THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 289th issue of the AGB Newsletter.

There are fantastic job prospects in Spain, and don't miss the updates about the IAU symposium on stellar outflows.

In a couple of weeks time, Gioia Rau will take over as Chair of the IAU Working Group on Red Giants and Supergiants. Exciting times ahead!

Feel welcome to submit discussion items or "opinion" pieces.

The next issue is planned to be distributed around the 1st of September (but this could be sooner due to vacation).

Editorially Yours,
Jacco van Loon, Ambra Nanni and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

What do Be stars turn into when they end core hydrogen burning?

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

Refereed Journal Papers

SPH modelling of companion-perturbed AGB outflows including a new morphology classification scheme

Silke Maes[1], Ward Homan[2,1], Jolien Malfait[1], Lionel Siess[2], Jan Bolte[1], Frederik De Ceuster[3,1] and Leen Decin[1,4]

[1]Instituut voor Sterrenkunde, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

[2]Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles (ULB), C.P. 226, 1050 Brussels, Belgium

[3]Department of Physics and Astronomy, University College London, Gower Place, London, WC1E 6BT, United Kingdom

[4]School of Chemistry, University of Leeds, Leeds LS2 9JT, United Kingdom

Asymptotic giant branch (AGB) stars are known to lose a significant amount of mass by a stellar wind, which controls the remainder of their stellar lifetime. High angular-resolution observations show that the winds of these cool stars typically exhibit mid- to small-scale density perturbations such as spirals and arcs, believed to be caused by the gravitational interaction with a (sub-)stellar companion. We aim to explore the effects of the wind-companion interaction on the 3D density and velocity distribution of the wind, as a function of three key parameters: wind velocity, binary separation and companion mass. For the first time, we compare the impact on the outflow of a planetary companion to that of a stellar companion. We intend to devise a morphology classification scheme based on a singular parameter. With our grid of models we cover the prominent morphology changes in a companion-perturbed AGB outflow: slow winds with a close, massive binary companion show a more complex, spiral morphology. Additionally, we prove that massive planets are able to significantly impact the density structure of an AGB wind. We find that the interaction with a companion affects the terminal velocity of the wind, which can be explained by the gravitational slingshot mechanism. We distinguish between two types of wind focussing to the orbital plane resulting from distinct mechanisms: global flattening of the outflow as a result of the AGB star's orbital motion and the formation of an EDE as a consequence of the companion's gravitational pull. We investigate different morphology classification schemes and uncover that the ratio of the gravitational potential energy density of the companion to the kinetic energy density of the AGB outflow yields a robust classification parameter for the models presented in this paper.

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Exploration of aspherical ejecta properties in type Ia supernovæ: progenitor dependence and applications to progenitor classification

Shing-Chi Leung[1], Roland Diehl[2,3], Ken'ichi Nomoto[4] and Thomas Siegert[5]

[1]TAPIR, Walter Burke Institute for Theoretical Physics, Mailcode 350-17, Caltech, Pasadena, CA 91125, USA

[2]Max-Planck-Institut für extraterrestrische Physik, Gießenbachstr. 1, 85741 Garching bei München, Germany

[3]Excellence Cluster Universe, Technische Universität München, Boltzmannstr. 2, D-85748, Garching bei München, Germany

[4]Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo Institutes for Advanced Study, The University of Tokyo, Kashiwa, Chiba 277-8583, Japan

[5]Center for Astrophysics and Space Sciences, University of California, San Diego, 9500 Gilman Dr, La Jolla, CA 92093, USA

Several explosions of thermonuclear supernovæ (SNe Ia) have been found to exhibit deviations from spherical symmetry upon closer inspection. Examples are the γ-ray lines from SN 2014J as measured by INTEGRAL/SPI, and morphology information from radioactive isotopes in older remnants such as Tycho. A systematic study on the effects of parameters such as ignition geometry and burning morphology in SNe Ia is still missing. We use a 2D hydrodynamics code with post-processing nucleosynthesis and simulate the double detonations in a sub-Chandrasekhar mass carbon-oxygen white dwarf starting from the nuclear runaway in the accumulated He envelope towards disruption of the white dwarf. We explore potential variety through four triggering scenarios that sample main asymmetry drivers. We further

investigate their global effects on the aspherical structure of the ejecta based on individual elements. We apply the results to the well observed SN 2014J and other recently observed SN remnants in order to illustrate how these new observational data together with other observed quantities help to constrain the explosion and the progenitors of SNe Ia.

