] vs. sigma relation, but a zero point discrepancy of 0.3 dex remains. This work demonstrates that current stellar yields are unable to simultaneously reproduce the large mean stellar [⟨N/Fe⟩] ratios inferred from integrated spectra of elliptical galaxies and the low N abundance measured in the gas of high redshift spheroids from absorption lines. However, it seems reasonable to suggest that there may be uncertainties in either the inferred stellar or gas-phase N abundances at the level of 0.3 dex.

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Unusual dust emission from planetary nebulae in the Magellanic Clouds

J. Bernard-Salas[1], *E. Peeters*[2,3], *G.C. Sloan*[1], *S. Gutenkunst*[1], *M. Matsuura*[4,5], *A.G.G.M. Tielens*[6], *A.A. Zijlstra*[7] *and J.R. Houck*[1]

[1]Cornell University, USA
[2]The University of Western Ontario, Canada
[3]SETI Institute, USA
[4]National Astronomical Observatory of Japan, Japan
[5]University College London, UK
[6]NASA Ames Research Center, USA
[7]Jodrell Bank Centre for Astrophysics, UK

We present a *Spitzer Space Telescope* spectroscopic study of a sample of 25 planetary nebulae in the Magellanic Clouds. The low-resolution modules are used to analyze the dust features present in the infrared spectra. This study complements a previous work by the same authors where the same sample was analyzed in terms of neon and sulfur abundances. Over half of the objects (14) show emission of polycyclic aromatic hydrocarbons, typical of carbon-rich dust environments. We compare the hydrocarbon emission in our objects to those of Galactic H II regions and planetary nebulae, and LMC/SMC H II regions. Amorphous silicates are seen in just two objects, enforcing the now well-known-fact that oxygen-rich dust is less common at low metallicities. Besides these common features, some planetary nebulae show very unusual dust. Nine objects show a strong silicon carbide feature at 11 μm and twelve of them show magnesium sulfide emission starting at 25 μm. The high percentage of spectra with silicon carbide in the Magellanic Clouds is not common. Two objects show a broad band which may be attributed to hydrogenated amorphous carbon and weak low-excitation atomic lines. It is likely that these nebulae are very young. The spectra of the remaining eight nebulae are dominated by the emission of fine-structure lines with a weak continuum due to thermal emission of dust, although in a few cases the S/N in the spectra is low, and weak dust features may not have been detected.

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New spectroscopic observations of the post-AGB Star V354 Lac = IRAS 22272+5435

V.G. Klochkova[1], *V.E. Panchuk*[1] *and N.S. Tavolganskaya*[1]

[1]Special Astrophysical Observatory, N. Arkhyz, 369167, Russia

The strongest absorption features with the lower-level excitation potentials $\chi_{\rm low} < 1$ eV are found to be split in the

high-resolution optical spectra of the post-AGB star V354 Lac taken in 2007–2008 with the 6-m telescope of the Special Astrophysical Observatory. Main parameters, $T_{\rm eff}$ = 5650 K, $\log g$ = 0.2, $\xi_{\rm t}$ = 5.0 km s^{-1}, and the abundances of 22 chemical elements in the star's atmosphere are found. The overabundance of the *s*-process chemical elements (Ba, La, Ce, Nd) in the star's atmosphere is partly due to the splitting of strong lines of the ions of these metals. The peculiarities of the spectrum in the wavelength interval containing the Li I λ 6707 Å line can be naturally explained only by taking the overabundances of the Ce II and Sm II heavy-metal ions into account. The best agreement with the synthetic spectrum is achieved assuming ε(Li I)=2.0, ε(Ce II)=3.2, and ε(Sm II)=2.7. The velocity field in whole both in the atmosphere and in the circumstellar envelope of V354 Lac remained stationary throughout the last 15 years of our observations.

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The 3D velocity structure of the planetary nebula NGC 7009

W. Steffen[1], *M. Espíndola*[2], *S. Martínez*[3] *and N. Koning*[4]

[1]Instituto de Astronomía, Universidad Autónoma de México, Ensenada, México

[2]Instituto Politécnico Nacional, México

[3]Benemérita Universidad Autónoma de Puebla, México

[4]Space Astronomy Laboratory, University of Calgary, Canada

In search for deviations from homologous expansion in planetary nebulae we present a 3D morphokinematical model of NGC 7009. The model has been constructed with Shape based on PV diagrams from the literature and HST images. We find that the data are consistent with a radial velocity field with increased gradient at high latitudes compared to the equatorial region (Model 1). In a second model we assume a linearly increasing radial velocity component with an added a poloidal component of order 10 km s^{-1} at latitudes around 70°. The true velocity field is likely to be in between these two limiting cases. We also find that the expansion of the ansae is non-radial with reference to the central star. Their velocity field is focused near the apparent exit points from the main shell. We predict the proper motion pattern for the model with a non-zero poloidal velocity component.

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Characteristics of the Galaxy according to Cepheids (& Planetary Nebulae)

Daniel J. Majaess[1,2], *David G. Turner*[1,2] *and David J. Lane*[1,2]

[1]Department of Astronomy & Physics, Saint Mary's University, Halifax, Nova Scotia, Canada

[2]The Abbey Ridge Observatory, Stillwater Lake, Nova Scotia, Canada

Classical and Type II Cepheids are used to reinvestigate specific properties of the Galaxy. A new Type II reddening-free Cepheid distance parameterization is formulated from LMC Cepheids (OGLE), with uncertainties typically no larger than 5–15%. A distance to the Galactic centre of $R_0 = 7.8 \pm 0.6$ kpc is derived from the median distance to Type II Cepheids in the bulge (OGLE), $R_0 = 7.7 \pm 0.7$ kpc from a distance to the near side of the bulge combined with an estimated bulge radius of 1.3 ± 0.3 kpc derived from planetary nebulae. The distance of the Sun from the Galactic plane inferred from classical Cepheid variables is $Z_\odot = 26 \pm 3$ pc, a result dependent on the sample's distance and direction because of the complicating effects of Gould's Belt and warping in the Galactic disk. Classical Cepheids and young open clusters delineate consistent and obvious spiral features, although their characteristics do not match conventional pictures of the Galaxy's spiral pattern. The Sagittarius-Carina arm is confirmed as a major spiral arm that appears to originate from a different Galactic region than suggested previously. Furthermore, a major feature is

observed to emanate from Cygnus-Vulpecula and may continue locally near the Sun. Significant concerns related to the effects of metallicity on the VI-based reddening-free Cepheid distance relations used here are allayed by demonstrating that the computed distances to the Galactic centre, and to several globular clusters (M 54, NGC 6441, M 15, and M 5) and galaxies (NGC 5128 and NGC 3198) which likely host Type II Cepheids: agree with literature results to within the uncertainties.

