THE AGB NEWSLETTER

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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 166$^{\rm th}$ issue of the AGB Newsletter. It features very interesting new results, for example on Betelgeuse, in the Magellanic Clouds and around (other) dwarf starburst galaxies as well as in M 32, whether RS Oph is going to blow up, potential solutions to the Cepheids mass-discrepancy problem and the identification of the 21- and 30-μm dust features, and last but not least the impressive success in measuring the masses of red giant stars from asteroseismological results in clusters.

Please read the invitation at the end of the Newsletter, to participate in the AAVSO. Professional astronomers have hugely benefitted from amateur astronomers around the world who monitor the brightness variations of many AGB variables (and other interesting objects such as R Corona Borealis stars). With amateur astronomers becoming ever more professional, they continue to make invaluable contributions to our field of research.

Also, don't miss the announcement of four (4!) different Ph.D. projects, at the IvS in wonderful Leuven, all within the area of evolved stars.

The next issue is planned to be distributed on the 1$^{\rm st}$ of June 2011.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

The ^{12}C : ^{13}C ratio in the circumburst medium of supernovae of type Ia could confirm their association with white dwarfs accreting from RGB or AGB companions.

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 contributions of interactive binary stars to double main sequence turn-offs and dual red clump of intermediate-age star clusters

Wuming Yang[1,2] *and Xiangcun Meng*[2]

[1]Department of Astronomy, Beijing Normal University, Beijing 100875, China

[2]School of Physics and Chemistry, Henan Polytechnic University, Jiaozuo 454000, Henan, China

Double or extended main-sequence turn-offs (DMSTOs) and dual red clump (RC) were observed in intermediate-age clusters, such as in NGC 1846 and 419. the DMSTOs are interpreted as that the cluster has two distinct stellar populations with differences in age of about 200–300 Myr but with the same metallicity. The dual RC is interpreted as a result of a prolonged star formation. Using a stellar population-synthesis method, we calculated the evolutions of binary-star stellar population. We found that binary interactions and merging can reproduce the dual RC in the color–magnitude diagrams of an intermediate-age cluster, whereas in actuality only a single population exists. Moreover, the binary interactions can lead to an extended MSTO rather than DMSTOs. However, the rest of main sequence, subgiant branch and first giant branch are hardly spread by the binary interactions. Part of the observed dual RC and extended MSTO may be the results of binary interactions and merger.

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The symbiotic system Z And: A spectral analysis of the 1984–1986 outburst

M. Contini[1]

[1]School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 69978, Israel

The visual magnitude profile of the symbiotic system Z And during the 1984–1986 activity period appears double peaked and the flux intensity is low compared to outbursts in other epochs. The detailed modeling of the observed spectra, accounting for the shells ejected by the red giant star, shows that the outburst is intrinsically single but distorted by the collision at different phases of the white dwarf wind with two close shells.

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The new carbon symbiotic star IPHAS J205836.43+503307.2

R.L.M. Corradi[1,2]*, L. Sabin*[3]*, U. Munari*[4]*, G. Cetrulo*[5]*, A. Englaro*[5]*, R. Angeloni*[6]*, R. Greimel*[7] *and A. Mampaso*[1,2]

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

[2]Departamento de Astrofísica, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain

[3]Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 877, 22800 Ensenada, B.C., México

[4]INAF, Osservatorio Astronomico di Padova, via dell'Osservatorio 8, 36012 Asiago (VI), Italy

[5]ANS Collaboration, c/o Osservatorio Astronomico, 36012 Asiago (VI), Italy

[6]Departamento de Astronomía y Astrofísica, Pontificia Universidad Catolica de Chile, Santiago, Chile

[7]Institut für Physik, Karl-Franzen Universität Graz, Universitätsplatz 5, 8010 Graz, Austria

