THE AGB NEWSLETTER

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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 156$^{\rm th}$ issue of the AGB Newsletter, slightly later than normal due to holidays (and a world cup semi-final). We hope you have enjoyed the Asymmetrical Planetary Nebulae meeting in England's Lake District, and look forward to the AGB star meeting in Vienna next month.

Last month's Food for Thought, "What do planets (and debris disks) *really* do to AGB stars?", generated two reactions. One regular contributor pointed out a meeting devoted to this question, as well as similar questions: http://www.sternwarte.uni-erlangen.de/conf2010/ He summarised: "Basically, planets can enhance mass loss. The main effect might be the formation of a hot (blue) HB star." Another respondent asked a related question, which we have made this month's Food for Thought.

The next issue is planned to be distributed on the 1$^{\rm st}$ of August 2010.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What is the effect of AGB star evolution on an asteroid belt or a Kuiper belt? Are the effects observable?

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

Gamma-ray flares from red giant/jet interactions in AGN

Maxim V. Barkov[1,2], Felix A. Aharonian[1,3] and Valentí Bosch-Ramon[1]

[1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

[2]Space Research Institute, 84/32 Profsoyuznaya Street, Moscow, 117997, Russia

[3]Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, Dublin 2, Ireland

Non-blazar AGN have been recently established as a class of gamma-ray sources. M 87, a nearby representative of this class, show fast TeV variability on timescales of a few days. We suggest a scenario of flare gamma-ray emission in non-blazar AGN based on a red giant interacting with the jet at the base. We solve the hydrodynamical equations that describe the evolution of the envelope of a red giant blown by the impact of the jet. If the red giant is at least slightly tidaly disrupted by the supermassive black hole, enough stellar material will be blown by the jet, expanding quickly until a significant part of the jet is shocked. This process can render suitable conditions for energy dissipation and proton acceleration, which could explain the detected day-scale TeV flares from M 87 via proton-proton collisions. Since the produced radiation would be unbeamed, such an events should be mostly detected from non-blazar AGN. They may be frequent phenomena, detectable in the GeV–TeV range even up to distances of ~ 1 Gpc for the most powerful jets. The counterparts at lower energies are expected to be not too bright. M 87, and nearby non-blazar AGN in general, can be fast variable sources of gamma-rays through red giant/jet interactions.

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Available from arXiv:1005.5252

Cold dust in three massive evolved stars in the LMC

Martha Boyer[1], B. Sargent[1], J.Th. van Loon[2], S. Srinivasan[3], G.C. Clayton[4], F. Kemper[5], L.J. Smith[1], M. Matsuura[6,7], Paul M. Woods[5], M. Marengo[8], M. Meixner[1], C. Engelbracht[9], K.D. Gordon[1], S. Hony[10], R. Indebetouw[11], K. Misselt[9], K. Okumura[10], P. Panuzzo[10], D. Riebel[12], J. Roman-Duval[1], M. Sauvage[10] and G.C. Sloan[13]

[1]Space Telescope Science Institute, USA

[2]School of Physical and Geographical Sciences, Lennard-Jones Laboratories, Keele University, UK

[3]Institut d'Astrophysique de Paris, France

[4]Louisiana State University, Department of Physics and Astronomy, USA

[5]Jodrell Bank Centre for Astrophysics, Alan Turing Building, School of Physics and Astronomy, University of Manchester, UK

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

[7]Mullard Space Science Laboratory, University College London, UK

[8]Department of Physics and Astronomy, Iowa State University, USA

[9]Steward Observatory, University of Arizona, USA

[10]CEA, Laboratoire AIM, Irfu/SAp, France

[11]National Radio Astronomy Observatory, Department of Astronomy, University of Virginia, USA