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New Magellanic Cloud R Coronae Borealis and DY Per type stars from the EROS-2 database: the connection between RCBs, DYPers and ordinary carbon stars

P. Tisserand[1,2]*, P. Wood*[1]*, J.B. Marquette*[3] *and the EROS-2 Collaboration*

[1]Research School of Astronomy and Astrophysics, ANU, Australia
[2]CEA, DSM, DAPNIA, Centre d'études de Saclay, France
[3]Institut d'Astrophysique de Paris, UMR7095 CNRS, France

R Coronae Borealis stars (RCB) are a rare type of evolved carbon-rich supergiant stars that are increasingly thought to result from the merger of two white dwarfs, called the Double degenerate scenario. This scenario is also studied as a source, at higher mass, of type Ia Supernovae (SnIa) explosions. Therefore a better understanding of RCBs composition would help to constrain simulations of such events. We searched for and studied RCB stars in the EROS Magellanic Clouds database. We also extended our research to DY Per type stars (DYPers) that are expected to be cooler RCBs ($T \sim 3500$ K) and much more numerous than their hotter counterparts. With the aim of studying possible evolutionary connections between RCBs and DYPers, and also ordinary carbon stars, we compared their publically available broad band photometry in the optical, near, and mid-infrared. The light curves of ~ 70 millions stars, monitored for 6.7 years (from July 1996 to February 2003), have been analysed to search for the main signature of RCBs and DYPers: a large (up to 9 mags) drop in luminosity. Carbon stars with fading episodes were also found by inspecting numerous light curves of objects that presented an infrared excess in the 2MASS and Spitzer- SAGE and S^{3}MC databases. Follow-up optical spectroscopy was used to confirm each photometric candidate found. We have discovered and confirmed 6 new Magellanic Cloud RCB stars and 7 new DYPers, but also listed new candidates: 3 RCBs and 14 DYPers. Optical and infrared colour magnitude diagrams that give new insights into these two sets of stars are discussed. We estimated a range of Magellanic RCB shell temperatures between 360 and 600 K. We confirm the wide range of absolute luminosity known for RCB stars, $M_V \sim -5.2$ to -2.6. Our study further shows that mid-infrared surveys are ideal to search for RCB stars, since they have thinner and cooler circumstellar shells than classical post-AGB stars. In addition, by increasing the number of known DYPers by $\sim 400\%$, we have been able to shed light on the similarities in the spectral energy distribution between DYPers and ordinary carbon stars. We also observed that DYPer circumstellar shells are fainter and hotter than those of RCBs. This suggests that DYPers may simply be ordinary carbon stars with ejection events, but more abundance analysis is necessary to give a status on a possible evolutionnary connexion between RCBs and DYPers.

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A molecular line survey of the extreme carbon star CRL 3068 at millimeter wavelengths

Yong Zhang[1]*, Sun Kwok*[1] *and Jun-ichi Nakashima*[1]

[1]Department of physics, University of Hong Kong, China

We present the results of a molecular line survey of the extreme carbon star CRL 3068. The observations were carried

out with the Arizona Radio Observatory (ARO) 12m telescope and the Heinrich Hertz Submillimeter Telescope (SMT) at the 2mm and 1.3mm atmospheric windows. The observations cover the frequency bands from 130–162 GHz and 219.5–267.5 GHz. The typical sensitivities achieved are $T_{\rm R} < 15$ mK and $T_{\rm R} < 7$ mK for the ARO 12m and SMT, respectively. Seventy two individual emission features belonging to 23 molecular species and isotopologues were detected. Only three faint lines remain unidentified. The species c-C_3H, CH_3CN, SiC_2, and the isotopologues, $C^{17}O$ and $C^{18}O$, $HC^{15}N$, $HN^{13}C$, $C^{33}S$, $C^{34}S$, ^{13}CS, ^{29}SiS, and ^{30}SiS are detected in this object for the first time. Rotational diagram analysis is carried out to determine the column densities and excitation temperatures. The isotopic ratios of the elements C, N, O, S, and Si have also been estimated. The results are consistent with stellar CNO processing and suggest that CRL 3068 is more carbon rich than IRC +10 216 and CIT 6. It is also shown that the chemical composition in CRL 3068 is somewhat different from that in IRC +10 216 with a more extensive synthesis of cyclic and long-chain molecules in CRL 3068. The results will provide valuable clues for better understanding circumstellar chemistry.

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Stellar sources of dust in the high redshift Universe

Rosa Valiante[1]*, Raffaella Schneider*[2]*, Simone Bianchi*[2] *and Anja C. Andersen*[3]

[1]Dipartimento di Astronomia, Università di Firenze, Largo Enrico fermi 2, 50125 Firenze, Italy

[2]Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, 50125 Firenze, Italy

[3]Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, DK-2100 Copenhagen, Denmark