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Damping of oscillations in red giants by resonant mode coupling

Nevin N Weinberg[1], *Phil Arras*[2] *and Debaditya Pramanik*[3]

[1]University of Texas at Arlington, USA
[2]University of Virginia, USA
[3]Massachusetts Institute of Technology, USA

Asteroseismic studies of red giants generally assume that the oscillation modes can be treated as linear perturbations to the background star. However, observations by the *Kepler* mission show that the oscillation amplitudes increase dramatically as stars ascend the red giant branch. The importance of nonlinear effects should therefore be assessed. In previous work, we found that mixed modes in red giants are unstable to nonlinear three-wave interactions over a broad range of stellar mass and evolutionary state. Here we solve the amplitude equations that describe the mode dynamics for large networks of nonlinearly coupled modes. The networks consist of stochastically driven parent modes coupled to resonant secondary modes (daughters, granddaughters, etc.). We find that nonlinear interactions can lower the energy of gravity-dominated mixed modes by $\gtrsim 80\%$ compared to linear theory. However, they have only a mild influence on the energy of pressure-dominated mixed modes. Expressed in terms of the dipole mode visibility V^2, i.e. the summed amplitudes of dipole modes relative to radial modes, we find that V^2 can be suppressed by 50–80% relative to the linear value for highly-evolved red giants whose frequency of maximum power $\nu_{\rm max} \lesssim 100$ μHz. However, for less evolved red giants with $150 \lesssim \nu_{\rm max} \lesssim 200$ μHz, V^2 is suppressed by only 10–20%. We conclude that resonant mode coupling can have a potentially detectable effect on oscillations at $\nu_{\rm max} \lesssim 100$ μHz but it cannot account for the population of red giants that exhibit dipole modes with unusually small amplitudes at high $\nu_{\rm max}$.

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The effect of continuum elimination in identifying circumstellar dust around Mira

Lisa M. Shepard[1] *and Angela K. Speck*[2]

[1]University of Missouri – Columbia, USA
[2]University of Texas – San Antonio, USA

Asymptotic Giant Branch (AGB) stars are major contributors of cosmic dust to the universe. Typically, dust around AGB stars is investigated via radiative transfer (RT) modeling, or via simple deconstruction of observed spectra. However, methodologies applied vary. Using archival spectroscopic, photometric, and temporal data for the archetypal dusty star, Mira, we identify its circumstellar silicate dust grains. This is achieved by matching the positions and widths of observed spectral features with laboratory data. To do this comparison properly, it is necessary to account for the continuum emission. Here we investigate various ways in which a continuum is eliminated from observational spectra and how it affects the interpretation of spectral features. We find that while the precise continuum shapes and temperatures do not have a critical impact on the positions and shapes of dust spectral features, it is important to eliminate continua in a specific way. It is important to understand what contributes to the spectrum in order to remove

the continuum in a way that allows comparison with laboratory spectra of candidate dust species. Our methodologies are applicable to optically thin systems, like that of Mira. Higher optical depths will require RT modeling, which cannot include many different potential astrominerals because there is a lack of complex refractive indices. Finally, we found that the classic silicate feature exhibited by Mira is not consistent with a real amorphous silicate alone but may be best explained with a small alumina contribution to match the observed FWHM of the $\sim$ 10-μm feature.