We are performing a search for symbiotic stars using IPHAS, the INT Hα survey of the northern Galactic plane, and follow-up observations. Candidate symbiotic stars are selected on the basis of their IPHAS and near-IR colours, and

spectroscopy and photometry are obtained to determine their nature. We present here observations of the symbiotic star candidate IPHAS J205836.43+503307.2. The optical spectrum shows the combination of a number of emission lines, among which are the high-excitation species of [O III], He II, [Ca V], and [Fe VII], and a red continuum with the features of a star at the cool end of the carbon star sequence. The nebular component is spatially resolved: the analysis of the spatial profile of the [N II]6583 line in the spectrum indicates a linear size of $\sim 2.5''$ along the east–west direction. Its velocity structure suggests an aspherical morphology. The near-infrared excess of the source, which was especially strong in 1999, indicated that a thick circumstellar dust shell was also present in the system. The carbon star has brightened in the last decade by two to four magnitudes at red and near-infrared wavelengths. Photometric monitoring during a period of 60 days from November 2010 to January 2011 reveals a slow luminosity decrease of 0.2 magnitudes. From the observed spectrophotometric properties and variability, we conclude that the source is a new Galactic symbiotic star of the D-type, of the rare kind that contains a carbon star, likely a carbon Mira. Only two other systems of this type are known in the Galaxy.

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Non-detection of magnetic fields in the central stars of the planetary nebulae NGC 1360 and LSS 1362

F. Leone[1], M.J. Martínez González[2,3], R.L.M. Corradi[2,3], G. Privitera[1] and R. Manso Sainz[2,3]

[1]Dipartamento de Fisica e Astronomia, Università di Catania, Sezione Astrofisica, Via S. Sofia 78, I-95123 Catania, Italy
[2]Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain
[3]Departamento de Astrofísica, Universidad de La Laguna, E-38205 La Laguna, Tenerife, Spain

The presence of magnetic fields is an attractive hypothesis for shaping planetary nebulae (PNe). We report on observations of the central star of the two PNe NGC 1360 and LSS 1326. We performed spectroscopy on circularly polarized light with the Focal Reducer and Low Dispersion Spectrograph at the Very Large Telescope of the European Southern Observatory. Contrary to previous reports, we find that the effective magnetic field, which is the average over the visible stellar disk of longitudinal components of the magnetic fields, is null within errors for both stars. We conclude that direct evidence of magnetic fields on the central stars of PNe is still missing – either the magnetic field is much weaker (< 600 G) than previously reported, or more complex (thus leading to cancellations), or both. Certainly, indirect evidence (e.g., maser emission) fully justify further efforts to point out the strength and morphology of such magnetic fields.

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Imaging the dynamical atmosphere of the red supergiant Betelgeuse in the CO first overtone lines with VLTI/AMBER

Keiichi Ohnaka[1], Gerd Weigelt[1], Florentin Millour[1,2], Karl-Heinz Hofmann[1], Thomas Driebe[1,3], Dieter Schertl[1], Alain Chelli[4], Fabrizio Massi[5], Romain Petrov[2] and Philippe Stee[2]

[1]Max-Planck-Institut für Radioastronomie, Bonn, Germany
[2]Observatoire de la Côte d'Azur, Nice, France
[3]Deutsches Zentrum für Luft- und Raumfahrt e.V., Bonn, Germany
[4]Institut de Planétologie et d'Astrophysique de Grenoble, Grenoble, France
[5]INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy

We present one-dimensional aperture synthesis imaging of the red supergiant Betelgeuse (α Ori) with VLTI/AMBER.