With the aim of investigatingwhether stellar sources can account for the $> 10^8$ $M_\odot$ dust masses inferred from mm/sub-mm observations of samples of $5 < z < 6.4$ quasars, we develop a chemical evolution model which follows the evolution of metals and dust on the stellar characteristic lifetimes, taking into account dust destruction mechanisms. Using a grid of stellar dust yields as a function of the initial mass and metallicity over the range 1–40 $M_\odot$ and 0–1 $Z_\odot$, we show that the role of AGB stars in cosmic dust evolution at high redshift might have been over-looked. In particular, we find that (i) for a stellar population forming according to a present-day Larson initial mass function (IMF) with $m_{\rm ch} = 0.35$ $M_\odot$, the characteristic timescale at which AGB stars dominate dust production ranges between 150 and 500 Myr, depending both on the assumed star formation history and on the initial stellar metallicity; (ii) this result is only moderately dependent on the adopted stellar lifetimes, but it is significantly affected by variations of the IMF: for a $m_{\rm ch} = 5$ $M_\odot$, dust from AGB starts to dominate only on timescales larger than 1 Gyr and SNe are found to dominate dust evolution when mch > 10 $M_\odot$. We apply the chemical evolution model with dust to the host galaxy of the most distant quasar at $z = 6.4$, SDSS J1148+5251. Given the current uncertainties on the star formation history of the host galaxy, we have considered two models: (i) the star formation history obtained in a numerical simulation by Li et al. (2007) which predicts that a large stellar bulge is already formed at $z = 6.4$, and (ii) a constant star formation rate of 1000 $M_\odot$ yr^{-1}, as suggested by the observations if most of the FIR luminosity is due to young stars. The total mass of dust predicted at $z = 6.4$ by the first model is 2×10^8 $M_\odot$, within the range of values inferred by observations, with a substantial contribution ($\sim 80\%$) of AGB-dust. When a constant star formation rate is adopted, the contribution of AGB-dust decreases to $\sim 50\%$ but the total mass of dust formed is a factor 2 smaller. Both models predict a rapid enrichment of the ISM with metals and a relatively mild evolution of the carbon abundance, in agreement with observational constraints. This supports the idea that stellar sources can account for the dust observed but show that the contribution of AGB stars to dust production cannot be neglected, even at the most extreme redshifts currently accessible to observations.

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An ISO/SWS study of the dust composition around S stars

S. Hony[1], *A.M. Heras*[2], *F.J. Molster*[3] *and K. Smolders*[4]

[1]Service d'Astrophysique, CEA-Saclay , France

[2]Research and Scientific Support Department-ESA/ESTEC, The Netherlands

[3]NOVA, Leiden,The Netherlands

[4]Instituut voor Sterrenkunde, K.U. Leuven, Belgium

We investigate the composition of the solid-state materials in the winds around S-type AGB stars. The S stars produce dust in their wind that bears a resemblance to the dust produced in some O-rich AGB stars. However, the reported resemblance is mostly based on IRAS/LRS spectra with limited spectral resolution, sensitivity, and wavelength coverage. We investigate the dust composition around S stars using ISO/SWS data that surpass the previous studies in terms of spectral resolution and wavelength coverage. We selected the dust producing S stars in the ISO/SWS archive with enough signal to perform a detailed dust analysis, and then compare the dust spectra from the 9 sources with the O-rich AGB spectra and a subset of M super-giants. We constructed average dust emission spectra of the different categories. We report the discovery of several previously unreported dust emission features in the S star spectra. The long wavelength spectra of W Aql and π^1 Gru exhibit the "30"-μm feature attributed to MgS. Two sources exhibit a series of emission bands between 20 and 40 μm that we tentatively ascribe to Diopside. We show that the 10–20-μm spectra of the S stars are significantly different from the O-rich AGB stars. The O-rich stars exhibit a structured emission feature that is believed to arise from amorphous silicate and aluminium-oxide. The S stars lack the substructure found in the O-rich stars. Instead they show a smooth peak with a varying peak-position from source to source. We suggest that this feature is caused by a family of related material, whose exact composition determines the peak position. The observed trend mimics the laboratory trend of non-stoichiometric silicates. In this scenario the degree of non-stoichiometry is related to the Mg to SiO_4 ratio, in other words, to the amount of free O available during the dust grain growth.

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The Rise of the AGB in the Galactic Halo: Mg Isotopic Ratios and High Precision Elemental Abundances in M 71 Giants

Jorge Meléndez[1] *and Judy Cohen*[2]

[1]CAUP, Portugal

[2]Caltech, USA

High-resolution ($R \sim 100\,000$), high signal-to-noise spectra of M 71 giants have been obtained with HIRES at the Keck-I Telescope in order to measure their Mg isotopic ratios, as well as elemental abundances of C, N, O, Na, Mg, Al, Si, Ca, Ti, Ni, Zr and La. We demonstrate that M71 has two populations, the first having weak CN, normal O, Na, Mg, and Al, and a low ratio of ^{26}Mg/Mg ($\sim 4\%$) consistent with models of galactic chemical evolution with no contribution from AGB stars. The Galactic halo could have been formed from the dissolution of globular clusters prior to their intermediate mass stars reaching the AGB. The second population has enhanced Na and Al accompanied by lower O and by higher ^{26}Mg/Mg ($\sim 8\%$), consistent with models which do incorporate ejecta from AGB stars via normal stellar winds. All the M 71 giants have identical [Fe/H], [Si/Fe], [Ca/Fe], [Ti/Fe] and [Ni/Fe] to within $\sigma = 0.04$ dex (10%). We therefore infer that the timescale for formation of the first generation of stars we see today in this globular cluster must be sufficiently short to avoid a contribution from AGB stars, i.e. less than ~ 0.3 Gyr. Furthermore, the Mg isotopic ratios in the second M 71 population, combined with their elemental abundances for the light elements, demonstrate that the difference must be the result of adding in the ejecta of intermediate mass AGB stars. Finally we suggest that the low amplitude of the abundance variations of the light elements within M 71 is due to a combination of its low mass and its relatively high Fe-metallicity.