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Studies of low-mass pulsating yellow supergiants

John R. Percy[1] *and Sara Haroon*[1]

[1]Department of Astronomy & Astrophysics, and Dunlap Institute, University of Toronto, Canada

We have carried out Fourier and wavelet analysis of long-term AAVSO visual observations of 14 RV, SRd, CW and related variable stars in some detail, and of 27 other such variables in less detail. The purpose was to investigate aspects of their complex variability, especially long-term changes in pulsation period, amplitude, and mean magnitude, and also the possible relationships between these types of variables. The mean amplitude variability does not seem to be a function of period, and is similar in RV and SRd stars. We have studied the periods of bimodal variables; there are very few with period ratios different from 2:1. We note with interest the apparent scarcity of "long secondary periods" in SRd stars, as compared with RV variables (the RVb phenomenon) which is believed to be due to binarity. We use wavelet analysis to study possible evolutionary period changes, as an alternative to the usual (O–C) method. We include miscellaneous comments on 17 stars in our total sample. Finally: we note that mean pulsational amplitudes of these stars, determined by Fourier analysis, are smaller than values determined by wavelet analysis, presumably because of the "wandering" periods in these stars.

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Presolar grain isotopic ratios as constraints to nuclear and stellar parameters of AGB nucleosynthesis

Sara Palmerini[1,2], *Maurizio Busso*[1,2], *Diego Vescovi*[3,4,2], *Eugenia Naselli*[5], *Angelo Pidatella*[5], *Riccardo Mucciola*[1,2], *Sergio Cristallo*[4,2], *David Mascali*[5], *Alberto Mengoni*[6,7], *Stefano Simonucci*[8,2] *and Simone Taioli*[9,10]

[1]University of Perugia, Italy
[2]INFN of Perugia, Italy
[3]Goethe University Frankfurt, Germany
[4]INAF, Osservatorio Astronomico d'Abruzzo, Italy
[5]INFN LNS, Italy
[6]ENEA of Bologna, Italy
[7]INFN of Bologna, Italy
[8]University of Camerino, Italy
[9]ECT*, Trento, Italy
[10]INFN TIFPA, Italy

Recent models for evolved low mass stars (with $M \leq 3$ M$_\odot$), undergoing the AGB phase assume that magnetic flux-tube buoyancy drives the formation of ^{13}C reservoirs in He-rich layers. We illustrate their crucial properties, showing how the low abundance of ^{13}C generated below the convective envelope hampers the formation of primary ^{14}N and the ensuing synthesis of intermediate-mass nuclei, like ^{19}F and ^{22}Ne. In the mentioned models, their production is therefore of a purely secondary nature. Shortage of primary ^{22}Ne has also important effects in reducing the neutron density. Another property concerns AGB winds, which are likely to preserve C-rich subcomponents, isolated by magnetic tension, even when the envelope composition is O-rich. Conditions for the formation of C-rich compounds are therefore found in stages earlier than previously envisaged. These issues, together with the uncertainties related to several nuclear physics quantities, are discussed in the light of the isotopic admixtures of s-process elements in presolar SiC grains of stellar origin, which provide important and precise constraints to the otherwise uncertain parameters. By comparing nucleosynthesis results with measured SiC data, it is argued that such a detailed series of constraints indicates the need for new measurements of weak interaction rates in ionized plasmas, as well as of neutron-capture cross sections, especially near the $N = 50$ and $N = 82$ neutron magic numbers. Nonetheless, the peculiarity of our models allows us to achieve fits to the presolar grain data of a quality so far never obtained in previously published attempts.

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Chemical compositions of red giant stars from Habitable Zone Planet Finder spectroscopy

Christopher Sneden[1], Melike Afsar[1,2], Zeynep Bozkurt[2], Gamze Bocek Topcu[2], Sergen Ozdemir[2], Gregory R. Zeimann[1], Cynthia S. Froning[1], Suvrath Mahadevan[3], Joe P. Ninan[3], Chad F. Bender[4], Ryan Terrien[5], Lawrence W. Ramsey[3], Karin Lind[6], Gregory N. Mace[1], Kyle F. Kaplan[7], Hwihyun Kim[8], Keith Hawkins[1] and Brendan P. Bowler[1]

[1]University of Texas at Austin, USA
[2]Ege University, Turkey
[3]Pennsylvania State University, USA
[4]University of Arizona, USA
[5]Carleton College, USA
[6]Stockholm University, Sweden
[7]NASA Ames Research Center, USA
[8]Gemini Observatory, Chile

