THE AGB NEWSLETTER

An electronic publication dedicated to Asymptotic Giant Branch stars and related phenomena

Official publication of the IAU Working Group on Abundances in Red Giants

No. 167 — 1 June 2011

http://www.astro.keele.ac.uk/AGBnews

Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 167$^{\rm th}$ issue of the AGB Newsletter. As always, it is full of informative and inspiring new results.

Looking for a postdoctoral researcher position? There's one in Tenerife!

The next issue is planned to be distributed (hopefully) in early July 2011.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Is there a place for solid hydrogen in circumstellar envelopes?

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

The oxygen abundance in the Solar Neighborhood

Mónica Rodríguez[1] *and Gloria Delgado-Inglada*[1]

[1]INAOE, México

We present a homogeneous analysis of the oxygen abundance in five H II regions and eight planetary nebulae (PNe) located at distances lower than 2 kpc and with available spectra of high quality. We find that both the collisionally excited lines and recombination lines imply that the PNe are overabundant in oxygen by about 0.2 dex. An explanation that reconciles the oxygen abundances derived with collisionally excited lines for H II regions and PNe with the values found for B-stars, the Sun, and the diffuse ISM requires the presence in H II regions of an organic refractory dust component that is not present in PNe. This dust component has already been invoked to explain the depletion of oxygen in molecular clouds and in the diffuse interstellar medium.

Accepted for publication in ApJ Letters
Available from arXiv:1105.0017

The mid-infrared diameter of W Hydrae

Ronny Zhao-Geisler[1], *Andreas Quirrenbach*[1], *Rainer Köhler*[1,3], *Bruno Lopez*[2] *and Christoph Leinert*[3]

[1]Zentrum für Astronomie der Universität Heidelberg (ZAH), Landessternwarte, Königstuhl 12, D-69120 Heidelberg, Germany

[2]Laboratoire Fizeau, Observatoire de la Cote d'Azur, BP. 4229, 06304 Nice Cedex 4, France

[3]Max-Planck-Institut für Astronomie, Königstuhl 17, D-69120 Heidelberg, Germany

Mid-infrared (8–13 μm) interferometric data of W Hya were obtained with MIDI/VLTI between April 2007 and September 2009, covering nearly three pulsation cycles. The spectrally dispersed visibility data of all 75 observations were analyzed by fitting a circular fully limb-darkened disk (FDD) model to all data and individual pulsation phases. Asymmetries were studied with an elliptical FDD. Modeling results in an apparent angular FDD diameter of W Hya of about 80 ± 1.2 mas (7.8 AU) between 8 and 10 μm, which corresponds to an about 1.9 times larger diameter than the photospheric one. The diameter gradually increases up to 105 ± 1.2 mas (10.3 AU) at 12 μm. In contrast, the FDD relative flux fraction decreases from 0.85 ± 0.02 to 0.77 ± 0.02, reflecting the increased flux contribution from a fully resolved surrounding silicate dust shell. The asymmetric character of the extended structure could be confirmed. An elliptical FDD yields a position angle of 11 ± 20 deg and an axis ratio of 0.87 ± 0.07. A weak pulsation dependency is revealed with a diameter increase of 5.4 ± 1.8 mas between visual minimum and maximum, while detected cycle-to-cycle variations are smaller. W Hya's diameter shows a behavior that is very similar to the Mira stars RR Sco and S Ori and can be described by an analogous model. The constant diameter part results from a partially resolved stellar disk, including a close molecular layer of H_2O, while the increase beyond 10 μm can most likely be attributed to the contribution of a spatially resolved nearby Al_2O_3 dust shell.

Accepted for publication in A&A
Available from arXiv:1105.0082

The 43-GHz SiO maser in the circumstellar envelope of the AGB star R Cassiopeiae

K.A. Assaf[1], *P.J. Diamond*[1,2], *A.M.S Richards*[1] *and M.D. Gray*[1]

[1]JBCA, Alan Turing Building, School of Physics and Astronomy, The University of Manchester, Oxford Road, Manchester, M13 9PL, UK

[2]CSIRO Astronomy and Space Sciences, P.O. Box 76, Epping, NSW 1710, Australia

We present multi-epoch, total intensity, high-resolution images of 43-GHz, $v = 1$, $J = 1-0$ SiO maser emission toward

the Mira variable R Cas. In total we have 23 epochs of data for R Cas at approximate monthly intervals over an optical pulsation phase range from 0.158 to 1.78. These maps show a ring-like distribution of the maser features in a shell, which is assumed to be centred on the star at a radius of 1.6 to 2.3 times the stellar radii. It is clear from these images that the maser emission is significantly extended around the star. At some epochs a faint outer arc can be seen at 2.2 stellar radii. The intensity of the emission waxes and wanes during the stellar phase. Some maser features are seen infalling as well as outflowing. We have made initial comparisons of our data with models by Gray et al. (2009).

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from arXiv:1105.1089

Solar-like oscillations from the depths of the red-giant star KIC 4351319 observed with *Kepler*

M.P. Di Mauro[1], *D. Cardini*[1], *G. Catanzaro*[2], *R. Ventura*[2], *C. Barban*[3], *T. R. Bedding*[4], *J. Christensen-Dalsgaard*[5], *J. De Ridder*[6], *S. Hekker*[7,8], *D. Huber*[4], *T. Kallinger*[9,10], *A. Miglio*[11], *J. Montalban*[11], *B. Mosser*[3], *D. Stello*[4], *K. Uytterhoeven*[12,13], *K. Kinemuchi*[14], *H. Kjeldsen*[5], *F. Mullally*[15] *and M. Still*[14]

[1]INAF – IASF, Istituto di Astrofisica Spaziale e Fisica Cosmica, Via del Fosso del Cavaliere 100, 00133 Roma, Italy
[2]INAF – Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95123 Catania, Italy
[3]LESIA, CNRS, Université Pierre et Marie Curie, Université Denis, Diderot, Observatoire de Paris, 92195 Meudon Cedex, France
[4]Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney , NSW 2006, Australia
[5]Institut for Fysik og Astronomi, Bygn. 1520, Århus Universitet, Ny Munkegade, DK-8000 Århus C, Denmark
[6]Instituut voor Sterrenkunde, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[7]School of Physics and Astronomy, University of Birmingham, Birmingham B 15 2TT, UK
[8]Astronomical Institute 'Anton Pannekoek', University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands
[9]Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada
[10]Institute of Astronomy, University of Vienna, 1180 Vienna, Austria
[11]Institut d'Astrophysique et de Géofisique de l'Université de Liège, Allée du 6 Août 17-B 4000 Liège, Belgium
[12]Laboratoire AIM, CEA/DSM-CNRS-Université Paris Diderot; CEA, IRFU, SAp, Centre de Saclay, 91191, Gif-sur-Yvette, France
[13]Kiepenheuer-Institut für Sonnenphysik, Schöneckstraße 6, 79104 Freiburg im Breisgau, Germany
[14]Bay Area Environmental Research Inst./NASA Ames Research Center, Moffett Field, CA 94035, USA
[15]SETI Institute/NASA Ames Research Center, Moffett Field, CA 94035, USA