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CNONa and $^{12}C/^{13}C$ in giant stars of 10 open clusters

R. Smiljanic[1], R. Gauderon[2], P. North[2], B. Barbuy[1], C. Charbonnel[3,4] and N. Mowlavi[5]

[1]Universidade de São Paulo, Brazil

[2]Laboratoire d'astrophysique, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

[3]Geneva Observatory, University of Geneva, Switzerland

[4]LATT, CNRS, Université de Toulouse, France

[5]Observatoire de Genève, Integral Science Data Center, Switzerland

Evolved low-mass stars of a wide range of metallicity bear signatures of a non-standard mixing event in their surface abundances of Li, C, and N, and in their $^{12}C/^{13}C$ ratio. A Na overabundance has also been reported in some giants of open clusters but remains controversial. The cause of the extra-mixing has been attributed to thermohaline convection that should take place after the RGB bump for low-mass stars and on the early-AGB for more massive objects. To track the occurrence of this process over a wide mass range, we derive in a homogeneous way the abundances of C, N, O, and Na, as well as the $^{12}C/^{13}C$ ratio in a sample of 31 giants of 10 open clusters with turn-off masses from 1.7 to 3.1 $M_\odot$. A group of first ascent red giants with $M/M_\odot \leq 2.5$ exhibits lower [N/C] ratios than those measured in clump giants of the same mass range, suggesting an additional increase in the [N/C] ratio after the first dredge-up. The sodium abundances corrected from NLTE are found to be about solar. [Na/Fe] shows a slight increase of 0.10 dex as a function of stellar mass in the 1.8 to 3.2 $M_\odot$ range covered by our sample, in agreement with standard first dredge-up predictions. Our results do not support previous claims of sodium overabundances as high as +0.60 dex. An anti-correlation between $^{12}C/^{13}C$ and turn-off mass is identified and interpreted as being caused by a post-bump thermohaline mixing. Moreover, we find low $^{12}C/^{13}C$ ratios in a few intermediate-mass early-AGB stars, confirming that an extra-mixing process also operates in stars that do not experienced the RGB bump. In this case, the extra-mixing possibly acts on the early-AGB, in agreement with theoretical expectations for thermohaline mixing. [abridged]

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Search for corannulene ($C_{20}H_{10}$) in the Red Rectangle

P. Pilleri[1,2], D. Herberth[3], T.F. Giesen[3], M. Gerin[4], C. Joblin[1,2], G. Mulas[5], G. Malloci[5], J.-U. Grabow[6], S. Brünken[7], L. Surin[3], B.D. Steinberg[8], K.R. Curtis[8] and L.T. Scott[8]

[1]Université de Toulouse, UPS, CESR, 9 avenue du colonel Roche, F-31028 Toulouse cedex 9, France

[2]CNRS, UMR5187, F-31028 Toulouse, France

[3]I. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

[4]LERMA-LRA, CNRS-UMR8112, Observatoire de Paris et École Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex 05, France

[5]INAF Osservatorio Astronomico di Cagliari, Astrochemistry Group, Strada n.54, Loc. Poggio dei Pini, 09012 Capoterra (CA), Italy

[6]Gottfried-Willhelm-Leibniz-Universität, Institut für Physikalische Chemie & Elektrochemie, Lehrgebiet A, Callinstraße 3A, D-30167 Hannover, Germany

[7]Laboratoire de Chimie Physique Moléculaire (LCPM), École Polytechnique Fédérale de Lausanne (EPFL), Station 6, CH-1015 Lausanne, Switzerland

[8]Merkert Chemistry Center, Boston College, Chestnut Hill, MA 02467-3860, USA

Polycyclic Aromatic Hydrocarbons (PAHs) are widely accepted as the carriers of the Aromatic Infrared Bands (AIBs), but an unambiguous identification of any specific interstellar PAH is still missing. For polar PAHs, pure rotational transitions can be used as spectral fingerprints for identification. Combining dedicated experiments, detailed simulations and observations, we explored the mm wavelength domain to search for specific rotational transitions of corannulene ($C_{20}H_{10}$). We performed high-resolution spectroscopic measurements and a simulation of the emission spectrum of UV-excited $C_{20}H_{10}$ in the environment of the Red Rectangle, calculating its synthetic rotational spectrum. Based on these results, we conducted a first observational campaign at the IRAM 30m telescope towards this source to search for several high-J rotational transitions of $C_{20}H_{10}$. The laboratory detection of the $J = 112 \leftarrow 111$ transition of corannulene showed that no centrifugal splitting is present up to this line. Observations with the IRAM 30m telescope towards the Red Rectangle do not show any corannulene emission at any of the observed frequencies,

down to a rms noise level of $T_{\rm mb} = 8$ mK for the $J = 135 \rightarrow 134$ transition at 137.615 GHz. Comparing the noise level with the synthetic spectrum, we are able to estimate an upper limit to the fraction of carbon locked in corannulene of about 1.0×10^{-5} relative to the total abundance of carbon in PAHs. The sensitivity achieved in this work shows that radio spectroscopy can be a powerful tool to search for polar PAHs. We compare this upper limit with models for the PAH size distribution, emphasising that small PAHs are much less abundant than predicted. We show that this cannot be explained by destruction but is more likely related to the chemistry of their formation in the environment of the Red Rectangle.

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The $\Sigma - D$ Analysis of Recently Detected Radio Planetary Nebulae in the Magellanic Clouds

B. Vukotić[1], *D. Urošević*[2,4], *M.D. Filipović*[3] *and J.L. Payne*[3]

[1]Astronomical Observatory Belgrade, Volgina 7, 11160 Belgrade-74, Serbia

[2]University of Belgrade, Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia

[3]University of Western Sydney, Locked Bag 1797, Penrith South, DC, NSW 1797, Australia

[4]Isaac Newton Institute of Chile, Yugoslavia Branch, Yugoslavia

Our aim is to investigate and analyze the radio surface brightness to diameter ($\Sigma - D$) relation for recently detected, bright radio-continuum planetary nebulae (PNe) in the Magellanic Clouds (MC). We apply a Monte Carlo analysis in order to account for sensitivity selection effects on measured $\Sigma - D$ relation slopes for bright radio PNe in the MCs. In the $\Sigma - D$ plane these radio MCs PNe are positioned among the brightest of the nearby Galactic PNe, and are close to the D^{-2} sensitivity line of the MCs radio maps. The fitted Large Magellanic Cloud (LMC) data slope appears to be influenced with survey sensitivity. This suggests the MCs radio PN sample represents just the "tip of the iceberg" of the actual luminosity function. Specifically, our results imply that sensitivity selection tends to flatten the slope of the $\Sigma - D$ relation. Although MCs PNe appear to share the similar evolution properties as Galactic PNe, small number of data points prevented us to further constrain their evolution properties.