We have used the Habitable Zone Planet Finder (HPF) to gather high-resolution, high signal-to-noise near-infrared spectra of 13 field red horizontal branch (RHB) stars, one open cluster giant, and one very metal-poor halo red giant. The HPF spectra cover the 0.81–1.28 μm wavelength range of the zyJ bands, partially filling the gap between the optical (0.4–1.0 μm) and infrared (1.5–2.4 μm) spectra already available for the program stars. We derive abundances of 17 species from LTE-based computations involving equivalent widths and spectrum syntheses, and estimate abundance corrections for the species that are most affected by departures from LTE in RHB stars. Generally good agreement is found between HPF-based metallicities and abundance ratios and those from the optical and infrared spectral regions. Light element transitions dominate the HPF spectra of these red giants, and HPF data can be used to derive abundances from species with poor or no representation in optical spectra (e.g., C I, P I, S I, K I). Attention is drawn to the HPF abundances in two field solar-metallicity RHB stars of special interest: one with an extreme carbon isotope ratio, and one with a rare, very large lithium content. The latter star is unique in our sample in exhibiting very strong He I 10830-Å absorption. The abundances of the open cluster giant concur with those derived from other wavelength regions. Detections of C I and S I in HD 122563 are reported, yielding the lowest metallicity determination of [S/Fe] from more than one multiplet.

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The updated BaSTI stellar evolution models and isochrones – II. α-Enhanced calculations

A. Pietrinferni[1], *S. Hidalgo*[2], *S. Cassisi*[1], *M. Salaris*[3], *A. Savino*[4], *A. Mucciarelli*[5], *K. Verma*[6], *V. Silva Auguirre*[6], *A. Aparicio*[2] *and J.W. Ferguson*[7]

[1]INAF – Astronomical Observatory of Abruzzo, Italy

[2]Istituto Astrofísico de Canarias, Tenerife, Spain

[3]Astrophysics Research Institute, Liverpool John Moores University, UK

[4]Astronomy Department, University of California, Berkeley, USA

[5]Dipartimento di Fisica e Astronomia, Università degli Studi di Bologna, Italy

[6]Stellar Astrophysics Centre, Department of Physics and Astronomy, Århus University, Denmark

[7]Department of Physics, Wichita State University, Wichita, USA

This is the second paper of a series devoted to present an updated release of the BaSTI (a Bag of Stellar Tracks and Isochrones) stellar model and isochrone library. Following the publication of the updated solar scaled library, here we present the library for α-enhanced heavy element distribution. These new α-enhanced models account for all improvements and updates in the reference solar metal distribution and physics inputs, as in the new solar scaled library. The models cover a mass range between 0.1 and 15 $M_\odot$, 18 metallicities between [Fe/H] $= -3.20$ and $+0.06$ with [α/Fe] $= +0.4$, and a helium to metal enrichment ratio $\Delta Y/\Delta Z = 1.31$. For each metallicity, He-enhanced stellar models are also provided. The isochrones cover (typically) an age range between 20 Myr and 14.5 Gyr, including consistently the pre-main sequence phase. Asteroseismic properties of the theoretical models have also been calculated. Models and isochrones have been compared with results from independent calculations, with the previous BaSTI release, and also with selected observations, to test the accuracy/reliability of these new calculations. All stellar evolution tracks, asteroseismic properties and isochrones are made publicly available at http://basti-iac.oa-teramo.inaf.it

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Presolar stardust in highly pristine CM chondrites Asuka 12169 and Asuka 12236

Larry R. Nittler[1], *Conel M.O'D. Alexander*[1], *Andrea Patzer* [1,2] *and Maximilien J. Verdier-Paoletti*[1,3]

[1]Earth and Planets Laboratory, Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington, DC 20015, USA

[2]Geosciences Center Göttingen, University of Göttingen, Goldschmidtstr. 1, 37077 Göttingen, Germany

[3]Institut de Minéralogie, de Physique des Materiaux, et de Cosmochimie (IMPMC), Sorbonne Université, Museum national d'Histoire naturelle, UPMC Université Paris 06, UMR CNRS 7590, IRD UMR 206, 75005 Paris, France