[12]Johns Hopkins University, Department of Physics and Astronomy, USA

[13]Department of Astronomy, Cornell University, USA

Massive evolved stars can produce large amounts of dust, and far-infrared (IR) data are essential for determining the contribution of cold dust to the total dust mass. Using Herschel, we search for cold dust in three very dusty massive evolved stars in the Large Magellanic Cloud: R 71 is a Luminous Blue Variable, HD 36402 is a Wolf-Rayet triple system, and IRAS 05280−6910 is a red supergiant. We model the spectral energy distributions using radiative transfer codes and find that these three stars have mass-loss rates up to 10^{-3} $M_\odot$ yr^{-1}, suggesting that high-mass

stars are important contributors to the life-cycle of dust. We found far-IR excesses in two objects, but these excesses appear to be associated with ISM and star-forming regions. Cold dust ($T < 100$ K) may thus not be an important contributor to the dust masses of evolved stars.

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Available from arXiv:1005.5167

Three-dimensional structure of the central region of NGC 7027: A quest for trails of high-velocity jets

Jun-ichi Nakashima[1], *Sun Kwok*[1], *Yong Zhang*[1] *and Nico Koning*[2]

[1]Department of Physics, University of Hong Kong, Pokfulam Road, Hong Kong, China
[2]Department of Physics and Astronomy, University of Calgary, Calgary, Canada T2N 1N4

We report on the results of a radio interferometric observation of NGC 7027 in the CO $J = 2$–1 and ^{13}CO $J = 2$–1 lines. The results are analyzed with morpho-kinematic models developed from the software tool SHAPE. Our goal is to reveal the morpho-kinematic properties of the central region of the nebula, and to explore the nature of unseen high-velocity jets that may have created the characteristic structure of the central region consisting of molecular and ionized components. A simple ellipsoidal shell model explains the intensity distribution around the systemic velocity, but the high velocity features deviate from the ellipsoidal model. Through the SHAPE automatic reconstruction model, we found a possible trail of a jet only in one direction, but no other possible holes were created by the passage of a jet.

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Available from arXiv:1006.0662
and from http://web.hku.hk/∼junichi/paper/

The morphology of IRC +10 420's circumstellar ejecta

Chelsea Tiffany[1], *Roberta M. Humphreys* [1], *Terry J. Jones*[1] *and Kris Davidson* [1]

[1]Astronomy Deprtment, University of Minnesota, USA

Images of the circumstellar ejecta associated with the post-red supergiant IRC +10 420 show a complex ejecta with visual evidence for episodic mass loss. In this paper we describe the transverse motions of numerous knots, arcs and condensations in the inner ejecta measured from second epoch HST/WFPC2 images. When combined with the radial motions for several of the features, the total space motion and direction of the outflows show that they were ejected at different times, in different directions, and presumably from separate regions on the surface of the star. These discrete structures in the ejecta are kinematically distinct from the general expansion of the nebula and their motions are dominated by their transverse velocities. They are apparently all moving within a few degrees of the plane of the sky. We are thus viewing IRC +10 420 nearly pole-on and looking nearly directly down onto its equatorial plane. We also discuss the role of surface activity and magnetic fields on IRC +10 420's recent mass loss history.

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KP Cyg: an unusual metal-rich RR Lyr type star of long period

S.M. Andrievsky[1], *V.V. Kovtyukh*[1], *George Wallerstein*[2], *S.A. Korotin*[1] *and Wenjin Huang*[2]

[1]Department of Astronomy and Astronomical Observatory, Odessa National University, Ukraine

[2]Department of Astronomy, University of Washington, USA

We present the results of a detailed spectroscopic study of the long period ($P = 0.856$ days) RR Lyrae star, KP Cyg. We derived abundances of many chemical elements including the light species, iron-group elements and elements of the s-processes. Most RR Lyrae stars with periods longer than 0.7 days are metal-deficient objects. Surprisingly, our results show that KP Cyg is very metal rich ([Fe/H] $= +0.18 \pm 0.23$). By comparison with a number of short period ($P = 1 \sim 6$ days), metal-rich CWB stars, we suggest that KP Cyg may be a very short period CWB star (BL Her star) rather than an RR Lyrae star. As seen in some CWB stars, KP Cyg shows strong excesses of carbon and nitrogen in its atmosphere. This indicates that the surface of KP Cyg has been polluted by material that has undergone helium burning (to enhance carbon) and proton capture (to transform carbon into nitrogen). We also note that UY CrB, whose period is 0.929 days, also shows an enhancement of C and N, and that two carbon cepheids of short period, V553 Cen and RT TrA, show similar excesses of carbon and nitrogen.