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Synthetic photometry for carbon rich giants, I. Hydrostatic dust-free models

B. Aringer[1,2,3], *L. Girardi*[2], *W. Nowotny*[1], *P. Marigo*[3] *and M.T. Lederer*[1]

[1]Department of Astronomy, University of Vienna, Türkenschanzstraße 17, A-1180 Wien, Austria, e-mail: aringer@astro.univie.ac.at

[2]Osservatorio Astronomico di Padova — INAF, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy, e-mail: leo.girardi@oapd.inaf.it

[3]Dipartimento di Astronomia, Università di Padova, Vicolo dell'Osservatorio 2, I-35122 Padova, Italy, e-mail: paola.marigo@unipd.it

We study the spectroscopic and photometric properties of carbon stars. In the first paper of this series we focus on objects that can be described by hydrostatic models neglecting dynamical phenomena like pulsation and mass loss. As a consequence, the reddening due to circumstellar dust is not included. Our results are collected in a database, which can be used in conjunction with stellar evolution and population synthesis calculations involving the AGB. We have computed a grid of 746 spherically symmetric COMARCS atmospheres covering effective temperatures between 2400 and 4000 K, surface gravities from $\log g = 0.0$ to -1.0, metallicities ranging from the solar value down to one tenth of it and C/O ratios in the interval between 1.05 and 5.0. Subsequently, we used these models to create synthetic low resolution spectra and photometric data for a large number of filter systems. The tables including the results are electronically available. We have selected some of the most commonly used colours in order to discuss their behaviour

as a function of the stellar parameters. A comparison with measured data shows that down to 2800 K the agreement between predictions and observations of carbon stars is good. Below this limit the synthetic colours are much too blue. The obvious reason for these problems is the neglect of circumstellar reddening and structural changes due to pulsation and mass loss.

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and from http://stev.oapd.inaf.it/synphot/Cstars/ (data)

A dam around the Water Fountain Nebula? The dust shell of IRAS 16342−3814 spatially resolved with VISIR/VLT

T. Verhoelst[1,2], *L.B.F.M. Waters*[1,3], *A. Verhoeff*[3], *C. Dijkstra, H. Van Winckel*[1], *J.W. Pel*[4] *and R.F. Peletier*[4]

[1]Institute of Astronomy, K.U. Leuven, Belgium
[2]University of Manchester, Jodrell Bank Centre for Astrophysics, Manchester, UK
[3]Astronomical Institute "Anton Pannekoek", University of Amsterdam, The Netherlands
[4]Kapteyn Astronomical Institute, Groningen, The Netherlands

Either by collimating a fast stellar wind or by driving a jet via accretion in the central system, dusty torii or stable disks may be crucial ingredients for the shaping of PNe. We study the dust distribution in the very young Proto-Planetary Nebule (PPN) IRAS 16342−3814, also known as the Water Fountain Nebula, which is known to show strong bipolar characteristics in the shape of two reflection lobes, and high-velocity collimated molecular outlfows. We use the new Mid-IR (MIR) instrument VISIR on the Very Large Telescope (VLT) both in imaging and spectroscopy mode at wavelengths from 8 to 13 μm. We present the first spatially resolved MIR observations of a dusty evolved star obtained with VISIR and find that the improved spatial resolution contradicts previous claims of an elliptical brightness distribution at the heart of IRAS 16342: we find the waist region to be dark even in the MIR. We show that the filling angle of the obscuring dust lane, which is made mostly of amorphous silicates, is very large, possibly even close to a spherically symmetric superwind as seen in OH/IR stars. We conclude that, in contrast to the multitude of recent dusty-disk detections in Post-AGB stars and PNe, IRAS 16342 does not show this extreme equatorial density enhancement, at least not on the scale of the dusty environment which lends the object its IR appearance. Rather, it appears that the observed precessing jets are shaping the bipolar nature in the remains of a spherically symmetric AGB superwind.

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Keck/HIRES Spectroscopy of V838 Monocerotis in October 2005

T. Kamiński[1], *M. Schmidt*[1], *R. Tylenda*[1], *M. Konacki*[1] *and M. Gromadzki*[1]

[1]N. Copernicus Astronomical Center, Toruń, Poland

V838 Mon erupted at the beginning of 2002 becoming an extremely luminous star. Among various scenarios proposed to explain the nature of the outburst the most promising is a stellar merger event. In this paper we investigate the observational properties of the star and its surroundings in the post outburst phase. We have obtained a high resolution optical spectrum of V838,Mon in October 2005 using the Keck I telescope.We have identified numerous atomic features and molecular bands present in the spectrum and provided an atlas of those features. In order to improve the spectrum interpretation we have performed simple modeling of the molecular bands. Our analysis indicates that the spectrum is dominated by molecular absorption features arising in photospheric regions with temperatures of $\sim$ 2400 K and in colder outer layers, where the temperature decreases down to $\sim$ 500 K. A number of resonance lines of neutral alkali metals are observed to show P-Cyg profiles. Particularly interesting are numerous prominent emission lines of [Fe II].

All of them show practically the same profile, which can be well described by a Lorentzian profile. In the blue part of the spectrum photospheric signatures of the B-type companion are easily seen. We have fitted the observed spectrum with a synthetic one and the obtained parameters are consistent with the B3 V type. We have also estimated radial and rotational velocities of the companion.

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An analysis of the spectrum of V838 Monocerotis in October 2005

R. Tylenda[1], *T. Kamiński*[1] *and M. Schmidt*[1]

[1]N. Copernicus Astronomical Center, Toruń, Poland

V838 Mon erupted at the beginning of 2002 becoming an extremely luminous star. Among various scenarios proposed to explain the nature of the outburst the most promising is a stellar merger event. We investigate the structure and evolution of the object in the decline from the 2002 eruption. We analyze and discuss the results of spectroscopic observations of the object obtained in October 2005 with the Keck/HIRES instrument. Modeling of the observed line profiles has been used to constrain physical parameters of the system.