We report a NanoSIMS search for presolar grains in the CM chondrites Asuka (A) 12169 and A 12236. We found 90 presolar O-rich grains and 25 SiC grains in A 12169, giving matrix-normalized abundances of 275 ($^{+55}_{-50}$, 1σ) ppm or, excluding an unusually large grain, 236 ($^{+37}_{-34}$) ppm for O-rich grains and 62 ($^{+15}_{-12}$) ppm for SiC grains. For A 12236, 18 presolar silicates and 6 SiCs indicate abundances of 58 ($^{+18}_{-12}$) and 20 ($^{+12}_{-8}$) ppm, respectively. The SiC abundances are in the typical range of primitive chondrites. The abundance of presolar O-rich grains in A 12169 is essentially identical to that in CO3.0 Dominion Range 08006, higher than in any other chondrites, while in A 12236 it is higher than found in other CMs. These abundances provide further strong support that A 12169 and A 12236 are the least-altered CMs as indicated by petrographic investigations. The similar abundances, isotopic distributions, silicate/oxide ratio, and grain sizes of the presolar O-rich grains found here to those of presolar grains in highly primitive CO, CR and ungrouped carbonaceous chondrites (CCs) indicate that the CM parent body(ies) accreted a similar population of presolar oxides and silicates in their matrices to those accreted by the parent bodies of the other CC groups. The lower abundances and larger grain sizes seen in some other CMs are thus most likely a result of parent-body alteration and not heterogeneity in nebular precursors. Presolar silicates are unlikely to be present in high abundances in returned samples from asteroids Ryugu and Bennu since remote-sensing data indicate that they have experienced substantial aqueous alteration.

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A comparison between X-shooter spectra and PHOENIX models across the HR diagram

Ariane Lançon[1]*, Anaïs Gonneau*[2]*, Kristiina Verro*[3]*, Philippe Prugniel*[4]*, Anke Arentsen*[5,1]*, Scott C. Trager*[3]*, Reynier Peletier*[3]*, Yan-Ping Chen*[6]*, Paula Coelho*[7]*, Jesus Falcón-Barroso*[8,9]*, Peter Hauschildt*[10]*, Tim-Oliver Husser*[11]*, Rashi Jain*[1]*, Mariya Lyubenova*[12]*, Lucimara Martins*[13]*, Patricia Sánchez-Blázquez*[14] *and Alexandre Vazdekis*[8,9]

[1]Université de Strasbourg, CNRS, Observatoire astronomique de Strasbourg, UMR7550, 67000 Strasbourg, France

[2]Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB30HA, UK

[3]Kapteyn Astronomical Institute, University of Groningen, Postbus 800, 9700 AV Groningen, The Netherlands

[4]Centre de Recherche Astrophysique de Lyon (CRAL, CNRS, UMR 5574), Université Lyon 1, École Nationale Supérieure de Lyon, Université de Lyon, France

[5]Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, 14482 Potsdam, Germany

[6]New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, UAE

[7]Universidade de São Paulo, Instituto de Astronomia, Geofísica e Ciencias Atmosféricas, Rua do Matão 1226, 05508-090 São Paulo, Brazil

[8]Instituto de Astrofísica de Canarias, Vía Láctea s/n, 38200 La Laguna, Tenerife, Spain

[9]Departamento de Astrofísica, Universidad de La Laguna, 38205 La Laguna, Tenerife, Spain

[10]Hamburger Sternwarte, University of Hamburg, Gojenbergsweg 112, 21029 Hamburg, Germany

[11]Institut für Astrophysik, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

[12]European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748, Garching bei München, Germany

[13]NAT–Universidade Cruzeiro do Sul, Rua Galvão Bueno, 868, São Paulo, SP, Brazil

[14]Departamento de Física Teórica, Universidad Autónoma de Madrid, 28049 Cantoblanco, Spain

The path towards robust near-infrared extensions of stellar population models involves the confrontation between empirical and synthetic stellar spectral libraries across the wavelength ranges of photospheric emission. Indeed, the theory of stellar emission enters all population synthesis models, even when this is only implicit in the association of fundamental stellar parameters with empirical spectral library stars. With its near-ultraviolet to near-infrared coverage, the X-shooter Spectral Library (XSL) allows us to examine to what extent models succeed in reproducing stellar energy distributions (SEDs) and stellar absorption line spectra simultaneously.