We reconstructed for the first time one-dimensional images in the individual CO first overtone lines. Our aim is to probe the dynamics of the inhomogeneous atmosphere and its time variation. Betelgeuse was observed between 2.28 and 2.31 μm with VLTI/AMBER using the 16-32-48 m telescope configuration with a spectral resolution up to 12000 and an angular resolution of 9.8 mas. The good nearly one-dimensional uv coverage allows us to reconstruct one-dimensional projection images (i.e., one-dimensional projections of the object's two-dimensional intensity distributions). The reconstructed one-dimensional projection images reveal that the star appears differently in the blue wing, line center, and red wing of the individual CO lines. The one-dimensional projection images in the blue wing and line center show a pronounced, asymmetrically extended component up to $\sim$1.3 stellar radii, while those in the red wing do not show such a component. The observed one-dimensional projection images in the lines can be reasonably explained by a model in which the CO gas within a region more than half as large as the stellar size is moving slightly outward with 0–5 km s^{-1}, while the gas in the remaining region is infalling fast with 20–30 km s^{-1}. A comparison between the CO line AMBER data taken in 2008 and 2009 shows a significant time variation in the dynamics of the CO line-forming region in the photosphere and the outer atmosphere. In contrast to the line data, the reconstructed one-dimensional projection images in the continuum show only a slight deviation from a uniform disk or limb-darkened disk. We derive a uniform-disk diameter of 42.05 ± 0.05 mas and a power-law-type limb-darkened disk diameter of 42.49 ± 0.06 mas and a limb-darkening parameter of $(9.7 \pm 0.5) \times 10^{-2}$. This latter angular diameter leads to an effective temperature of 3690 ± 54 K for the continuum-forming layer. These diameters confirm that the near-IR size of Betelgeuse was nearly constant over the last 18 years, in marked contrast to the recently reported noticeable decrease in the mid-IR size. The continuum data taken in 2008 and 2009 reveal no or only marginal time variations, much smaller than the maximum variation predicted by the current three-dimensional convection simulations. Our two-epoch AMBER observations show that the outer atmosphere extending to $\sim$1.3–1.4 stellar radii is asymmetric and its dynamics is dominated by vigorous, inhomogeneous large-scale motions, whose overall nature changes drastically within one year. This is likely linked to the wind-driving mechanism in red supergiants.

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Oxygen- and carbon-rich variable red giant populations in the Magellanic Clouds from EROS, OGLE, MACHO, and 2MASS photometry

M. Wiśniewski[1], *J.B. Marquette*[2,3], *J.P. Beaulieu*[2,3], *A. Schwarzenberg-Czerny*[1,4], *P. Tisserand*[5,6] *and É. Lesquoy*[6,2,3]

[1]Nicolaus Copernicus Astronomical Centre, Bartycka 18, 00-716 Warsaw, Poland

[2]UPMC Université Paris 06, UMR7095, Institut d'Astrophysique de Paris, F-75014, Paris, France

[3]CNRS, UMR7095, Institut d'Astrophysique de Paris, F-75014, Paris, France

[4]Adam Mickiewicz University Observatory, ul. Słoneczna 36, PL 60-286, Poznań, Poland

[5]Research School of Astronomy & Astrophysics, Mount Stromlo Observatory, Cotter Road, Weston ACT 2611, Australia

[6]CEA, DSM, DAPNIA, Centre d'Études de Saclay, 91191 Gif-sur-Yvette Cedex, France

The carbon-to-oxygen (C/O) ratio of asymptotic giant branch (AGB) stars constitutes an important index of evolutionary and environment/metallicity factor. We develop a method for mass C/O classification of AGBs in photometric surveys without using periods. For this purpose we rely on the slopes in the tracks of individual stars in the colour–magnitude diagram. We demonstrate that our method enables the separation of C-rich and O-rich AGB stars with little confusion. For the Magellanic Clouds we demonstrate that this method works for several photometric surveys and filter combinations. As we rely on no period identification, our results are relatively insensitive to the phase coverage, aliasing, and time-sampling problems that plague period analyses. For a subsample of our stars, we verify our C/O classification against published C/O catalogues. With our method we are able to produce C/O maps of the entire Magellanic Clouds. Our purely photometric method for classification of C- and O-rich AGBs constitutes a method of choice for large, near-infrared photometric surveys. Because our method depends on the slope of colour–magnitude variation but not on magnitude zero point, it remains applicable to objects with unknown distances.