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The puzzling dredge-up pattern in NGC 1978

Michael T. Lederer[1], *Thomas Lebzelter*[1], *Sergio Cristallo*[2], *Oscar Straniero*[2], *Kenneth H. Hinkle*[3] *and Bernhard Aringer*[1,4,5]

[1]University of Vienna, Department of Astronomy, Türkenschanzstraße 17, A-1180 Vienna, Austria

[2]INAF, Osservatorio Astronomico di Collurania, 64100 Teramo, Italy

[3]National Optical Astronomy Observatories, PO Box 26732, Tucson, AZ 85726, USA

[4]Osservatorio Astronomico di Padova — INAF, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy

[5]Dipartimento di Astronomia, Università di Padova, Vicolo dell'Osservatorio 2, I-35122 Padova, Italy

Low-mass stars are element factories that efficiently release their products in the final stages of their evolution by means of stellar winds. Since they are large in number, they contribute significantly to the cosmic matter cycle. To assess this contribution quantitatively, it is crucial to obtain a detailed picture of the stellar interior, particularly with regard to nucleosynthesis and mixing mechanisms. We seek to benchmark stellar evolutionary models of low-mass stars. In particular, we measure the surface abundance of ^{12}C in thermally pulsing AGB stars with well-known mass and metallicity, which can be used to infer information about the onset and efficiency of the third dredge-up. We recorded high-resolution near-infrared spectra of AGB stars in the LMC cluster NGC 1978. The sample comprised both oxygen-rich and carbon-rich stars, and is well-constrained in terms of the stellar mass, metallicity, and age. We derived the C/O and ^{12}C/^{13}C ratio from the target spectra by a comparison to synthetic spectra. Then, we compared the outcomes of stellar evolutionary models with our measurements. The M stars in NGC 1978 show values of C/O and ^{12}C/^{13}C that can best be explained with moderate extra-mixing on the RGB coupled to a moderate oxygen enhancement in the chemical composition. These oxygen-rich stars do not seem to have undergone third dredge-up episodes (yet). The C stars show carbon-to-oxygen and carbon isotopic ratios consistent with the occurrence of the third dredge-up. We did not find S stars in this cluster. None of the theoretical schemes that we considered was able to reproduce the observations appropriately. Instead, we discuss some non-standard scenarios to explain the puzzling abundance pattern in NGC 1978.

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Mass-Loss History of the AGB star, R Cas

Toshiya Ueta[1], *Robert E. Stencel*[1], *Issei Yamamura*[2], *Hideyuki Izumiura*[3], *Yoshikazu Nakada*[4,5], *Mikako Matsuura*[6], *Yoshifusa Ita*[2,6], *Toshihiko Tanabé*[4], *Hinako Fukushi*[4], *Noriyuki Matsunaga*[6], *Hiroyuki Mito*[5] *and Angela K. Speck*[7]

[1]University of Denver, USA
[2]Institute of Space and Astronautical Science, JAXA, Japan
[3]Okayama Astrophysical Observatory, NAOJ, Japan
[4]Institute of Astronomy, School of Science, University of Tokyo, Japan
[5]Kiso Observatory, Institute of Astronomy, University of Tokyo, Japan
[6]National Astronomical Observatory of Japan, Japan
[7]University of Missouri, USA

We report here on the discovery of an extended far-infrared shell around the AGB star, R Cassiopeia, made by *AKARI* and *Spitzer*. The extended, cold circumstellar shell of R Cas spans nearly 3′ and is probably shaped by interaction with the interstellar medium. This report is one of several studies of well-resolved mass-loss histories of AGB stars under *AKARI* and *Spitzer* observing programs labeled "Excavating Mass-Loss History in Extended Dust Shells of Evolved Stars (MLHES)".

Poster contribution, published in "AKARI, a light to illuminate the misty Universe"
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3-D Dynamics of Interactions between Stellar Winds and the Interstellar Medium as Seen by *AKARI* and *Spitzer*

Toshiya Ueta[1], *Hideyuki Izumiura*[2], *Issei Yamamura*[3], *Robert E. Stencel*[1], *Yoshikazu Nakada*[4,5], *Mikako Matsuura*[6], *Yoshifusa Ita*[3,6], *Toshihiko Tanabé*[4], *Hinako Fukushi*[4], *Noriyuki Matsunaga*[6], *Hiroyuki Mito*[5] *and Angela K. Speck*[7]

[1]University of Denver, USA
[2]Okayama Astrophysical Observatory, NAOJ, Japan
[3]Institute of Space and Astronautical Science, JAXA, Japan
[4]Institute of Astronomy, School of Science, University of Tokyo, Japan
[5]Kiso Observatory, Institute of Astronomy, University of Tokyo
[6]National Astronomical Observatory of Japan, Japan
[7]University of Missouri, USA

Recent far-infrared mapping of mass-losing stars by the *AKARI* Infrared Astronomy Satellite and *Spitzer Space Telescope* have suggested that far-infrared bow shock structures are probably ubiquitous around these mass-losing stars, especially when these stars have high proper motion. Higher spatial resolution data of such far-infrared bow shocks now allow detailed fitting to yield the orientation of the bow shock cone with respect to the heliocentric space motion vector of the central star, using the analytical solution for these bow shocks under the assumption of momentum conservation across a physically thin interface between the stellar winds and interstellar medium (ISM). This fitting analysis of the observed bow shock structure would enable determination of the ambient ISM flow vector, founding a new technique to probe the 3-D ISM dynamics that are local to these interacting systems. In this review, we will demonstrate this new technique for three particular cases, Betelgeuse, R Hydrae, and R Cassiopeiae.