We present the results of the asteroseismic analysis of the red-giant star KIC 4351319 (TYC 3124-914-1), observed for 30 days in short-cadence mode with the *Kepler* satellite. The analysis has allowed us to determine the large and small frequency separations, $\Delta\nu_0 = 24.6 \pm 0.2$ μHz and $\delta\nu_{02} = 2.2 \pm 0.3$ μHz respectively, and the frequency of maximum oscillation power, $\nu_{\max} = 386.5 \pm 4.0$ μHz.
The high signal-to-noise ratio of the observations allowed us to identify 25 independent pulsation modes whose frequencies range approximately from 300 to 500 μHz.
The observed oscillation frequencies together with the accurate determination of the atmospheric parameters (effective temperature, gravity and metallicity), provided by additional ground-based spectroscopic observations, enabled us to theoretically interpret the observed oscillation spectrum.
KIC 4351319 appears to oscillate with a well defined solar-type p-modes pattern due to radial acoustic modes and non-radial nearly pure p modes. In addition, several non-radial mixed modes have been identified.
Theoretical models well reproduce the observed oscillation frequencies and indicate that this star, located at the base of the ascending red-giant branch, is in the hydrogen-shell burning phase, with a mass of $\sim 1.3 M_\odot$, a radius of ~ 3.4 $R_\odot$ and an age of ~ 5.6 Gyr. The main parameters of this star have been determined with an unprecedent level of precision for a red-giant star, with uncertainties of 2% for mass, 7% for age, 1% for radius, and 4% for luminosity.

Accepted for publication in MNRAS
Available from arXiv:1105.1076

Possible implications of the planet orbiting the red horizontal branch star HIP 13044

Ealeal Bear[1], *Noam Soker*[1] *and Amos Harpaz*[1]

[1]Technion, Israel

We propose a scenario to account for the surprising orbital properties of the planet orbiting the metal poor red horizontal branch star HIP 13044. The orbital period of 16.2 days implies that the planet went through a common envelope phase inside the red giant branch (RGB) stellar progenitor of HIP 13044. The present properties of the star imply that the star maintained a substantial envelope mass of 0.3 $M_{\odot}$, raising the question of how the planet survived the common envelope before the envelope itself was lost? If such a planet enters the envelope of an RGB star, it is expected to spiral-in to the very inner region within < 100 yr, and be evaporated or destructed by the core. We speculate that the planet was engulfed by the star as a result of the core helium flash that caused this metal poor star to swell by a factor of ~ 3–4. The evolution following the core helium flash is very rapid, and some of the envelope is lost due to the interaction with the planet, and the rest of the envelope shrinks within about a hundred years. This is about equal to the spiraling-in time, and the planet survived.

Accepted for publication in ApJ Letters
Available from arXiv:1104.4545

A new planetary nebula in the outer reaches of the Galaxy

K. Viironen[1,2,3], *A. Mampaso*[1,4], *R.L.M. Corradi*[1,4], *J.E. Drew*[5], *D.J. Frew*[6], *C. Giammanco*[1,4], *R. Greimel*[7], *T. Liimets*[8,9], *J.E. Lindberg*[8,10], *M. Rodríguez*[11], *L. Sabin*[12], *S.E. Sale*[13,5,14,15], *P.A. Wilson*[8,16] *and A.A. Zijlstra*[17]

[1]Instituto de Astrofísica de Canarias (IAC), C/Vía Láctea s/n, 38200 La Laguna, Tenerife, Spain
[2]Centro Astronómico Hispano Alemán, Calar Alto, C/Jesús Durbán Remón 2-2, E-04004 Almeria, Spain
[3]Centro de Estudios de Física del Cosmos de Aragón (CEFCA), C/General Pizarro 1-1, E-44001 Teruel, Spain
[4]Departamento de Astrofísica, Universidad de La Laguna, Av. Astrofísico Francisco Sánchez, s/n, 38206 La Laguna, Spain
[5]Centre for Astrophysics Research, University of Hertfordshire, College Lane, Hatfield AL10 9AB, UK
[6]Department of Physics and Astronomy, Macquarie University, North Ryde, NSW 2109, Australia
[7]Institut für Physik, Karl-Franzens Universität Graz, Universitätsplatz 5,8010 Graz, Austria
[8]Nordic Optical Telescope, Ap. 474, E-38700, S/C de La Palma, S/C de Tenerife, Spain
[9]Tartu Observatory, Tõravere, 61602, Estonia
[10]Centre for Star and Planet Formation, Natural History Museum of Denmark, University of Copenhagen, Øster Voldgade 5–7, DK-1350 Copenhagen, Denmark
[11]Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), Apdo. Postal 51 y 216, 72000 Puebla, México
[12]Instituto de Astronomía UNAM, Km. 103 Carretera Tijuana–Ensenada, C.P. 22860, Ensenada, Baja California, México
[13]Imperial College London, Blackett Laboratory, Prince Consort Road, London SW7 2AZ, UK
[14]Departamento de Física y Astronomía, Facultad de Ciencias, Universidad de Valparaíso, Ave. Gran Bretaña 1111, Playa Ancha, Casilla 53, Valparaíso, Chile
[15]Departamento de Astronomía y Astrofísica, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, Casilla 306, Santiago 22, Chile
[16]Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, N-0315 Oslo, Norway
[17]Jodrell Bank Centre for Astrophysics, Alan Turing Building, University of Manchester, Manchester, M13 9PL, UK

A proper determination of the abundance gradient in the Milky Way requires the observation of objects at large galactiocentric distances. With this aim, we are exploring the planetary nebula population towards the Galactic Anticentre. In this article, the discovery and physico-chemical study of a new planetary nebula towards the Anticentre direction, IPHASX J052531.19+281945.1 (PNG 178.1−04.0), is presented.
The planetary nebula was discovered from the IPHAS survey. Long-slit follow-up spectroscopy was carried out to confirm its planetary nebula nature and to calculate its physical and chemical characteristics.
The newly discovered planetary nebula turned out to be located at a very large galactocentric distance ($D_{\rm GC} = 20.8 \pm 3.8$ kpc), larger than any previously known planetary nebula with measured abundances. Its relatively high

oxygen abundance ($12 + \log(\mathrm{O/H}) = 8.36 \pm 0.03$) supports a flattening of the Galactic abundance gradient at large galactocentric distances rather than a linearly decreasing gradient.