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Available from arXiv:1006.0511

The discovery of the most metal-rich White Dwarf: Composition of a tidally disrupted extrasolar dwarf planet

P. Dufour[1], *M. Kilic*[2], *G. Fontaine*[1], *P. Bergeron*[1], *F.-R. Lachapelle*[1], *S.J. Kleinman*[3] *and S.K. Leggett*[3]

[1]Université de Montréal, Canada

[2]Smithsonian Astrophysical Observatory, USA

[3]Gemini Observatory, USA

Cool white dwarf stars are usually found to have an outer atmosphere that is practically pure in hydrogen or helium. However, a small fraction have traces of heavy elements that must originate from the accretion of extrinsic material, most probably circumstellar matter. Upon examining thousands of Sloan Digital Sky Survey spectra, we discovered that the helium-atmosphere white dwarf SDSS J073842.56+183509.6 shows the most severe metal pollution ever seen in the outermost layers of such stars. We present here a quantitative analysis of this exciting star by combining high S/N follow-up spectroscopic and photometric observations with model atmospheres and evolutionary models. We determine the global structural properties of our target star, as well as the abundances of the most significant pollutants in its atmosphere, i.e., H, O, Na, Mg, Si, Ca, and Fe. The relative abundances of these elements imply that the source of the accreted material has a composition similar to that of Bulk Earth. We also report the signature of a circumstellar disk revealed through a large infrared excess in JHK photometry. Combined with our inferred estimate of the mass of the accreted material, this strongly suggests that we are witnessing the remains of a tidally disrupted extrasolar body that was as large as Ceres.

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Spitzer-IRS spectral fitting of discs around binary post-AGB stars — Corrigendum

C. Gielen[1], *H. Van Winckel*[1], *M. Min*[2], *L.B.F.M. Waters*[1,3], *T. Lloyd Evans*[4], *M. Matsuura*[5], *P. Deroo*[6], *C. Dominik*[7,3], *M. Reyniers*[8] *and the SAGE-Spec team*[9]

[1]Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

[2]Astronomisch Instituut Utrecht, Universiteit Utrecht, Princetonplein 5, 3584 CC Utrecht, The Netherlands

[3]Sterrenkundig Instituut 'Anton Pannekoek', Universiteit Amsterdam, Kruislaan 403, 1098 Amsterdam, The Netherlands

[4]SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, UK

[5]UCL-Institute of Origins, Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK ; UCL-Institute of Origins, Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK

[6]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

[7]Department of Astrophysics, Radboud University Nijmegen, PO Box 9010, 6500 GL Nijmegen, The Netherlands

[8]The Royal Meteorological Institute of Belgium, Department Observations, Ringlaan 3, 1180 Brussels, Belgium

[9]http://sage.stsci.edu/team_N2.php

Recently, we have discovered an error in our Monte-Carlo spectral fitting routine, more specifically where the errors on the fluxes were rescaled to get a reduced χ^2 of 1. The rescaled errors were too big, resulting in too wide a range of good fits in our 100 step Monte-Carlo routine. This problem affects Figs. 7–9 and Tables A.1, A.2 in Gielen et al. (2008), Table 3 in Gielen et al. (2009a), and Table 4 in Gielen et al. (2009b). We corrected for this error and present the new values and errors in the tables below. The new values and errors nearly all fall within the old error range. Our best χ^2 values and overall former scientific results are not affected. With these new errors some possible new trends in the dust parameters might be observed. These will be discussed in an upcoming paper where we extend the sample presented in Gielen et al. (2008) with newly obtained *Spitzer*-IRS data.