Oral contribution, published in "AKARI, a light to illuminate the misty Universe"
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The 3D Structure of the Ring Nebula

W. Steffen[1], *J.A. Lopez*[1], *N. Koning*[2], *S. Kwok*[3], *H. Riesgo*[1], *M.G. Richer*[1] *and C. Morisset*[1]

[1]Instituto de Astronomía, UNAM, México

[2]Department of Physics and Astronomy, University of Calgary, Canada

[3]Department of Physics, University of Hong Kong, Hong Kong

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

Poster contribution, published in Asymmetrical Planetary Nebulae IV, 2007, La Palma, Canary Islands, eds. R. Corradi, A. Manchado & N. Soker
Available from http://www.iac.es/proyecto/apn4/pages/proceedings.php , http://www. astrosen.unam.mx/shape

Post-AGB stars in the AKARI survey

Natasza Siódmiak[1], *Nick Cox*[2], *Ryszard Szczerba*[1] *and Pedro García-Lario*[2]

[1]N. Copernicus Astronomical Center, Toruń, Poland

[2]Herschel Science Centre, European Space Astronomy Centre, Spain

Obscured by their circumstellar dusty envelopes post-AGB stars emit a large fraction of their energy in the infrared and thus, infrared sky surveys like IRAS were essential for discoveries of post-AGBs in the past. Now, with the AKARI infrared sky survey we can extend our knowledge about the late stages of stellar evolution. The long-term goal of our work is to define new photometric criteria to distinguish new post-AGB candidates from the AKARI data.

Poster contribution, published in "AKARI, a light to illuminate the misty Universe"
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Galactic planetary nebulae in the AKARI far-infrared surveyor bright source catalog

Nick Cox[1], *Arturo Manchado*[2,3], *Pedro García-Lario*[1] *and Ryszard Szczerba*[4]

[1]Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain

[2]Instituto d'Astrofísica de Canarias, Spain

[3]CSIC, Spain

[4]N. Copernicus Astronomical Center, Toruń, Poland

We present the results of our preliminary study of all known Galactic PNe (included in the Kerber 2003 catalog) which are detected by the AKARI/FIS All-Sky Survey as identified in the AKARI/FIS Bright Source Catalog (BSC) Version Beta-1.

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An AKARI-FIS survey of post-AGB stars and (proto) planetary nebulae: an analysis of extended emission and the spectral energy distribution.

Nick Cox[1], *Pedro García-Lario*[1], *Anibal García-Hernández*[2] *and Arturo Manchado*[2,3]

[1]Herschel Science Centre, European Space Astronomy Centre, European Space Agency, Spain

[2]Instituto d'Astrofísica de Canarias, Spain

[3]CSIC, Spain

We present first preliminary results from AKARI/FIS pointed observations of post-AGB stars and planetary nebulae (PNe). A first analysis of the radial (azimuthally averaged) profile of the observed sources shows no evidence for excess emission due to the presence of circumstellar dust. No (detached) circumstellar faint dust-shells are seen in the image maps. Also, we present here first results of aperture flux photometry at wavelengths of 65, 90, 140 and 160 μm. Results are compared with IRAS flux densities as well as the beta release of the FIS Bright Source Catalog. Finally, spectral energy distributions are given, by way of an example, for two individual targets in our sample.

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Extra-Mixing in Luminous Cool Red Giants. Hints from Evolved Stars with and without Li

R. Guandalini[1,2], *S. Palmerini*[1,2], *M. Busso*[1,2] *and S. Uttenthaler*[3]

[1]Dipartimento di Fisica, Università degli Studi di Perugia, Perugia, Italy

[2]INFN Sezione di Perugia, Perugia, Italy

[3]Instituut voor Sterrenkunde, K.U. Leuven, Leuven, Belgium

We present an analysis of Li abundances in low mass stars (LMS) during the Red Giant Branch (RGB) and Asymptotic Giant Branch (AGB) stages, based on a new determination of their luminosities and evolutionary status. By applying recently suggested models for extra-mixing, induced by magnetic buoyancy, we show that both Li-rich and Li-poor stars can be accounted for. The simplest scenario implies the development of fast instabilities on the RGB, where Li is produced. When the yields increase in strength, buoyancy slows down and Li is destroyed. ^{3}He is consumed, at variable rates. The process continues on the AGB, where however moderate mass circulation rates have little effect on Li due to the short time available. O-rich and C-rich stars show different histories of Li production/destruction, possibly indicative of different masses. More complex transport schemes are allowed by magnetic buoyancy, with larger effects on Li, but most normal LMS seem to show only the range of Li variation discussed here.

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Nucleosynthesis of light element isotopes in evolved stars experiencing extended mixing

S. Palmerini[1,2], *M. Busso*[1,2], *E. Maiorca*[1,2] *and R. Guandalini*[1,2]

[1]Dipartimento di Fisica, Università degli Studi di Perugia, Perugia, Italy

[2]INFN Sezione di Perugia, Perugia, Italy

We present computations of nucleosynthesis in red giants and asymptotic giant branch stars of Population I experiencing extended mixing. The assumed physical cause for mass transport is the buoyancy of magnetized structures,

according to recent suggestions. The peculiar property of such a mechanism is to allow for both fast and slow mixing phenomena, as required for reproducing the spread in Li abundances displayed by red giants and as discussed in an accompanying paper. We explore here the effects of this kind of mass transport on CNO and intermediate-mass nuclei and compare the results with the available evidence from evolved red giants and from the isotopic composition of presolar grains of AGB origin. It is found that a good general accord exists between predictions and measurements; in this framework we also show which type of observational data best constrains the various parameters. We conclude that magnetic buoyancy, allowing for mixing at rather diferent speeds, can be an interesting scenario to explore for explaining together the abundances of CNO nuclei and of Li.