Accepted for publication in A&A
Available from arXiv:1105.0157

The evolutionary state of Miras with changing pulsation periods

Stefan Uttenthaler[1,2], Koen Van Stiphout[1,3], Kevin Voet[1], Hans Van Winckel[1], Sophie Van Eck[4], Alain Jorissen[4], Franz Kerschbaum[2], Gert Raskin[1], Saskia Prins[1], Wim Pessemier[1], Christoffel Waelkens[1], Yves Frémat[5], Herman Hensberge[5], Louis Dumortier[5] and Holger Lehmann[6]

[1]Instituut voor Sterrenkunde, University of Leuven, Belgium
[2]University of Vienna, Department of Astronomy, Austria
[3]Instituut voor Kern- en Stralingsfysica, University of Leuven, Belgium
[4]Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Belgium
[5]Royal Observatory of Belgium, Brussels, Belgium
[6]Thüringer Landessternwarte Tautenburg, Tautenburg, Germany

Context: Miras are long-period variables thought to be in the asymptotic giant branch (AGB) phase of evolution. In about one percent of known Miras, the pulsation period is changing. It has been speculated that this changing period is the consequence of a recent thermal pulse in these stars. Aims: We aim to clarify the evolutionary state of these stars, and to determine in particular whether or not they are in the thermally-pulsing (TP-)AGB phase.
Methods: One important piece of information that has been neglected so far when determining the evolutionary state is the presence of the radio-active s-process element technetium (Tc). We obtained high-resolution, high signal-to-noise-ratio optical spectra of a dozen prominent Mira variables with changing pulsation period to search for this indicator of TPs and dredge-up. We also use the spectra to measure lithium (Li) abundances. Furthermore, we establish the evolutionary states of our sample stars by means of their present-day periods and luminosities.
Results: Among the twelve sample stars observed in this programme, five were found to show absorption lines of Tc. BH Cru is found to be a carbon-star, its period increase in the past decades possibly having stopped by now. We report a possible switch in the pulsation mode of T UMi from Mira-like to semi-regular variability in the past two years. R Nor, on the other hand, is probably a fairly massive AGB star, which could be true for all meandering Miras. Finally, we assign RU Vul to the metal-poor thick disk with properties very similar to the short-period, metal-poor Miras.
Conclusions: We conclude that there is no clear correlation between period change class and Tc presence. The stars that are most likely to have experienced a recent TP are BH Cru and R Hya, although their rates of period change are quite different.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1105.2198

An envelope disrupted by a quadrupolar outflow in the pre-planetary nebula IRAS 19475+3119

Ming-Chien Hsu[1,2] and Chin-Fei Lee[1]

[1]Academia Sinica Institute of Astronomy and Astrophysics, Taiwan
[2]Department of Physics, National Taiwan University, Taiwan

IRAS 19475+3119 is a quadrupolar pre-planetary nebula (PPN), with two bipolar lobes, one in the East–West (E–W) direction and one in the SouthEast–NorthWest (SE–NW) direction. We have observed it in CO $J = 2 - 1$ with the Sub-millimeter Array at $\sim 1''$ resolution. The E–W bipolar lobe is known to trace a bipolar outflow and it is detected

at high velocity. The SE–NW bipolar lobe appears at low velocity, and could trace a bipolar outflow moving in the plane of the sky. Two compact clumps are seen at low velocity around the common waist of the two bipolar lobes, spatially coincident with the two emission peaks in the NIR, tracing dense envelope material. They are found to trace the two limb-brightened edges of a slowly expanding torus-like circumstellar envelope produced in the late AGB phase. This torus-like envelope originally could be either a torus or a spherical shell, and it appears as it is now because of the two pairs of cavities along the two bipolar lobes. Thus, the envelope appears to be disrupted by the two bipolar outflows in the PPN phase.

Accepted for publication in ApJ
Available from arXiv:1105.2410

Chemical signature indicating a lack of massive stars in dwarf galaxies

Takuji Tsujimoto[1]

[1]National Astronomical Observatory of Japan, Japan

Growing evidence supports an unusual elemental feature appearing in nearby dwarf galaxies, especially dwarf spheroidals (dSphs), indicating a key process of galaxy evolution that is different from that of the Galaxy. In addition to the well-known deficiency of α-elements in dSphs, recent observations have clearly shown that s-process elements (Ba) are significantly enhanced relative to Fe, α-, and r-process elements. This enhancement occurs in some dSphs as well as in the Large Magellanic Cloud, but is unseen in the Galaxy. Here we report that this feature is evidence of the lack of very massive stars (> 25 $M_\odot$) as predicted in the low star formation rate environment, and we conclude that the unique elemental feature of dwarf galaxies including a low-α/Fe ratio in some low-metallicity stars is, at least in some part, characterized by a different form of the initial mass function. We present a detailed model for the Fornax dSph galaxy and discuss its complex chemical enrichment history together with the nucleosynthesis site of the light s-process element Y.

Accepted for publication in ApJ
Available from arXiv:1105.3218

X-ray and UV emission from the recurrent nova RS Ophiuchi in quiescence: Signatures of accretion and shocked gas

Thomas Nelson[1,2], *Koji Mukai*[1,3], *Marina Orio*[4,5], *Gerardo Juan Manuel Luna*[6,7] *and Jennifer Sokoloski*[8]

[1]NASA/GSFC, USA
[2]now at University of Minnesota, USA
[3]University of Maryland, Baltimore County, USA
[4]INAF Padova, Italy
[5]University of Wisconsin, Madison, USA
[6]Center for Astrophysics, Harvard University, USA
[7]now at ICATE, Argentina
[8]Columbia University, USA