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Hubble Space Telescope study of resolved red giant stars in the outer halos of nearby dwarf starburst galaxies

Agnieszka Rys[1,2,3,4], *Aaron J. Grocholski*[1,5], *Roeland P. van der Marel*[1], *Alessandra Aloisi*[1] *and Francesca Annibali*[6]

[1]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

[2]Astronomical Observatory, Adam Mickiewicz University, Słoneczna 36, 60-286 Poznań, Poland

[3]Instituto de Astrofísica de Canarias (IAC), 38200 La Laguna, Tenerife, Spain

[4]Departamento de Astrofísica, Universidad de La Laguna (ULL), 38205 La Laguna, Tenerife, Spain

[5]Astronomy Department, Yale University, New Haven, CT 06520, USA

[6]INAF — Osservatorio Astronomico di Padova, vicolo dell'Osservatorio 5, 35122 Padova, Italy

Context. Central starbursts in galaxies are an extreme example of ongoing galaxy evolution. The outer parts of galaxies contain a fossil record of galaxy formation and evolution processes in the more distant past. The characterization of resolved stellar populations allows one a detailed study of these topics.
Aims. We observed the outer parts of NGC 1569 and NGC 4449, two of the closest and strongest dwarf starburst galaxies in the local universe, to characterize their stellar density and populations, and obtain new insights into the structure, formation, and evolution of starburst galaxies and galaxy halos.
Methods. We obtained *HST*/WFPC2 images between 5 and 8 scale radii from the center, along the intermediate and minor axes. We performed point-source photometry to determine color magnitude diagrams of I vs. $V-I$. We compared the results at different radii, including also our prior *HST*/ACS results for more centrally located fields.
Results. We detect stars in the RGB and TP-AGB (carbon star) phases in all outer fields, but not younger stars such as those present at smaller radii. The RGB star density profile is well fit by either a de Vaucouleurs profile or a power-law profile, but has more stars at large radii than a single exponential. To within the uncertainties, there are no radial gradients in the RGB color or carbon-to-RGB-star ratio at large radii.
Conclusions. The galaxies have faint outer stellar envelopes that are not tidally truncated within the range of radii addressed by our study. The density profiles suggest that these are not outward extensions of the inner disks, but are instead distinct stellar halos. This agrees with other work on galaxies of similar morphology. The presence of such halos is consistent with predictions of hierarchical galaxy formation scenarios. The halos consist of intermediate-age/old stars, confirming the results of other studies that have shown the starburst phenomenon to be very centrally concentrated. There is no evidence for stellar-population age/metallicity gradients within the halos themselves.

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Connecting RS Oph to [some] Type Ia Supernovae

F. Patat[1], *N.N. Chugai*[2], *Ph. Podsiadlowski*[3], *E. Mason*[4,5], *C. Melo*[5] *and L. Pasquini*[1]

[1]European Southern Observatory, Germany

[2]Institute of Astronomy RAS, Moscow, Russia

[3]Department of Astrophysics, University of Oxford, UK

[4]European Space Agency–Space Telescope Science Institute, Baltimore, USA

[5]European Southern Observatory, Chile

Aims. Recurrent nova systems like RS Oph have been proposed as a possible channel to Type Ia Supernova explosions, based on the high mass of the accreting white dwarf. Additional support to this hypothesis has been recently provided by the detection of circumstellar material around SN 2006X and SN 2007le, showing a structure compatible with that expected for recurrent nova outbursts. In this paper we investigate the circumstellar environment of RS Oph and its structure, with the aim of establishing a firmer and independent link between this class of objects and Type Ia SN progenitors.
Methods. We study the time evolution of Ca II, Na I and K I absorption features in RS Oph, before, during, and after the last outburst, using multi-epoch, high-resolution spectroscopy, and applying the same method adopted for SN 2006X and SN 2007le.

Results. A number of components, blue-shifted with respect to the systemic velocity of RS Oph, are detected. In particular, one feature strongly weakens in the first two weeks after the outburst, simultaneously with the disappearance of very narrow P-Cyg profiles overimposed on the much wider nova emission lines of H, He, Fe II and other elements. *Conclusions.* We interpret these facts as the signature of density enhancements in the circumstellar material, suggesting that the recurrent eruptions might indeed create complex structures within the material lost by the donor star. This establishes a strong link between RS Oph and the progenitor system of the Type Ia SN 2006X, for which similar features have been detected.