As a first example, this study compares the stellar spectra of XSL with those of the Göttingen Spectral Library, which are based on the PHOENIX synthesis code. The comparison was carried out both separately in the three arms of the X-shooter spectrograph known as UVB, VIS and NIR, and jointly across the whole spectrum. We did not discard the continuum in these comparisons; only reddening was allowed to modify the SEDs of the models.

When adopting the stellar parameters published with data release DR2 of XSL, we find that the SEDs of the models are consistent with those of the data at temperatures above 5000 K. Below 5000 K, there are significant discrepancies in the SEDs. When leaving the stellar parameters free to adjust, satisfactory representations of the SEDs are obtained down to about 4000 K. However, in particular below 5000 K and in the UVB spectral range, strong local residuals associated with intermediate resolution spectral features are then seen; the necessity of a compromise between reproducing the line spectra and reproducing the SEDs leads to dispersion between the parameters favored by various spectral ranges. We describe the main trends observed and we point out localized offsets between the parameters preferred in this global fit to the SEDs and the parameters in DR2. These depend in a complex way on the position in the Hertzsprung–Russell diagram (HRD). We estimate the effect of the offsets on bolometric corrections as a function of position in the HRD and use this for a brief discussion of their impact on the studies of stellar populations. A review of the literature shows that comparable discrepancies are mentioned in studies using other theoretical and empirical libraries.

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New temperature and metallicity scale of cool giants from K-band spectra

Supriyo Ghosh[1], *D.K. Ojha*[1] *and J.P. Ninan*[2,3]

[1]Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai 400 005, India

[2]Department of Astronomy and Astrophysics, 525 Davey Laboratory, The Pennsylvania State University, University Park, PA 16802, USA

[3]Center for Exoplanets and Habitable Worlds, 525 Davey Laboratory, The Pennsylvania State University, University Park, PA 16802, USA

We present here quantitative diagnostic tools for cool giants that employ low-resolution near-infrared spectroscopy in the K-band for stellar population studies. In this study, a total of 260 cool giants (177 stars observed with X-Shooter and 83 stars observed with NIFS) are used covering a wider metallicity range than in earlier works. We measure equivalent widths of some of the selected important K-band spectral features like Na I, Fe I and ^{12}CO after degrading the spectral resolution ($R \sim 1200$) to investigate the spectral behaviour with fundamental parameters (e.g., effective temperature and metallicity). We derive empirical relations to measure effective temperature using the ^{12}CO first-overtone band at 2.29 μm and 2.32 μm and show a detailed quantitative metallicity dependence of these correlations. We find that the empirical relations based on solar-neighbourhood stars can incorporate large uncertainty in evaluating $T_{\rm eff}$ for metal-poor or metal-rich stars. Furthermore, we explore all the spectral lines to establish the empirical relation with metallicity and find that the quadratic fit of the combination of Na I and ^{12}CO at 2.29 μm lines yields a reliable empirical relation at [Fe/H] ≤ -0.4 dex, while a linear fit of any line offers a good metallicity scale for stars having [Fe/H] ≥ 0.0 dex.

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Spectroscopic and photometric monitoring of a poorly known highly luminous OH/IR star: IRAS 18278+0931

Supriyo Ghosh[1,2], *Soumen Mondal*[1], *Ramkrishna Das*[1] *and Somnath Dutta*[1,3]