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A hybrid steady-state magnetohydrodynamic dust-driven stellar wind model for AGB stars

Anand Thirumalai[1] *and Jeremy S. Heyl*[1]

[1]Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada, V6T 1Z1

We present calculations for a magnetised hybrid wind model for Asymptotic Giant Branch (AGB) stars. The model incorporates a canonical Weber–Davis (WD) stellar wind with dust grains in the envelope of an AGB star. The resulting hybrid picture preserves traits of both types of winds. It is seen that this combination requires that the dust-parameter ($\Gamma_{\rm d}$) be less than unity in order to achieve an outflow. The emergence of critical points in the wind changes the nature of the dust-driven outflow, simultaneously, the presence of a dust condensation radius changes the morphology of the magnetohydrodynamic (MHD) solutions for the wind. In this context, we additionally investigate the effect of having magnetic-cold spots on the equator of an AGB star and its implications for dust formation; which are seen to be consistent with previous findings.

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Automated measurements of spinel stardust from the Murray meteorite

Frank Gyngard[1], *Ernst Zinner*[1], *Larry R. Nittler*[2], *Alain Morgand*[3], *Frank J. Stadermann*[1] *and K. Mairin Hynes*[1]

[1]Laboratory for Space Sciences and Department of Physics, Washington University, USA

[2]Department of Terrestrial Magnetism, Carnegie Institution of Washington, USA

[3]Cameca, France

We report new O isotopic data on 41 presolar oxide grains, 38 $MgAl_2O_4$ (spinel) and 3 Al_2O_3 from the CM2 meteorite

Murray, identified with a recently developed automated measurement system for the NanoSIMS. We have also obtained Mg–Al isotopic results on 29 of the same grains (26 spinel and 3 Al_2O_3). The majority of the grains have O isotopic compositions typical of most presolar oxides, fall well into the four previously defined groups, and are most likely condensates from either red giant branch or asymptotic giant branch stars. We have also discovered several grains with more unusual O and Mg compositions suggesting formation in extreme astrophysical environments, such as novae and supernovae. One of these grains has massive enrichments in ^{17}O, ^{25}Mg, and ^{26}Mg, which are isotopic signatures indicative of condensation from nova ejecta. Two grains of supernova origin were also discovered: one has a large $^{18}O/^{16}O$ ratio typical of Group 4 presolar oxides; another grain is substantially enriched in ^{16}O, and also contains radiogenic ^{44}Ca from the decay of ^{44}Ti, a likely condensate from material originating in the O-rich inner zones of a Type II supernova. In addition, several Group 2 presolar spinel grains also have large ^{25}Mg and ^{26}Mg isotopic anomalies that are difficult to explain by standard nucleosynthesis in low-mass stars. Auger elemental spectral analyses were performed on the grains and qualitatively suggest that presolar spinel may not have higher-than- stoichiometric Al/Mg ratios, in contrast to SIMS results obtained here and reported previously.

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IR photometry and models of dust shells for two RCB stars

M.B. Bogdanov[1], *Olga G. Taranova*[2] *and V.I. Shenavrin*[2]

[1]Saratov State University, Astrakhanskaya st. 83, Saratov, 410012 Russia

[2]Sternberg Astronomical Institute, Universitetskii pr. 13, Moscow, 119992 Russia

We present JHKLM photometry obtained in 1984–2009 for the RCB stars UV Cas and SU Tau. No major fadings characteristic of RCB stars were detected during the observations of UV Cas, while two events of this kind occurred for SU Tau. The observed flux and color-index variations can be explained with a changing dust concentration in the line of sight, and possibly variations of the stellar temperature. We use the measured fluxes, supplemented with observations in the intermediate IR, to compute spherically symmetric dust-shell models for the stars. The mass-loss rate is estimated to be 1.7×10^{-6} $M_\odot$ yr^{-1} for UV Cas and 4.1×10^{-6} $M_\odot$ yr^{-1} for SU Tau.