RS Ophiuchi is a recurrent nova system that experiences outbursts every ~ 20 years, implying accretion at a high rate onto a massive white dwarf. However, previous X-ray observations of the system in quiescence have detected only faint emission that is difficult to reconcile with the high accretion rate predicted by nova theory for such frequent outbursts. Here, we use new *Chandra* and XMM-*Newton* observations obtained 537 and 744 days after the 2006 outburst to constrain both the accretion rate onto the white dwarf and the properties of the nova ejecta at these times. We detect low level UV variability with the XMM-*Newton* Optical Monitor on day 744 that is consistent with accretion disk

flickering, and use this to place a lower limit on the accretion rate. The X-ray spectra in both observations are well described by a two component thermal plasma model. The first component originates in the nova shell, which can emit X-rays for up to a decade after the outburst. The other component likely arises in the accretion disk boundary layer, and can be equally well fit by a single temperature plasma or a cooling flow model. Although the flux of the single temperature model implies an accretion rate that is 40 times lower than theoretical predictions for RS Oph, the best fit cooling flow model implies $\dot{M} < 1.2 \times 10^{-8}$ $M_\odot$ yr^{-1} 537 days after the outburst, which is within a factor of 2 of the theoretical accretion rate required to power an outburst every 20 years. Furthermore, we place an upper limit on the accretion rate through an optically thick region of the boundary layer of 2.0×10^{-8} $M_\odot$ yr^{-1}. Thus, the X-ray emission in quiescence is consistent with the accretion rate expectations of nova theory. Finally, we discuss the possible origins of the low temperature associated with the accretion component, which is a factor of 10 lower than in T CrB, an otherwise similar recurrent nova.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1105.2569

Interstellar solid hydrogen

Ching Yeh Lin[1], *Andrew Gilbert*[1] *and Mark Walker*[2]

[1]Research School of Chemistry, Australian National University, Australia
[2]Manly Astrophysics, Australia

We consider the possibility that solid molecular hydrogen is present in interstellar space. If so cosmic-rays and energetic photons cause ionisation in the solid leading to the formation of H_6^+. This ion is not produced by gas-phase reactions and its radiative transitions therefore provide a signature of solid H_2 in the astrophysical context. The vibrational transitions of H_6^+ are yet to be observed in the laboratory, but we have characterised them in a quantum-theoretical treatment of the molecule; our calculations include anharmonic corrections, which are large. Here we report on those calculations and compare our results with astronomical data. In addition to the H_6^+ isotopomer, we focus on the deuterated species $(HD)_3^+$ which is expected to dominate at low ionisation rates as a result of isotopic condensation reactions. We can reliably predict the frequencies of the fundamental bands for five modes of vibration. For $(HD)_3^+$ all of these are found to lie close to some of the strongest of the pervasive mid-infrared astronomical emission bands, making it difficult to exclude hydrogen precipitates on observational grounds. By the same token these results suggest that $(HD)_3^+$ could be the carrier of the observed bands. We consider this possibility within the broader picture of ISM photo-processes and we conclude that solid hydrogen may indeed be abundant in astrophysical environments.

Accepted for publication in ApJ
Available from arXiv:1105.1861

The expansion proper motions of the planetary nebula NGC 6302 from *HST* imaging

C. Szyszka[1], *A.A. Zijlstra*[1] *and J.R. Walsh*[2]

[1]School of Physics & Astronomy, University of Manchester, Manchester M13 9PL, UK
[2]European Southern Observatory, Karl-Schwarzschild Straße 2, D85748 Garching, Germany

Planetary nebulae expand on time scales of 10^3–10^4 yr. For nearby objects, their expansion can be detected within years to decades. The pattern of expansion probes the internal velocity field and provides clues to the nebula ejection mechanism. In the case of non-symmetric nebulae, and bipolar nebulae in particular, it can also provide information on the development of the morphology. We have measured the expansion proper motions in NGC 6302 from two

epochs of *HST* imaging, separated by 9.43 years. This is used to determine the expansion age and the structure of the velocity field. We use *HST* images in the [N II] 6583Å filter from *HST* WF/PC2 and WFC3. The proper motions were obtained for a set of 200 individual tiles within 90″ of the central star. The velocity field shows a characteristic linear increase of velocity with radial distance (a so-called *Hubble* flow). It agrees well with a previous determination by Meaburn et al. (2008), made in a lobe further from the star, which was based on a much longer time span, but ground-based imaging. The pattern of proper motion vectors is mostly radial and the origin is close to the position of the central star directly detected by Szyszka et al. (2009). The results show that the lobes of NGC 6302 were ejected during a brief event 2250 ± 35 yr ago. In the inner regions there is evidence for a subsequent acceleration of the gas by an additional 9.2 km s^{-1}, possibly related to the onset of ionization. The dense and massive molecular torus was ejected over 5000 yr, ending about 2900 yr ago. The lobes were ejected after a short interlude (the 'jet lag') of ~ 600 yr during a brief event. The torus and lobes originate from separate mass-loss events with different physical processes. The delay between the cessation of equatorial mass loss and the ejection of the lobes provides an important constraint for explaining the final mass-loss stages of the progenitor stellar system.

Accepted for publication in MNRAS
Available from arXiv:1105.3381

Modelling the warm H_2 infrared emission of the Helix nebula cometary knots

Isabel Aleman[1,2], *Albert A. Zijlstra*[1], *Mikako Matsuura*[3,4], *Ruth Gruenwald*[2] *and Rafael K. Kimura*[2]

[1]Jodrell Bank Centre for Astrophysics, The Alan Turing Building, School of Physics and Astronomy, The University of Manchester, Oxford Rd., Manchester, M13 9PL, UK

[2]IAG-USP, Universidade de São Paulo, Cidade Universitária, Rua do Matão 1226, São Paulo, SP, 05508-090, Brazil

[3]Institute of Origins, Astrophysics Group, Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, UK

[4]Institute of Origins, Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK

Molecular hydrogen emission is commonly observed in planetary nebulae. Images taken in infrared H_2 emission lines show that at least part of the molecular emission is produced inside the ionised region. In the best-studied case, the Helix nebula, the H_2 emission is produced inside cometary knots (CKs), comet-shaped structures believed to be clumps of dense neutral gas embedded within the ionised gas. Most of the H_2 emission of the CKs seems to be produced in a thin layer between the ionised diffuse gas and the neutral material of the knot, in a mini photodissociation region (PDR). However, PDR models published so far cannot fully explain all the characteristics of the H_2 emission of the CKs. In this work, we use the photoionisation code AANGABA to study the H_2 emission of the CKs, particularly that produced in the interface H^+/H^0 of the knot, where a significant fraction of the H_2 $1-0$ S(1) emission seems to be produced. Our results show that the production of molecular hydrogen in such a region may explain several characteristics of the observed emission, particularly the high excitation temperature of the H_2 infrared lines. We find that the temperature derived from H_2 observations even of a single knot, will depend very strongly on the observed transitions, with much higher temperatures derived from excited levels. We also proposed that the separation between the Hα and [N II] peak emission observed in the images of CKs may be an effect of the distance of the knot from the star, since for knots farther from the central star the [N II] line is produced closer to the border of the CK than Hα.