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The angular diameter and effective temperature of the lithium-rich K giant HD 148293 from the CHARA Array

Ellyn K. Baines[1], *Harold A. McAlister*[2], *Theo A. ten Brummelaar*[2], *Nils H. Turner*[2], *Judit Sturmann*[2], *Laszlo Sturmann*[2], *P. J. Goldfinger*[2], *Christopher D. Farrington*[2] *and Stephen T. Ridgway*[3]

[1]Naval Research Laboratory, USA

[2]Center for High Angular Resolution Astronomy, Georgia State University, USA

[3]National Optical Astronomy Observatory, USA

We measured the angular diameter of the lithium-rich K giant star HD 148293 using Georgia State University's Center for High Angular Resolution Astronomy (CHARA) Array interferometer. We used our measurement to calculate the star's effective temperature, which allowed us to place it on an H–R diagram to compare it with other Li-rich giants. Its placement supports the evidence presented by Charbonnel & Balachandran (2000) that it is undergoing a brief stage in its evolution where Li is being created.

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A test of time-dependent theories of stellar convection

T. Gastine[1] *and B. Dintrans*[2]

[1]Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Straße 2, 37191 Katlenburg–Lindau, Germany

[2]Institut de Recherche en Astrophysique et Planétologie, CNRS/Université de Toulouse, 14 Av. Edouard Belin, 31400 Toulouse, France

Context: In Cepheids close to the red edge of the classical instability strip, a coupling occurs between the acoustic oscillations and the convective motions close to the surface. The best topical models that account for this coupling rely on 1-D time-dependent convection (TDC) formulations. However, their intrinsic weakness comes from the large number of unconstrained free parameters entering into the description of turbulent convection.
Aims: We compare two widely used TDC models with the first 2-D non-linear direct numerical simulations (DNS) of the convection-pulsation coupling in which the acoustic oscillations are self-sustained by the κ-mechanism.
Methods: The free parameters appearing in the Stellingwerf and Kuhfuß TDC recipes are constrained using a χ^2-test with the time-dependent convective flux that evolves in nonlinear simulations of highly-compressible convection with the κ-mechanism.
Results: This work emphasises some inherent limits to TDC models, that is, the temporal variability and non-universality of their free parameters. More importantly, within these limits, Stellingwerf's formalism is found to give better spatial and temporal agreements with the nonlinear simulation than Kuhfuß's one. It may therefore be preferred in 1-D TDC hydrocodes or stellar evolution codes.

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The Planetary Nebulae population in the central regions of M 32: the SAURON view

Marc Sarzi[1], *Gary Mamon*[2], *Michele Cappellari*[3], *Eric Emsellem*[4,5], *Roland Bacon*[5], *Roger L.D. Davies*[3] *and Tim de Zeeuw*[4]

[1]University of Hertfordshire, UK
[2]IAP Paris, France
[3]Oxford University, UK
[4]ESO, Munich, Germany
[5]Observatoire de Lyon, France

Extragalactic Planetary Nebulae (PNe) are not only useful as distance signposts or as tracers of the dark-matter content of their host galaxies, but constitute also good indicators of the main properties of their parent stellar populations. Yet, so far, the properties of PNe in the optical regions of galaxies where stellar population gradients can be more extreme have remained largely unexplored, mainly because the detection of PNe with narrow-band imaging or slit-less spectroscopy is considerably hampered by a strong stellar background. Integral-field spectroscopy (IFS) can overcome this limitation, and here we present a study of the PN population in the nearby compact elliptical M 32. Using SAURON data taken with just two 10-minutes-long pointings we have doubled the number of known PNe within the effective radius of M 32, detecting PNe five times fainter than previously found in narrow-band images that collected nearly the same number of photons. Furthermore, by carefully accounting for the incompleteness of our survey we could conclude, despite having only 15 sources, that the central PNe population of M 32 is consistent with the generally adopted shape for the PNe Luminosity Function and its typical normalization observed in early-type galaxies. Finally, owing to the proximity of M 32 and to UV images taken with *HST*, we could identify the most likely candidates for the central star of a subset of our detected PNe and conclude that these stars are affected by substantial amounts of circumstellar dust extinction, a finding that could reconcile the intriguing discrepancy previously reported in M 32 between model predictions and observations for the later stages of stellar evolution. Considering the modest time investment on a 4m-class telescope that delivered these results, this work illustrates the potential of future IFS studies for the central PNe population of early-type galaxies.