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Coordinated analyses of presolar grains in the Allan Hills 77307 and Queen Elizabeth Range 99177 meteorites

Ann N. Nguyen[1], *Larry R. Nittler*[1], *Frank J. Stadermann*[2], *Rhonda M. Stroud*[3] *and Conel M. O'D. Alexander*[1]

[1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, USA

[2]Laboratory for Space Sciences and the Physics Department, Washington University, USA

[3]Naval Research Laboratory, Code 6366, USA

We report the identification of presolar silicates ($\sim$ 177 ppm), presolar oxides ($\sim$ 11 ppm), and one presolar SiO_2 grain in the ALHA 77307 chondrite. Three grains having Si isotopic compositions similar to SiC X and Z grains were also identified, though the mineral phases are unconfirmed. Similar abundances of presolar silicates ($\sim$ 152 ppm) and oxides ($\sim$ 8 ppm) were also uncovered in the primitive CR chondrite QUE 99177, along with 13 presolar SiC grains and one presolar silicon nitride. The O isotopic compositions of the presolar silicates and oxides indicate that most of the grains condensed in low-mass red giant and asymptotic giant branch stars. Interestingly, unlike presolar oxides, few presolar silicate grains have isotopic compositions pointing to low-metallicity, low-mass stars (Group 3). The ^{18}O-rich (Group 4) silicates, along with the few Group 3 silicates that were identified, likely have origins in supernova outflows. This is supported by their O and Si isotopic compositions. Elemental compositions for 74 presolar silicate grains were determined by scanning Auger spectroscopy. Most of the grains have non-stoichiometric

elemental compositions inconsistent with pyroxene or olivine, the phases commonly used to fit astronomical spectra, and have comparable Mg and Fe contents. Non-equilibrium condensation and/or secondary alteration could produce the high Fe contents. Transmission electron microscopic analysis of three silicate grains also reveals non-stoichiometric compositions, attributable to non-equilibrium or multistep condensation, and very fine-scale elemental heterogeneity, possibly due to subsequent annealing. The mineralogies of presolar silicates identified in meteorites thus far seem to differ from those in interplanetary dust particles.

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Spitzer spectroscopy of mass loss and dust production by evolved stars in globular clusters

G.C. Sloan[1], *N. Matsunaga*[2,3], *M. Matsuura*[4], *A.A. Zijlstra*[5], *K.E. Kraemer*[6], *P.R. Wood*[7], *J. Nieusma*[1,8,9], *J. Bernard-Salas*[1], *D. Devost*[10] *and J.R. Houck*[1]

[1]Cornell University, USA
[2]Kyoto University, Japan
[3]Tokyo University, Japan
[4]University College London, UK
[5]University of Manchester, UK
[6]Air Force Research Laboratory, USA
[7]Australian National University, Australia
[8]College of New Jersey, USA
[9]University of Michigan, USA
[10]Canada France Hawaii Telescope, USA

We have observed a sample of 35 long-period variables and four Cepheid variables in the vicinity of 23 Galactic globular clusters using the Infrared Spectrograph on the Spitzer Space Telescope. The long-period variables in the sample cover a range of metallicities from near solar to about $1/40^{\rm th}$ solar. The dust mass-loss rate from the stars increases with pulsation period and bolometric luminosity. Higher mass-loss rates are associated with greater contributions from silicate grains. The dust mass-loss rate also depends on metallicity. The dependence is most clear when segregating the sample by dust composition, less clear when segregating by bolometric magnitude, and absent when segregating by period. The spectra are rich in solid-state and molecular features. Emission from alumina dust is apparent across the range of metallicities. Spectra with a 13-μm dust emission feature, as well as an associated feature at 20 μm, also appear at most metallicities. Molecular features in the spectra include H_2O bands at 6.4–6.8 μm, seen in both emission and absorption, SO_2 absorption at 7.3–7.5 μm, and narrow emission bands from CO_2 from 13.5 to 16.8 μm. The star Lyngå 7 V1 has an infrared spectrum revealing it to be a carbon star, adding to the small number of carbon stars associated with Galactic globular clusters.