Accepted for publication in MNRAS
Available from arXiv:1105.3506

Planetary nebulae in the elliptical galaxy NGC 4649 (M 60): kinematics and distance redetermination

A.M. Teodorescu[1], *R.H. Méndez*[1], *F. Bernardi*[2], *J. Thomas*[3], *P. Das*[3] *and O. Gerhard*[3]

[1]Institute for Astronomy, Univ. of Hawaii, 2680 Woodlawn Drive, Honolulu, Hawaii, USA

[2]Universita di Pisa, Largo B. Pontecorvo 5, 56127, Pisa, Italy

[3]Max Planck Institut für Extraterrestrische Physik, P.O. Box 1603, D-85740 Garching bei München, Germany

Using a slitless spectroscopy method with (a) the 8.2-m Subaru telescope and its FOCAS Cassegrain spectrograph, and (b) the ESO Very Large Telescope (VLT) unit 1 (Antu) and its FORS2 Cassegrain spectrograph, we have detected 326 planetary nebulae (PNs) in the giant Virgo elliptical galaxy NGC 4649 (M 60), and we have measured their radial velocities. After rejecting some PNs more likely to belong to the companion galaxy NGC 4647, we have built a catalog with kinematic information for 298 PNs in M 60. Using these radial velocities we have concluded that they support the presence of a dark matter halo around M 60. Based on an isotropic, two-component Hernquist model, we estimate the dark matter halo mass within 3 R_e to be 4×10^{11} $M_\odot$, which is almost one half of the total mass of about 10^{12} $M_\odot$ within 3 R_e. This total mass is similar to that estimated from globular cluster, XMM-*Newton* and *Chandra* observations. The dark matter becomes dominant outside. More detailed dynamical modeling of the PN data is being published in a companion paper. We have also measured the $m(5007)$ magnitudes of many of these PNs, and built a statistically complete sample of 218 PNs. The resulting PN luminosity function (PNLF) was used to estimate a distance modulus of 30.7 ± 0.2 mag, equivalent to 14 ± 1 Mpc. This confirms an earlier PNLF distance measurement, based on a much smaller sample. The PNLF distance modulus remains smaller than the surface brightness fluctuation (SBF) distance modulus by 0.4 mag.

Accepted for publication in Astrophysical Journal
Available from arXiv:1105.1209

The correlation between C/O ratio, metallicity and the initial WD mass for SNe Ia

Xiangcun Meng [1] *and Wuming Yang*[1]

[1]School of Physics and Chemistry, Henan Polytechnic, China

When type Ia supernovae (SNe Ia) were chosen as distance indicator to measure cosmological parameters, *Phillips* relation was applied. However, the origin of the scatter of the maximum luminosity of SNe Ia (or the variation of the production of ^{56}Ni) is still unclear. The metallicity and the carbon abundance of white dwarf (WD) before supernova explosion are possible key, but neither of them has an ability to interpret the scatter of the maximum luminosity of SNe Ia. In this paper, we want to check whether or not the carbon abundance can be affected by initial metallicity. We calculated a series of stellar evolution. We found that when $Z \leq 0.02$, the carbon abundance is almost independent of metallicity if it is plotted against the initial WD mass. However, when $Z > 0.02$, the carbon abundance is not only a function of the initial WD mass, but also metallicity, i.e. for a given initial WD mass, the higher the metallicity, the lower the carbon abundance. Based on some previous studies, i.e. both a high metallicity and a low carbon abundance lead to a lower production of ^{56}Ni formed during SN Ia explosion, the effects of the carbon abundance and the metallicity on the amount of ^{56}Ni are enhanced by each other, which may account for the variation of maximum luminosity of SNe Ia, at least qualitatively. Considering that the central density of WD before supernova explosion may also play a role on the production of ^{56}Ni and the carbon abundance, the metallicity and the central density are all determined by the initial parameters of progenitor system, i.e. the initial WD mass, metallicity, orbital period and secondary mass, the amount of ^{56}Ni might be a function of the initial parameters. Then, our results might construct a bridge linking the progenitor model and the explosion model of SNe Ia.

Accepted for publication in A&A
Available from arXiv:1105.2860

High-resolution spectroscopic observations of the metal-poor, chemically peculiar and high velocity Fehrenbach & Duflot star

N.A. Drake[1] *and C.B. Pereira*[2]

[1]Sobolev Astronomical Institute, St. Petersburg State University Universitetski pr. 28, St. Petersburg 198504, Russia

[2]Observatório Nacional, Rua José Cristino, 77, CEP 20921-400, São Cristóvão, Rio de Janeiro-RJ., Brazil

We determine the atmospheric parameters and abundance pattern of the chemically peculiar metal-poor Feh–Duf star to more clearly understand its evolutionary state and the nature of the s-element enhancement in this star. We used high resolution optical spectroscopy and determined atmospheric parameters and abundances were determined for the local-thermodynamic-equilibrium model atmospheres of Kurucz using the spectral analysis code MOOG. The derived abundances shows that the Feh–Duf star is a low-metallicity ([Fe/H] = -1.93) star with high carbon and heavy s-element abundances, while the abundance of the light s-process element yttrium is low ([Y/Fe] = -0.07). The oxygen abundance is lower than for Galactic halo stars of similar metallicity. We conclude that the Feh–Duf star could be a CH star with C/O = 1.3. Another possibility is that the Fehrenbach & Duflot star could be an early-AGB star. The Fehrenbach & Duflot star is also a lead star with [Pb/Ce] = +0.69. In addition, it displays an extreme retrograde motion ($v_{\rm GRF} = -259$ km s^{-1}) which in combination with its underabundance of α-elements suggests that this star may have been captured by the Milky Way galaxy.

Accepted for publication in Astronomy & Astrophysics

Computing the dust distribution in the bowshock of a fast moving, evolved star

Allard Jan van Marle[1], *Zakaria Meliani*[1], *Rony Keppens*[1] *and Leen Decin*[2]

[1]Centre for Plasma Astrophysics, K.U. Leuven, Belgium

[2]Institute of Astronomy, K.U. Leuven, Belgium

We study the hydrodynamical behavior occurring in the turbulent interaction zone of a fast moving red supergiant star, where the circumstellar en interstellar material collide.

In this wind–interstellar medium collision, the familiar bow shock, contact discontinuity, and wind termination shock morphology forms, with localized instability development.