[1]S.N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata-700 106, India

[2]Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai 400 005, India

[3]Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 106, Taiwan

We present the time-dependent properties of a poorly known OH/IR star, IRAS 18278+0931 (hereafter, IRAS 18+09), towards the Ophiuchus constellation. We have carried out long-term optical/near-infrared photometric and spectroscopic observations to study the object. From optical R- and I-band light curves, the period of IRAS 18+09 is estimated to be 575 ± 30 days and the variability amplitudes range from $\Delta R \sim 4.0$ mag to $\Delta I \sim 3.5$ mag. From the standard Period–Luminosity (PL) relations, the distance to the object, 4.0 ± 1.3 kpc, is estimated. Applying this distance in the radiative transfer model, the spectral energy distribution (SED) is constructed from multi-wavelength photometric and IRAS-LRS spectral data, which provides the luminosity, optical depth, and gas mass-loss rate of the object to be 9600 ± 500 L$_\odot$, 9.1 ± 0.6 at 0.55 μm and 1.0×10^{-6} M$_\odot$ yr^{-1}, respectively. The current mass of the object infers in the range 1.0–1.5 M$_\odot$ assuming solar metallicity. Notably, the temporal variation of atomic and molecular features (e.g., TiO, Na I, Ca I, CO, H_2O) over the pulsation cycle of the OH/IR star illustrates the sensitivity of the spectral features to the dynamical atmosphere as observed in pulsating AGB stars.

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The red supergiant binary fraction as a function of metallicity in M 31 and M 33

Kathryn F. Neugent[1]

[1]University of Washington and Lowell Observatory, USA

Recent work measuring the binary fraction of evolved red supergiants (RSGs) in the Magellanic Clouds points to a value between 15% and 30%, with the majority of the companions being unevolved B-type stars as dictated by stellar evolution. Here I extend this research to the Local Group galaxies M 31 and M 33 and investigate the RSG binary fraction as a function of metallicity. Recent near-IR photometric surveys of M 31 and M 33 have led to the identification of a complete sample of RSGs down to a limiting $\log L/L_\odot \geq 4.2$. To determine the binary fraction of these M 31 and M 33 RSGs, I used a combination of newly obtained spectroscopy to identify single RSGs and RSG+OB binaries, as well as archival UV, visible, and near-IR photometry to probabilistically classify RSGs as either single or binary based on their colors. I then adjusted the observed RSG+OB binary fraction to account for observational biases. The resulting RSG binary fraction in M 33 shows a strong dependence on galactocentric distance, with the inner regions having a much higher binary fraction ($41.2^{+12.0}_{-7.3}$%) than the outer regions ($15.9^{+12.4}_{-1.9}$%). Such a trend is not seen in M 31; instead, the binary fraction in lightly reddened regions remains constant at $33.5^{+8.6}_{-5.0}$%. I conclude that the changing RSG binary fraction in M 33 is due to a metallicity dependence, with higher-metallicity environments having higher RSG binary fractions. This dependence most likely stems not from changes in the physical properties of RSGs due to metallicity but from changes in the parent distribution of OB binaries.

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Job Advert

Centro de Astrobiología (CAB, CSIC–INTA)
Postdoctoral Junior Leader Fellowships 2022, Incoming Programme

"la Caixa" Foundation is offering 25 three-year postdoctoral fellowships to hire experienced researchers of all nationalities to carry out their work at accredited centres with the Severo Ochoa or María de Maeztu excellence award, Institutos de Salud Carlos III and units evaluated as excellent by the Fundação para a Ciência e a Tecnologia of Portugal. The research must be carried out in the research areas of Science, Technology, Engineering and Mathematics (STEM), including Bio and Health Sciences. The deadline for applications is 7 October 2021 at 2 pm (Spain time).

I would like to take this opportunity to express our interest in hosting researchers with experience in evolved stars studies to work at the Centro de Astrobiología (CAB, INTA–CSIC) in Madrid, Spain. More specifically, I offer the possibility to join our group in our studies of the physics and chemistry of circumstellar envelopes around AGB and post-AGB stars and Planetary Nebulæ based on multi-wavelength data. Interested candidates with observational and/or theoretical/modelling background are welcome. Details on the call are provided below. Contact me if you have any doubts (Carmen Sanchez Contreras: csanchez@cab.inta-csic.es)

About Centro de Astrobiología (CAB, CSIC–INTA)

Centro de Astrobiología (CAB) is a joint research center of the Spanish National Research Council (CSIC) and the National Institute of Aerospace Technology (INTA). Created in 1999, it was the world's first center dedicated specifically to astrobiological research and the first non-US associate member of NASA's Astrobiology Institute (now the NASA Astrobiology Program). It is an interdisciplinary research center whose main objective is to study the origin, presence and influence of life in the universe. Its staff includes scientists specialized in a wide range of fields such as biology, chemistry, geology, physics, genetics, ecology, astrophysics, planetology, engineering, mathematics and computer science. In 2017, CAB was distinguished by the Ministry of Science and Innovation as "María de Maeztu Unit of Excellence", for the period July 1, 2018 to June 30, 2022.