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The optically bright post-AGB population of the LMC

E. van Aarle[1], *H. Van Winckel*[1], *T. Lloyd Evans*[2], *T. Ueta*[3], *P.R. Wood*[4] *and A.G. Ginsburg*[5]

[1]Instituut voor Sterrenkunde, K.U. Leuven, Celestijnenlaan 200D bus 2401, B-3001 Leuven, Belgium
[2]SUPA, School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, Scotland, UK
[3]Department of Physics and Astronomy, University of Denver, 2112 E. Wesley, Denver, CO 80208, USA
[4]Mount Stromlo Observatory, Cotter Road, Weston Creek, ACT 2611, Australia
[5]Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, CO 80309, USA

The detected variety in chemistry and circumstellar shell morphology of the limited sample of Galactic post-AGB stars is so large that there is no consensus yet on how the different objects are linked by evolutionary channels. The evaluation is complicated by the fact that their distances and hence luminosities remain largely unknown. Via cross-correlation of the *Spitzer* SAGE catalogue with optical catalogues we selected a sample of LMC post-AGB candidates based on their [8]–[24] colour index and estimated luminosity. We determined the fundamental properties of the central stars of 105 of these objects using low-resolution, optical spectra that we obtained at Siding Spring Observatory and SAAO, and constructed a catalogue of 70 high probability and 1337 candidate post-AGB stars that is available at the CDS. The sample forms an ideal testbed for stellar evolution theory predictions of the final phase of low- and intermediate-mass stars, because the distance and hence luminosity and also the current and initial mass of these objects is well constrained. About half of the objects in our sample of post-AGB candidates show a spectral energy distribution (SED) that is indicative of a disc rather than an expanding and cooling AGB remnant. Like in the Galaxy, the disc sources are likely associated with binary evolution. Important side products of this research are catalogues

of candidate young stellar objects, candidate supergiants with circumstellar dust, and discarded objects for which a spectrum was obtained. These too are available at the CDS.

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The Cepheid mass discrepancy and pulsation-driven mass loss

Hilding R. Neilson[1]*, Matteo Cantiello*[1] *and Norbert Langer*[1]

[1]Argelander Institute for Astronomy, Bonn, Germany

Context. A longstanding challenge for understanding classical Cepheids is the Cepheid mass discrepancy, where theoretical mass estimates using stellar evolution and stellar pulsation calculations have been found to differ by approximately 10–20%.
Aims. We study the role of pulsation-driven mass loss during the Cepheid stage of evolution as a possible solution to this mass discrepancy.
Methods. We computed stellar evolution models with a Cepheid mass-loss prescription and various amounts of convective core overshooting. The contribution of mass loss towards the mass discrepancy is determined using these models.
Results. Pulsation-driven mass loss is found to trap Cepheid evolution on the instability strip, allowing them to lose about 5–10% of their total mass when moderate convective core overshooting, an amount consistent with observations of other stars, is included in the stellar models.
Conclusions. We find that the combination of moderate convective core overshooting and pulsation-driven mass loss can solve the Cepheid mass discrepancy.

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Candidate carriers and synthetic spectra of the 21- and 30-μm protoplanetary bands

Renaud Papoular[1]

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

Computational chemistry is used here to determine the vibrational line spectrum of several candidate molecules. It is shown that the thiourea functional group, associated with various carbonaceous structures (mainly compact and linear aromatic clusters), is able to mimic the 21-μm band emitted by a number of proto-planetary nebulae. The combination of nitrogen and sulphur in thiourea is the essential source of emission in this model: the band disappears if these species are replaced by carbon.
The astronomical 21-μm feature extends redward to merge with another prominent band peaking between 25 and 30 μm, also known as the 30-μm band. It is found that the latter can be modelled by the combined spectra of aliphatic chains, made of CH_2 groups, oxygen bridges and OH groups, which provide the 30-μm emission. The absence of oxygen all but extinguishes the 30-μm emission. The emission between the 21- and 30-μm bands is provided mainly by thiourea attached to linear aromatic clusters.
The chemical software reveals that the essential role of the heteroatoms N, S and O stems from their large electronic charge. It also allows to determine the type of atomic vibration responsible for the different lines of each structure, which helps selecting the most relevant structures.
Obviously, no single structure can exhibit the required spectrum, for each only contributes discrete lines which cannot be broadened enough by usual mechanisms. A total of 22 structures have been selected here, but their list is far from being exhaustive; they are only intended as examples of 3 generic classes. However the concatenation, interpolation and smoothing of the computed line spectra deliver continuous spectra of the overall emission of the selected candidates.