Our model includes a detailed treatment of dust grains in the stellar wind, and takes into account the drag forces between dust and gas. The dust is treated as pressureless gas components binned per grainsize, for which we use ten representative grainsize bins.

Our simulations allow to deduce how dust grains of varying sizes become distributed throughout the circumstellar medium.

We show that smaller dust grains (radius < 0.045 μm) tend to be strongly bound to the gas and therefore follow the gas density distribution closely, with intricate finestructure due to essentially hydrodynamical instabilities at the wind-related contact discontinuity. Larger grains which are more resistant to drag forces are shown to have their own unique dust distribution, with progressive deviations from the gas morphology.

Specifically, small dust grains stay entirely within the zone bound by shocked wind material. The large grains are capable of leaving the shocked wind layer, and can penetrate into the shocked or even unshocked interstellar medium. Depending on how the number of dust grains varies with grainsize, this should leave a clear imprint in infrared observations of bowshocks of red supergiants and other evolves stars.

Accepted for publication in ApJL

Available from arXiv:1105.2387

Determination of stellar parameters of C-rich hydrostatic stars from spectro-interferometric observations

C. Paladini[1]*, G.T. van Belle*[2]*, B. Aringer*[3]*, J. Hron*[1]*, P. Reegen*[1]*, C.J. Davis*[4] *and T. Lebzelter*[1]

[1]University of Vienna, Austria

[2]ESO Garching, Germany

[3]INAF Padova, Italy

[4]JAC Hilo, Hawai'i, USA

Giant stars, and especially C-rich giants, contribute significantly to the chemical enrichment of galaxies. The determination of precise parameters for these stars is a necessary prerequisite for a proper implementation of this evolutionary phase in the models of galaxies. Infrared interferometry opened new horizons in the study of the stellar parameters of giant stars, and provided new important constraints for the atmospheric and evolutionary models.We aim to determine which stellar parameters can be constrained by using infrared interferometry and spectroscopy, in the case of C-stars what is the precision which can be achieved and what are the limitations. For this purpose we obtained new infrared spectra and combined them with unpublished interferometric measurements for five mildly variable carbon-rich asymptotic giant branch stars. The observations were compared with a large grid of hydrostatic model atmospheres and with new isochrones which include the predictions of the thermally pulsing phase. For the very first time we are able to reproduce spectra in the range between 0.9 and 4 μm, and K broad band interferometry with hydrostatic model atmospheres. Temperature, mass, $\log g$, C/O and a reasonable range for the distance were derived for all the objects of our study. All our targets have at least one combination of best-fitting parameters which lays in the region of the HR-diagram where C-stars are predicted. We confirm that low resolution spectroscopy is not sensitive to the mass and $\log g$ determination. For hydrostatic objects the 3 μm feature is very sensitive to temperature variations therefore it is a very powerful tool for accurate temperature determinations. Interferometry can constrain mass, radius and $\log g$ but a distance has to be assumed. The large uncertainty in the distance measurements available for C-rich stars remains a major problem.

Accepted for publication in A&A

Available from arXiv:1105.4535

On the polarisation of the Red Rectangle optical emission bands

N.L.J. Cox[1]*, B.H. Foing*[2]*, J. Cami*[3,5] *and P.J. Sarrre*[4]

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

[2]ESA Research and Scientific Support Department, P.O. Box 299, 2200-AG Noordwijk, The Netherlands

[3]Department of Physics & Astronomy, University of Western Ontario, London, ON N6A 3K7, Canada

[4]School of Chemistry, The University of Nottingham, University Park, Nottingham, NG7 2RD, United Kingdom

[5]SETI Institute, 189 Bernardo Ave., Suite 100, Mountain View, CA 94043, United States of America

The origin of the narrow optical emission bands seen toward the Red Rectangle is not yet understood. In this paper we investigate further the proposal that these are due to luminescence of large carbonaceous molecules. Polarised signals of several percent could be expected from certain asymmetric molecular rotators. The ESPaDOnS echelle spectrograph mounted at the CFHT was used to obtain high-resolution optical spectropolarimetric data of the Red Rectangle nebular emission. The RRBs at 5800, 5850, and 6615 Å are detected in spectra of the nebular emission 7″ and 13″ North–East from the central star. The 5826 and 6635 Å RRB are detected only at the position nearest to the central star. For both positions the Stokes Q and U spectra show no unambiguous polarisation signal in any of the RRBs. We derive an upper limit of 0.02% line polarisation for these RRBs. A tentative feature with peak polarisation of 0.05% is seen for the 5800 RRB at 7″ offset. However, the Null spectra suggest that this may be an instrumental artifact. The lack of a clear polarisation signal for the five detected RRBs implies that, if the emission is due to luminescence of complex organics, these gas-phase molecular carriers are likely to have a high degree of symmetry, as they do not exhibit a Q-branch in their rotational profile, although this may be modified by statistical effects.

Accepted for publication in Astronomy & Astrophysics

Available from arXiv:1105.4795

Chemical composition of evolved stars in the open cluster NGC 2506

Šarūnas Mikolaitis[1], *Gražina Tautvaišienė*[1], *Raffaele Gratton*[2], *Angela Bragaglia*[3] *and Eugenio Carretta*[3]

[1]Institute of Theoretical Physics and Astronomy, Vilnius University, Lithuania

[2]INAF – Osservatorio Astronomico di Padova, Italy

[3]INAF – Osservatorio Astronomico di Bologna, Italy

In this study we present abundances of ^{12}C, ^{13}C, N, O and up to 26 other chemical elements in two first ascent giants and two core-helium-burning 'clump' stars of the open cluster NGC 2506. Abundances of carbon were derived using the C_2 Swan (0,1) band head at 5635.5 Å. The wavelength interval 7940–8130 Å, with strong CN features, was analysed in order to determine nitrogen abundances and carbon isotope ratios. The oxygen abundances were determined from the [O I] line at 6300 Å. NGC 2506 was found to have a mean [Fe/H] $= -0.24 \pm 0.05$ (standard deviation). Compared with the Sun and other dwarf stars of the Galactic disc, mean abundances in the investigated clump stars suggest that carbon is depleted by about 0.2 dex, nitrogen is overabundant by about 0.3 dex and other chemical elements have abundance ratios close to solar. The C/N and ^{12}C/^{13}C ratios are lowered to 1.25 ± 0.27 and 11 ± 3, respectively.