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and from http://isc.astro.cornell.edu/∼sloan/library/2010/globulars/

Dust grain growth in the interstellar medium of $5 < z < 6.5$ quasars

Michał J. Michałowski[1], *Eric J. Murphy*[2], *Jens Hjorth*[3], *Darach Watson*[3], *Christa Gall*[3] *and James S. Dunlop*[1,4]

[1]Scottish Universities Physics Alliance, Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, EH9 3HJ, UK
[2]Spitzer Science Center, MC 314-6, California Institute of Technology, Pasadena, CA 91125, USA
[3]Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, 2100 Copenhagen Ø, Denmark
[4]Department of Physics & Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada

We investigate whether stellar dust sources i.e. asymptotic giant branch (AGB) stars and supernovae (SNe) can

account for dust detected in $5 < z < 6.5$ quasars (QSOs). We calculate the required dust yields per AGB star and per SN using the dust masses of QSOs inferred from their millimeter emission and stellar masses approximated as the difference between the dynamical and the H_2 gas masses of these objects. We find that AGB stars are not efficient enough to form dust in the majority of the $z > 5$ QSOs, whereas SNe may be able to account for dust in some QSOs. However, they require very high dust yields even for a top-heavy initial mass function. This suggests additional non-stellar dust formation mechanism e.g. significant dust grain growth in the interstellar medium of at least three out of nine $z > 5$ QSOs. SNe (but not AGB stars) may deliver enough heavy elements to fuel this growth.

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Abell 41: shaping of a planetary nebula by a binary central star?

D. Jones[1], *M. Lloyd*[1], *M. Santander-García*[2,3,4], *J.A. López*[5], *J. Meaburn*[1], *D.L. Mitchell*[1], *T.J. O'Brien*[1], *D. Pollacco*[6], *M.M. Rubio-Díez*[7,2] *and N.M.H. Vaytet*[8]

[1]Jodrell Bank Centre for Astrophysics, University of Manchester, UK
[2]Isaac Newton Group (ING), Spain
[3]Instituto de Astrofísica de Canarias (IAC), Spain
[4]Universidad de La Laguna, Spain
[5]Universidad Nacional Autónoma de México (UNAM), México
[6]Queen's University Belfast (QUB), UK
[7]Centro de Astrobiología CSIC-INTA, Spain
[8]CEA Saclay, France

We present the first detailed spatio-kinematical analysis and modelling of the planetary nebula Abell 41, which is known to contain the well-studied close-binary system MT Ser. This object represents an important test case in the study of the evolution of planetary nebulae with binary central stars as current evolutionary theories predict that the binary plane should be aligned perpendicular to the symmetry axis of the nebula. Deep narrowband imaging in the light of [N II], [O III] and [S II], obtained using ACAM on the William Herschel Telescope, has been used to investigate the ionisation structure of Abell 41. Longslit observations of the Hα and [N II] emission were obtained using the Manchester Echelle Spectrometer on the 2.1-m San Pedro Mártir Telescope. These spectra, combined with the narrowband imagery, were used to develop a spatio-kinematical model of [N II] emission from Abell 41. The best fitting model reveals Abell 41 to have a waisted, bipolar structure with an expansion velocity of ~ 40 km s^{-1} at the waist. The symmetry axis of the model nebula is within 5 degrees of perpendicular to the orbital plane of the central binary system. This provides strong evidence that the close-binary system, MT Ser, has directly affected the shaping of its nebula, Abell 41. Although the theoretical link between bipolar planetary nebulae and binary central stars is long established, this nebula is only the second to have this link, between nebular symmetry axis and binary plane, proved observationally.