When background dust emission is added, model spectra are obtained, which are able to satisfactorily reproduce recent observations of proto-planetary nebulae.
The relative numbers of atomic species used in this model are typically H:C:O:N:S=53:36:8:2:1.

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Asteroseismic inferences on red giants in open clusters NGC 6791, NGC 6819 and NGC 6811 using *Kepler*

S. Hekker[1,2], *S. Basu*[3], *D. Stello*[4], *T. Kallinger*[5], *F. Grundahl*[6], *S. Mathur*[7], *R.A. García*[8], *B. Mosser*[9], *D. Huber*[4], *T.R. Bedding*[4], *R. Szabo*[10], *J. De Ridder*[11], *W.J. Chaplin*[2], *Y. Elsworth*[2], *S.J. Hale*[2], *J. Christensen-Dalsgaard*[6], *R.L. Gilliland*[12], *M. Still*[13], *S. McCauliff*[14] *and E.V. Quintana*[15]

[1]Astronomical Institute "Anton Pannekoek", University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands
[2]School of Physics and Astronomy, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom
[3]Department of Astronomy, Yale University, P.O. Box 208101, New Haven CT 06520-8101, USA
[4]Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia
[5]Department of Physics and Astronomy, University of British Colombia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada
[6]Department of Physics and Astronomy, Building 1520, Aarhus University, 8000 Aarhus C, Denmark
[7]High Altitude Observatory, NCAR, P.O. Box 3000, Boulder, CO 80307, USA
[8]Laboratoire AIM, CEA/DSM–CNRS, Université Paris 7 Diderot, IRFU/SAp, Centre de Saclay, 91191, GIf-sur-Yvette, France
[9]LESIA, UMR8109, Université Pierre et Marie Curie, Université Denis Diderot, Observatoire de Paris, 92195 Meudon Cedex, France
[10]Konkoly Observatory of the Hungarian Academy of Sciences, Konkoly Thege Miklós út 15-17, H-1121 Budapest, Hungary
[11]Instituut voor Sterrenkunde, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[12]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[13]Bay Area Environmental Research Institute / Nasa Ames Research Center, Moffett Field, CA 94035, USA
[14]Orbital Sciences Corporation / Nasa Ames Research Center, Moffett Field, CA 94035, USA
[15]SETI Institute / Nasa Ames Research Center, Moffett Field, CA 94035, USA

Context: Four open clusters are present in the *Kepler* field of view and timeseries of nearly a year in length are now available. These timeseries allow us to derive asteroseismic global oscillation parameters of red-giant stars in the three open clusters NGC 6791, NGC 6819 and NGC 6811. From these parameters and effective temperatures, we derive mass, radii and luminosities for the clusters as well as field red giants.
Aims: We study the influence of evolution and metallicity on the observed red-giant populations.
Methods: The global oscillation parameters are derived using different published methods and the effective temperatures are derived from 2MASS colours. The observational results are compared with BaSTI evolution models.
Results: We find that the mass has significant influence on the asteroseismic quantities Δ_ν vs. $\nu_{\rm max}$ relation, while the influence of metallicity is negligible, under the assumption that the metallicity does not affect the excitation / damping of the oscillations. The positions of the stars in the H–R diagram depend on both mass and metallicity. Furthermore, the stellar masses derived for the field stars are bracketed by those of the cluster stars.
Conclusions: Both the mass and metallicity contribute to the observed difference in locations in the H–R diagram of the old metal-rich cluster NGC 6791 and the middle-aged solar-metallicity cluster NGC 6819. For the young cluster NGC 6811, the explanation of the position of the stars in the H–R diagram challenges the assumption of solar metallicity, and this open cluster might have significantly lower metallicity [Fe/H] in the range -0.3 to -0.7 dex. Also, nearly all the observed field stars seem to be older than NGC 6811 and younger than NGC 6791.