Accepted for publication in MNRAS
Available from arXiv:1105.4047

Spitzer spectra of evolved stars in ω Centauri and their low-metallicity dust production

Iain McDonald [1,2], *Jacco Th. van Loon*[2], *Gregory C. Sloan*[3], *Andrea K. Dupree*[4], *Albert A. Zijlstra*[1], *Martha L. Boyer*[5], *Robert D. Gehrz*[6], *Aneurin Evans*[2], *Charles E. Woodward*[6] *and Christian I. Johnson*[7]

[1]Jodrell Bank Centre for Astrophysics, Alan Turing Building, Manchester, M13 9PL, UK

[2]Lennard-Jones Laboratories, Keele University, Staffordshire, ST5 5BG, UK

[3]Cornell University, Astronomy Department, Ithaca, NY 14853-6801, USA

[4]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[5]STScI, 3700 San Martin Drive, Baltimore, MD 21218, USA

[6]Department of Astronomy, 116 Church Street SE, University of Minnesota, Minneapolis, MN 55455, USA

[7]Department of Physics and Astronomy, UCLA, 430 Portola Plaza, Box 951547, Los Angeles, CA 90095-1547, USA

Dust production is explored around 14 metal-poor ([Fe/H] $= -1.91$ to -0.98) giant stars in the Galactic globular cluster ω Centauri using new *Spitzer* IRS spectra. This sample includes the cluster's post-AGB and carbon stars and is thus the first representative spectral study of dust production in a metal-poor ([Fe/H] < -1) population. Only the more metal rich stars V6 and V17 ([Fe/H] $= -1.08$, -1.06) exhibit silicate emission, while the five other stars with mid-infrared excess show only a featureless continuum which we argue is caused by metallic iron dust grains. We examine the metallicity of V42, and find it is likely part of the metal-rich population ([Fe/H] ~ -0.8). Aside from the post-AGB star V1, we find no star from the cluster's bulk, metal-poor ([Fe/H] < -1.5) population − including the carbon stars − to be producing detectable amounts of dust. We compare the dust production to the stars' Hα line profiles obtained at the Magellan/Clay telescope at Las Campanas Observatory, finding pulsation shocking in the strongest pulsators (V6, V17 and V42), but evidence of outflow in all other stars. We conclude that the onset of dust production does not signify a fundamental change in the material leaving the star. Our data add to a growing body of evidence that metallic iron dominates dust production in metal-poor, oxygen-rich stars, but that dust is probably not the primary accelerant of winds in this mass–metallicity regime.

Accepted for publication in MNRAS
Available from arXiv:1104.5155

Discovery of close binary central stars in the planetary nebulae NGC 6326 and NGC 6778

B. Miszalski[1,2,3], *D. Jones*[4], *P. Rodríguez-Gil*[5,6], *H.M. J. Boffin*[4], *R.L.M. Corradi*[5,6] *and M. Santander-García*[7,8,5]

[1]Centre for Astrophysics Research, STRI, University of Hertfordshire, College Lane Campus, Hatfield AL10 9AB, UK

[2]South African Astronomical Observatory, P.O. Box 9, Observatory, 7935, South Africa

[3]Southern African Large Telescope Foundation, P.O. Box 9, Observatory, 7935, South Africa

[4]European Southern Observatory, Alonso de Cordova 3107, Casilla 19001, Santiago, Chile

[5]Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenrife, Spain

[6]Departmento de Astrofísica, Universidad de La Laguna, E-38205 La Laguna, Tenerife, Spain

[7]Observatorio Astronómico Nacional, Ap 112, 28803 Alcalá de Henares, Spain

[8]CAB, INTA-CSIC, Ctra de Torrejón a Ajalvir, km 4, 28850 Torrejón de Ardoz, Madrid, Spain

We present observations proving the close binary nature of the central stars belonging to the planetary nebulae (PNe) NGC 6326 and NGC 6778. Photometric monitoring reveals irradiated lightcurves with orbital periods of 0.372 and 0.1534 days, respectively, constituting firm evidence that they passed through a common-envelope (CE) phase. Unlike most surveys for close binary central stars (CSPN) however, the binary nature of NGC 6326 was first revealed spectroscopically and only later did photometry obtain an orbital period. Gemini South observations revealed a large 160 km s^{-1} shift between the nebula and emission lines of C III and N III well known to originate from irradiated atmospheres of main-sequence companions. These so-called weak emission lines are fairly common in PNe and measurement of their radial velocity shifts in spectroscopic surveys could facilitate the construction of a statistically significant sample of post-CE nebulae. There is growing evidence that this process can be further accelerated by pre-selecting nebulae with traits of known post-CE nebulae. Both NGC 6326 and NGC 6778 were selected for their rich attribution of low-ionisation filaments and collimated outflows, thereby strengthening the connection between these traits and post-CE CSPN.

Accepted for publication in Astronomy and Astrophysics
Available from arXiv:1105.5731

The VMC Survey. II. A multi-wavelength study of LMC planetary nebulae and their mimics

B. Miszalski[1,2,3], *R. Napiwotzki*[1], *M.-R.L. Cioni*[1,4], *M.A.T. Groenewegen*[5], *J.M. Oliveira*[6] *and A. Udalski*[7]

[1]Centre for Astrophysics Research, STRI, University of Hertfordshire, College Lane Campus, Hatfield AL10 9AB, UK

[2]South African Astronomical Observatory, P.O. Box 9, Observatory, 7935, South Africa

[3]Southern African Large Telescope Foundation, P.O. Box 9, Observatory, 7935, South Africa

[4]University Observatory Munich, Scheinerstraße 1, D-81679, München, Germany

[5]Royal Observatory of Belgium, Ringlaan 3, 1180 Ukkel, Belgium

[6]School of Physical & Geographical Sciences, Lennard-Jones Laboratories, Keele University, Staffordshire ST5 5BG, UK

[7]Warsaw University Observatory, Al. Ujazdowskie 4, PL-00-478, Warsaw, Poland

The VISTA Magellanic Cloud (VMC) survey is assembling a deep, multi-epoch atlas of YJK_s photometry across the Magellanic Clouds. Prior to the VMC survey only the brightest Magellanic Cloud PNe (MCPNe) were accessible at near-infrared (NIR) wavelengths. It is now possible for the first time to assemble the NIR properties of MCPNe and to identify contaminating non-PNe mimics which are best revealed at NIR wavelengths (e.g., H II regions and symbiotic stars). To maintain the unique scientific niche that MCPNe occupy these contaminants must be removed. Here we conduct a VMC-led, multi-wavelength study of 102 objects previously classified as PNe that are located within the first six VMC tiles observed. We present images, photometry, lightcurves, diagnostic colour–colour diagrams and spectral energy distributions used to analyse the entire sample. At least five PNe have newly resolved nebula morphologies, a task previously only possible with the *HST*. A total of 45/67 (67%) objects catalogued by Reid & Parker (RP) were reclassified as non-PNe, most of which were located in the vicinity of 30 Doradus. This sample included 16 field stars, 5 emission line stars, 19 H II regions, 4 symbiotic star candidates and 1 young stellar object. We discuss possible

selection effects responsible for their inclusion in the RP catalogue and the implications for binary central star surveys targeting LMC PNe. A total of five new LMC symbiotic star candidates were identified, compared to eight previously known, underlining the important role the VMC survey will have in advancing Magellanic symbiotic star studies.