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The pulsation of AGB stars in the Magellanic Cloud clusters NGC 1978 and NGC 419

D. Kamath[1], *P.R. Wood*[1], *I. Soszyński*[2] *and T. Lebzelter*[3]

[1]Research School of Astronomy & Astrophysics, Australian National University, Weston Creek, ACT 2611, Australia
[2]Warsaw University Observatory, Aleje Ujazdowskie 4, 00-478 Warszawa, Poland
[3]Institute of Astronomy, University of Vienna, Türkenschanzstraße 17, 1180 Vienna, Austria

The intermediate-age Magellanic Cloud clusters NGC 1978 and NGC 419 are each found to contain substantial numbers

of pulsating AGB stars, both oxygen-rich and carbon-rich. Each cluster also contains two pulsating asymptotic giant branch (AGB) stars which are infrared sources with a large mass-loss rate. Pulsation masses have been derived for the AGB variables, from the lowest luminosity O-rich variables to the most evolved infrared sources. It is found that the stars in NGC 1978 have a mass of 1.55 $M_\odot$ early on the AGB while the NGC 419 stars have a mass of 1.87 $M_\odot$ early on the AGB. These masses are in good agreement with those expected from the cluster ages determined by main-sequence turnoff fitting. Nonlinear pulsation models fitted to the highly evolved AGB stars show that a substantial amount of mass loss has occurred during the AGB evolution of these stars. An examination of the observed mass loss on the AGB, and the AGB tip luminosities, shows that in both clusters the mass loss rates computed from the formula of Vassiliadis & Wood (1993) reproduce the observations reasonably well. The mass loss rates computed from the formula of Blöcker (1995) terminate the AGB in both clusters at a luminosity which is much too low.

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The Ap 2-1 nebula and the surrounding molecular cloud G 35.2−0.74: an active star forming region

Paron Sergio[1] *and Weidmann Walter*[2]

[1]Instituto de Astronomía y Física del Espacio (CONICET-UBA), CC 67, Suc. 28, 1428 Buenos Aires, Argentina
[2]Observatorio Astronómico Córdoba, Universidad Nacional de Córdoba, Argentina

Using data from large-scale surveys: 2MASS, GLIMPSE, MIPSGAL, VGPS, GRS, and IPHAS, we performed a multiwavelength study of the ISM in a region of about $20' \times 20'$ towards the molecular cloud G 35.2−0.74. Additionally, the Ap 2-1 nebula, that is seen in projection over the molecular cloud, was studied using optical data obtained with the 2.15 m telescope at CASLEO, Argentina. From the H I absorption study we estimate a distance of ~ 2 kpc for Ap 2-1 confirming that the nebula is embedded in the south portion of the molecular cloud G 35.2−0.74. Performing a photometric study and analysing the spectral energy distributions of the sources likely embedded in the cloud, we confirm that this region is very active in star formation, mainly towards the north, where we discover a cluster of young stellar objects. From the H and [N II] lines we obtain a radial velocity of $v_{\rm LSR} \sim 31$ km s^{-1} for the Ap 2-1 nebula, in coincidence with the velocity of the molecular cloud. Finally, we conclude that Ap 2-1 is an H II region probably excited by an early B-type star.

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New R Coronae Borealis stars discovered in OGLE-III Galactic Bulge fields from their mid- and near-infrared properties

P. Tisserand[1]*, Ł. Wyrzykowski*[2,3]*, P.R. Wood*[1]*, M.K. Szymański*[3]*, M. Kubiak*[3]*, G. Pietrzyński*[3,4]*, I. Soszyński*[3]*, O. Szewczyk*[3,4]*, K. Ulaczyk*[3] *and R. Poleski*[3]

[1]Research School of Astronomy and Astrophysics, Australian National University, Australia
[2]Institute of Astronomy, University of Cambridge, England
[3]Warsaw University Astronomical Observatory, Poland
[4]Universidad de Concepción, Departamento de Fisica, Chile