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Theses

Spitzer survey of dust grain processing in stable discs around binary post-AGB stars

Clio Gielen[1]

[1]Instituut voor Sterrenkunde, K.U. Leuven, Belgium

In this work we present the results of a spectral survey of evolved stars, obtained with the IRS spectrograph aboard the Spitzer satellite. We selected 21 Galactic and 4 extragalactic LMC sources from a larger sample of evolved stars, believed to be part of a binary system and which are surrounded by a stable dusty disc. By combining high-spectral resolution observations with detailed models describing dust properties and disc structure, we found that the infrared spectra and the spectral energy distributions indeed confirm the suspected disc hypothesis, and allow us to constrain the disc composition and structure. All stars show features due to oxygen-rich dust species, specifically amorphous and crystalline silicates, with evidence for strong grain processing in the form of crystallinisation and grain growth. The observed dust profiles can be well modellen using irregular grains, with typical sizes above 0.1 μm. Dust temperatures derived from full-spectral fitting indicate that cool crystalline grains must be present, which could point to strong radial mixing in the disc. Two sample stars, HD 52961 and EP Lyr, have emission features due to CO_2 gas, and the latter also shows evidence for a mixed chemistry, with emission due to crystalline silicates and class-C PAHs. Detailed 2D disc modelling indicates that all the discs are well described by passively irradiated flared circumbinary discs, with a puffed-up inner rim. Submillimetre data points to the presence of extremely large grains, which will settle to the midplane, creating a vertical distributions in grain sizes. In general we found that the composition and structure of the circumbinary discs around these evolved binaries are very similar to the protoplanetary discs seen around young stellar objects. The origin and evolution of the disc is still unkown, but appears to play a significant role in the further evolution of the entire binary system, since we find evidence for a shortcut of the previous AGB evolution of our sample stars.

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An Observational Study of Post-Asymptotic Giant Branch Stars

Timur Sahin[1,2]

[1]Armagh Observatory, Northern Ireland

[2]Department of Pure and Applied Physics, The Queen's University of Belfast, Belfast, Northern Ireland

In this thesis, we present an LTE model atmosphere analyses of a group of early B-type postasymptotic giant branch (pAGB) stars. With initial masses $\lesssim$9 $M_{\odot}$, post-AGB stars form an important group of evolved stars and provide a unique opportunity to study stellar evolution almost on a human time-scale. Post-AGB stars have spectral types ranging from K to B and luminosities between 10^3 and 10^4 $L_{\odot}$. These objects ended their asymptotic giant branch (AGB) evolution phase with a period of strong mass loss (10^{-7}–10^{-4} $M_{\odot}$ yr^{-1}) and have been evolving from cooler to hotter temperatures at almost constant luminosity on a timescale of $\sim 10^4$ yr.

B-type pAGB stars span a wide range in effective temperature (10 000–30 000 K). Their expected surface gravities (log g) and effective temperatures (T_{eff}) coincide with those of B stars evolving from the main sequence. Therefore systematic observational analyses are required to to distinguish these two groups. Furthermore, post-AGB stars may be divided into four distinct groups based on their chemical composition. In this thesis, groups I and II represent post-AGB stars which are very metal deficient with C/O > 1 and metal poor with C/O < 1, when compared with the Sun, respectively. The question is whether hot pAGB stars belong to either of these four groups. Three further objectives included:

1. to discover whether post-AGB star have helium-normal or helium-rich photospheres.
2. the detection and measurement of s-process element abundances (e.g., Sr, Y, Ba, Hf).
3. to determine whether they show any anomaly in phosphorus abundance such as that seen in the extreme helium stars (EHes).

High-resolution échelle spectra of several post-AGB stars were obtained at the AAT in 1999 and 2005 in order to study chemical composition, rotation velocities and other fundamental properties. Echelle spectra present many difficulties for data reduction, including the problems of order rectification and merging. To address these problems we developed an échelle spectrum reduction package, known as TIGER. These spectra were analyzed using model atmospheres and synthetic spectra computed with the Armagh LTE stellar atmospheres software. The semiautomated spectral fitting package SFIT was used to measure the stellar surface parameters and composition.

The results show that T_{eff} of the programme stars are in the range 15 000–25 000 K and log g are in the range 2.5–3.0. In addition to being metal-poor stars, they show mostly C/O < 1. Several of our programme stars, namely HD 119608, LSS 4331, LSS 5112, and LB 3116 confirm this. The majority of hot post-AGB stars can be identified with the group II, metal-poor and C-deficient post-AGB stars. The model atmosphere parameters, LTE element abundances and estimated distance obtained here support the idea that programme stars are in true post-AGB stars.

We detected helium enrichment in the post-AGB stars Hen 3-1428 and LSS 4331. We did not detect any evidence of s-process elements, primarily because of the high T_{eff} of our targets. Our results do not show overabundance in phosphorus for any hot pAGB stars. Since we used the same atomic data and methods, we conclude that the enhancement of phosphorus previously found in some EHe stars is real.

We studied stellar wind signatures for the post-AGB star LSIV −12 111. Emission line equivalent widths for Balmer lines show changes between two different epochs. Hen 3-1428 and LSIV −12 111 show blue shifted absorption lines. A stellar wind is clearly present in both stars.

We compared variability of a group of post-AGB and a group EHe stars using archival photometry. We did not detect variability in EHe stars. We detected variability in five post-AGB stars. Large variations in HR 4049, HD 213985, and HD 52961 appear to be related to the binary period.

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Job Advert

postdoctoral position on AGB and post-AGB stars. Deadline July 1st

Applications are invited for a postdoctoral research associate position, to work with Prof. Zijlstra, within the field of mass loss and circumstellar matter of AGB and post-AGB stars. The position is for up to 36 months from October 2009, and is based at the Jodrell Bank Centre for Astrophysics of the University of Manchester. The research area of the group includes ground-based (VLT, VLTI) and space-based (Spitzer) observations, abundance analysis, and stardust. We invite aplications from people with interests in any of these areas.

The JBCA is one of the largest astrophysics groups in the UK, with 26 academic staf. We operate e-Merlin, have one of the ALMA regional support centres, and host the development office for the SKA. The stars and interstellar matter group also works with the cosmochemistry group in the school of Earth Sciences, on the topic of the origin of proto-solar dust.

More information on the JBCA can be obtained from http://www.jb.man.ac.uk/

Albert Zijlstra (a.zijlstra@manchester.ac.uk)

See also http://www.manchester.ac.uk/aboutus/jobs/research/vacancy/index.htm?ref=157281