Accepted for publication in Astronomy and Astrophysics
Available from arXiv:1105.5732
and from http://star.herts.ac.uk/∼mcioni/vmc/

Conference Papers

Why galaxies care about post-AGB stars

Hans Van Winckel[1]

[1]Instituut voor Sterrenkunde, KULeuven, Belgium

Post-AGB stars evolve on a very fast track and hence not many are known. Their spectral properties make them, in principle, ideal objects to test our theories on the late phases of stellar evolution. This has, however, proven much more difficult than anticipated, mainly because the morphological, dynamical and chemical diversity in Galactic post-AGB stars is very large indeed. Here I focus on recent results and touch upon the bright near future of post-AGB research.

Oral contribution, published in "Why Galaxies care about AGB stars II", Vienna 2010
Available from arXiv:1105.0615

Spin period evolution of GX 1+4

A. González-Galán[1], *E. Kuulkers*[2], *P. Kretschmar*[2], *S. Larsson*[3], *K. Postnov*[4], *A. Kochetkova*[4] *and M.H. Finger*[5,6]

[1]Department of Physics, Systems Engineering and Sign Theory, Alicante University, P.O. Box 99 E-03080 Alicante, Spain
[2]European Space Agency, European Space Astronomy Centre, P.O. Box 78, 28691, Villanueva de la Cañada, Madrid, Spain
[3]Department of Astronomy, Stockholm University, SE-106 91 Stockholm, Sweden
[4]Sternberg Astronomical Institute, 119992, Moscow, Russia
[5]National Space Science and Technology Center, 320 Sparkman Drive, Huntsville, AL 35805, USA
[6]Universities Space Research Association, 6767 Old Madison Pike, Suite 450, Huntsville, AL 35806, USA

We report on the long-termevolution of the spin period of the symbiotic X-ray pulsar GX 1+4 and a possible interpretation within a model of quasi-spherical accretion. New period measurements from *Beppo*SAX/WFC, INTEGRAL/ISGRI and *Fermi*/GBM observations have been combined with previously published data from four decades of observations. During the 1970s GX 1+4 was spinning up with the fastest rate among the known X-ray pulsars at the time. In the mid 1980s it underwent a change during a period of low X-ray flux and started to spin down with a rate similar in magnitude to the previous spin up rate. The spin period has changed from $\sim$ 110 s to $\sim$ 160 s within the last three decades. Our results demonstrate that the overall spin down trend continues and is stronger than ever. We compare the observations with predictions from a model assuming quasi-spherical accretion from the slow wind of the M giant companion.

Oral contribution, published in Proceedings of Science, "INTEGRAL 2010", 016
Available from arXiv:1105.1907

Job Advert

Postdoc in abundance calculation

The IAC (Tenerife, Spain), the leading Astrophysical Center in Spain, invites applications for ONE postdoctoral research contract within the framework of the Planetary Nebulae project (311585) whose PI is Dr. Arturo Manchado.

The main purpose of the position is to work as postdoctoral researcher within the framework of the Planetary Nebulae project on the updating of the calculation code of nebular abundances; NEBULAR (http://stsdas.stsci.edu/nebular/), from the intensity of photo-ionized gas emission lines. The successful candidate will work in collaboration with the author of the code, Dick Shaw, in order to migrate it from its present environment (Iraf) to a more adequate environment (based on Python) which has a better graphic interface, with the goal of making it VO compatible and thus serve the entire community in any environment.

The postdoctoral researcher will also update the atomic parameter database to make the abundance calculations more reliable. The number of emission lines to be analysed will be increased, including those to be observed in the infrared, both by Earth-based and space telescopes. The implementation of the calculation of abundances with recombination lines, both from helium and other heavy elements will also be considered. The new code will eventually be applied to several astrophysical objects such as planetary nebulae (PNe) (including *Spitzer* IRS data obtained from Magellanic Cloud and Galactic PNe).

The program will be as follows:

- The candidate will update the database of the atomic parameters, as well as migrate the code to an environment more convenient for the user (based on Python);
- The candidate will increase the code in order to include recombination lines in the optical range, as well as colissional excitation lines in the near, mid and far infrared;
- The candidate will apply the calculation code of abundances in different astrophysical environments; like Galactic and MC PNe.

Special consideration will be given to those candidates with:

- Experience in the calculation of chemical abundances in photo-ionized regions;
- Experience in programming and scripting languages (FORTRAN, C, Python);
- Experience working with *Spitzer* IRS data.

Doctorate: Applicants must have a PhD in Astrophysics or Physics and the doctoral certificate at the moment of starting their appointment (second semester 2011).

NOTE: Applicants who prepared their thesis at the IAC must present written evidence of having spent one continuous year, or 18 accumulated months, in other research institutes.

Duration: Two years, starting during the second semester 2011.

Remuneration: The gross annual salary is 32.886 Euros per annum, subject to up to 20% tax and Social Security deductions. Medical insurance under the Spanish National Health Service will be provided, and will also cover your accompanying partner and children (if relevant).

Non-UE citizens: If you are citizen of a country not belonging to the European Union, you are not allowed to sign any contract with the IAC until you obtain the compulsory documentation required to live and work in Spain (Visa, Residence Permit, Work Permit Waiver). Please contact the Spanish consulate in your country for details.

Compulsory documentation to submit:

- The Application Form: WORD or PDF;
- Curriculum Vitae, bibliography, brief statement of research interests, and a covering letter telling us about the skills you can bring to the job;
- A certificate stating you have obtained your PhD or that you will have it at the moment of signing the contract in the case of being the successful candidate;
- Three letters of recommendation must be sent (electronic submission preferred); directly by researchers or professionals familiar with your work, to the Secretariat of the IAC's Research Division: secinv@iac.es

Applications must be sent by electronic submission to the Secretariat of the Research Division, secinv@iac.es.

Questions about the position are encouraged and can be addressed to the PI of the project; Dr. Arturo Manchado: amt at iac.es

See also http://www.iac.es/info.php?op1=26&id=327