An R Coronae Borealis (RCB) star is a rare type of supergiant star that is increasingly thought to be the evolved merger product of two white dwarfs. Recently, many of them have been found distributed in a thin disk structure embedded inside the Galactic Bulge. This unexpected high density can give us more insight into the nature and age of RCB stars. We applied and tested successfully a new technique to find RCB stars based on the particular infrared emission. We demonstrated that RCB stars can now be found without the need of a light curve analysis, and therefore outside optically monitored fields. The selection of RCB candidates was based on their near-infrared excess and

on particular mid-infrared emission of RCB shells, using photometric data from the 2MASS and *Spitzer*/GLIMPSE surveys. The OGLE light curves of all RCB candidates were then inspected visually and the ones presenting large and fast declines were followed-up spectroscopically. We discovered two new R Coronae Borealis stars, but also propose four new candidates. We stress that all of the 7 known RCB stars located in both *Spitzer*/GLIMPSE and OGLE-III fields were re-discovered, which indicates the high efficiency of our analysis. The new technique proposed to find RCB stars has been successful. It can now be extented to larger area, specially where the instellar extinction is too high to have been monitored by microlensing surveys, i.e. the inner part of the Galactic Bulge.

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Low metallicity AGB models: H profile in the ^{13}C-pocket and the effect on the s-process

S. Bisterzo[1] *and S. Cristallo*[2,3]

[1]Dipartimento di Fisica Generale, Università di Torino, Italy
[2]Departamento de Física Teórica y del Cosmos, Universidad de Granada, Spain
[3]INAF Osservatorio Astronomico di Collurania, Teramo, Italy

The ^{13}C(a, n)^{16}O reaction is the major neutron source in low mass asymptotic giant branch (AGB) stars, where the main and the strong s process components are synthesised. After a third dredge-up (TDU) episode, ^{13}C burns radiatively in a thin pocket which forms in the top layers of the He-intershell, by proton capture on the abundant ^{12}C. Therefore, a mixing of a few protons from the H-rich envelope into the He-rich region is requested. However, the origin and the efficiency of this mixing episode are still matter of debate and, consequently, the formation of the ^{13}C-pocket represents a significant source of uncertainty affecting AGB models.We analyse the effects on the nucleosynthesis of the s-elements caused by the variation of the hydrogen profile in the region where the ^{13}C-pocket forms for an AGB model with $M = 2$ M$_\odot$ and [Fe/H] $= -2.3$. In particular, we concentrate on three isotopes (^{89}Y, ^{139}La and ^{208}Pb), chosen as representative of the three s-process peaks.

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The role of primary ^{16}O as a neutron poison in AGB stars and fluorine primary production at halo metallicities

R. Gallino[1]*, S. Bisterzo*[1]*, S. Cristallo*[2,3] *and O. Straniero*[3]

[1]Dipartimento di Fisica Generale, Università di Torino, Italy
[2]Departamento de Física Teórica y del Cosmos, Universidad de Granada, Spain
[3]INAF-Osservatorio Astronomico di Collurania, Teramo, Italy

The discovery of a historical bug in the s-post-process AGB code obtained so far by the Torino group forced us to reconsider the role of primary ^{16}O in the ^{13}C-pocket, produced by the ^{13}C(a, n)^{16}O reaction, as important neutron poison for the build up of the s-elements at Halo metallicities. The effect is noticeable only for the highest ^{13}C-pocket efficiencies (cases ST*2 and ST). For Galactic disc metallicities, the bug effect is negligible. A comparative analysis of the neutron poison effect of other primary isotopes (^{12}C, ^{22}Ne and its progenies) is presented. The effect of proton captures, by ^{14}N(n, p)^{14}C, boosts a primary production of Fluorine in Halo AGB stars, with [F/Fe] comparable to [C/Fe], without affecting the s-elements production.

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