CAB participates in different missions and instruments of great astrobiological relevance, such as CARMENES, CHEOPS, PLATO, the *James Webb* Space Telescope (JWST) and the BepiColombo mission of the European Space Agency (ESA). It has also developed instruments for international space missions such as REMS and TWINS, on Mars since 2012 and 2018 respectively, and MEDA and RLS, which will arrive in 2021 (Feb.) and 2023 respectively. In addition, since its creation, the center has been working on the development of the SOLID instrument, aimed at the search for life in planetary exploration.

Candidate requirements

In order to get accepted in the Incoming program, candidates must meet the following requirements:

- **Experience:** They should have earned their doctoral degree two to seven years prior to the deadline of the call for applications. The date of the doctoral thesis defence will be understood as the date when the doctoral degree was obtained. In the cases of interruption of the research activity between the date of obtaining the doctoral degree and the call deadline, the candidate may request an extension of the period in which the doctoral degree must have been obtained.
- **Geographic mobility:** For candidates applying to Spanish centres or units: Candidates must not have resided or have carried out their main activity (work, studies, etc.) in Spain for more than twelve months in the three years immediately preceding the closing date of the call. Short stays, such as holidays, will not be taken into account.
  For candidates applying to Portuguese units: Candidates must not have resided or have carried out their main activity (work, studies, etc.) in Portugal for more than twelve months in the three years immediately preceding the closing date of the call. Short stays, such as holidays, will not be taken into account. Special mobility condition could apply for the in the cases of interruption of the research activity or researchers who have spent time in the procedure for obtaining the refugee status under the Geneva Convention.
- **Complete applications:** Only candidates whose applications meet all the requirements of the call may be accepted.

More information in "la Caixa" website
(https://fundacionlacaixa.org/en/postdoctoral-fellowships-junior-leader-incoming)

Application: "la Caixa" fellowship application website (https://candidate.lacaixafellowships.org/login)

See also https://cab.inta-csic.es/

Announcement

IAUS366: The Origin of Outflows in Evolved Stars
Virtual meeting only

Dear participants,

Due to the rising uncertainty related to the covid-19 pandemic, the SOC/LOC unfortunately had to make the decision to move the IAUS366 conference (01/11/2021–05/11/2021) to a fully online event via Zoom, with posters and coffee breaks on Gather.town, and Slack for further discussions.

The conference will run for ∼five hours a day, at times that work for people in different time zones. Most likely three days will be calibrated to Europa/Africa time zones, one day to the Americas and one day to Australasia, depending on the number of participants. More information on the schedule will appear on the conference website (www.iaus366.be) soon.

If you already registered for the conference you do not need to register again. If you already made the conference fee payment, this will be reimbursed to you in the following weeks. Besides talks and poster contributions, there will also be the possibility for contributed 3-min prerecorded pitch talks. If you already submitted a poster/talk contribution, but would like to change it to a pitch talk, please submit a new abstract.

Even though the programme will be fully online, we can welcome a limited number of participants to Leuven, where they can follow the online conference from rooms provided by the Institute of Astronomy, and can interact with the local team. Please contact us via iausleuven@kuleuven.be for more information if you are interested in travelling to Leuven.

Please note the following changes to the conference deadlines:

- Deadline contributed talk abstracts: 10 September 2021
- Announcement selected contributed talks: 1 October 2021
- Deadline poster and pitch-talk abstracts: 10 October 2021
- Registration closes: 15 October 2021
- Conference starts: 1 November 2021

Regards,
The IAUS366 SOC/LOC

See also www.iaus366.be