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Conference Paper

Hydrodynamic simulations of shell convection in stellar cores

Miroslav Mocák[1], *Ewald Müller*[2] *and Lionel Siess*[1]

[1]Institute of Astronomy and Astrophysics at the Université Libre de Bruxelles, Belgium
[2]Max-Planck-Institut für Astrophysik, Garching bei München, Germany

Shell convection driven by nuclear burning in a stellar core is a common hydrodynamic event in the evolution of many types of stars. We encounter and simulate this convection (i) in the helium core of a low-mass red giant during core helium flash leading to a dredge-down of protons across an entropy barrier, (ii) in a carbon–oxygen core of an intermediate-mass star during core carbon flash, and (iii) in the oxygen and carbon burning shell above the silicon–sulfur rich core of a massive star prior to supernova explosion. Our results, which were obtained with the hydrodynamics code HERAKLES, suggest that both entropy gradients and entropy barriers are less important for stellar structure than commonly assumed. Our simulations further reveal a new dynamic mixing process operating below the base of shell convection zones.

Oral contribution, published in "Red Giants as Probes of the Structure and Evolution of the Milky Way"; 15–17 November 2010; Rome
Available from arXiv:1104.3843

Job Advert

4 PhD positions

The Instituut voor Sterrenkunde (IvS) of the Katholieke Universiteit Leuven, Belgium is a young and active research group of some 50 scientists, engineers and administrative staff (http://www.ster.kuleuven.be). The institute is involved in several international networks and research projects, involving telescopes at international observatories and space missions. The institute is also responsible for the organization of the Master in Astronomy & Astrophysics of the Faculty of Science at Leuven University and the Advanced Master of Space Studies.

With these vacancies, we are searching for motivated PhD students to work on our projects on:

1) Binary stellar evolution and the hot subdwarf stars (promotors: Roy Oestensen, Hans Van Winckel)

2) Post-AGB stars of the LMC, SMC and Galactic Bulge (promotors: Hans Van Winckel, Joris Blommaert)

3) The circumstellar environment of evolved stars as traced by molecules (promotor: Leen Decin)

4) Study of mass flows from evolved stars with *Herschel* (promotor: Christoffel Waelkens)

http://phd.kuleuven.be/set/

See also http://www.ster.kuleuven.be/vacancies/

Announcement

Invitation for participation in the AAVSO

The American Association of Variable Star Observers is a global membership organization of amateur and professional astronomers devoted to variable star observation and research. In 2011 we celebrate the Centennial of our founding, and in this anniversary year we invite all members of the AGB research community to explore what the AAVSO has to offer, and to participate in the activities of our organization.

The AAVSO currently holds the world's most comprehensive and longest-spanning archive of variable star observations, all of which are now available free and on demand via the AAVSO website. We also provide a number of additional tools including: annual LPV predictions for observation planning, all-sky $BVgri$ photometry from our ongoing APASS project, plot-on-demand charts with hundreds of modern and revised sequences, online access to historic time-of-maximum LPV data, access to our observer community via Alert and Special Notices and Observing Campaigns, and our own peer-reviewed Journal of the AAVSO.

AGB stars have historically been a major focus of the AAVSO observer community, and we invite input and guidance from the AGB research community on new and useful observing programs where amateur visual and instrumental observers can make valuable contributions. AAVSO observers have a wide range of instrumentation and capabilities, from visual observation of Miras and semiregulars to instrumental time-series, optical spectroscopy, and even J- and H-band photometry of brighter targets. We invite you to make use of the AAVSO's extensive data archives, and to interact with the observers who continue to provide variable star light curves to the astronomical community. We especially welcome the participation of the professional research community in our online discussion groups and website forum, and encourage researchers who make use of AAVSO data to provide feedback, guidance, and encouragement to the observers.

Please visit the AAVSO website at http://www.aavso.org and take advantage of all that we have to offer to observers, researchers, and the wider community.

With best wishes,
Matthew Templeton
AAVSO

See also http://www.aavso.org