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. 191 — 2 June 2013

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 191st issue of the AGB Newsletter. One often learns more from what one cannot explain than from what one appears to explain, and likewise it is important to evaluate the consequences of our limited knowledge – it is therefore commended that the Pisa group investigate the range of predictions from their models depending on the input data. Other interesting studies concern the Galactic Bulge (or Galactic Disc, as it may be), dust production in the Magellanic Clouds, new insights from stellar clusters, symbiotic binaries and planetary nebulæ and supernovæ, and all the rest.

Please tell your brightest masters students to apply for the PhD position at Leuven. And don't forget to post your own job announcements (all levels) on the newsletter.

It is great to see tools being made public that encourage the astronomical community to attempt to analyse their data or model their cases in a more sophisticated manner. So please do have a look at SHAPE and DDSCAT, and consider.

The next issue is planned to be distributed around the 1st of July.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Solar-type stars near AGB stars are good targets for SETI as technologically advanced life might have migrated from the AGB star to the solar-type star.

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

Coevolution of dust, gas, and stars in galaxies – I. Spatial distributions and scaling-relations of dust and molecular hydrogen

Kenji Bekki[1]

[1]ICRAR at UWA, Australia

We investigate the time evolution of dust properties, molecular hydrogen (H_2) contents, and star formation histories in galaxies by using our original chemodynamical simulations. The simulations include the formation of dust in the stellar winds of supernovæ (SNe) and asymptotic giant branch (AGB) stars, the growth and destruction processes of dust in the interstellar medium (ISM), the formation of polycyclic aromatic hydrocarbon (PAH) dust in carbon-rich AGB stars, the H_2 formation on dust grains, and the H_2 photo-dissociation due to far ultra-violet (FUV) light in a self-consistent manner. We focus mainly on disk galaxies with different total masses in this preliminary study. The principle results are as follows: The star formation histories of disk galaxies can be regulated by the time evolution of interstellar dust, mainly because the formation rates of H_2 can be controlled by dust properties. The observed correlation between dust-to-gas-ratios (D) and gas-phase oxygen abundances ($A_{\rm O} = 12 + \log({\rm O/H})$) can be reproduced reasonably well in the present models. The disks show negative radial gradients (i.e., larger in inner regions) of H_2 fraction ($f_{\rm H_2}$), PAH-to-dust mass ratio ($f_{\rm PAH}$), D, and $A_{\rm O}$ and these gradients evolve with time. The surface-mass densities of dust ($\Sigma_{\rm dust}$) are correlated more strongly with the total surface gas densities than with those of H_2. Local gaseous regions with higher D are more likely to have higher $f_{\rm H_2}$ in individual disks and total H_2 masses correlate well with total dust masses. More massive disk galaxies are more likely to have higher D, $f_{\rm PAH}$, and $f_{\rm H_2}$ and smaller dust-to-stellar mass ratios. We also compare between galactic star formation histories in the metallicity-dependent and dust-dependent star formation models and find no major differences.

Accepted for publication in MNRAS
Available from arXiv:1304.1633

A double white-dwarf cooling sequence in ω Centauri

A. Bellini[1], *J. Anderson*[1], *M. Salaris*[2], *S. Cassisi*[3], *L.R. Bedin*[4], *G. Piotto*[5,4] *and P. Bergeron*[6]

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

[2]Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead, CH41 1LD, United Kingdom

[3]Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Collurania, via Mentore Maggini, I-64100 Teramo, Italy

[4]Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Padova, v.co dell'Osservatorio 5, I-35122, Padova, Italy

[5]Dipartimento di Fisica e Astronomia "Galileo Galilei", Università di Padova, v.co dell'Osservatorio 3, I-35122, Padova, Italy

[6]Département de Physique, Université de Montréal, C.P. 6128, Succ. Centre-Ville, Montréal, Québec H3C 3J7, Canada

We have applied our empirical-PSF-based photometric techniques on a large number of calibration-related WFC3/UVIS UV–B exposures of the core of ω Centauri, and found a well-defined split in the bright part of the white-dwarf cooling sequence (WDCS). The redder sequence is more populated by a factor of ~ 2. We can explain the separation of the two sequences and their number ratio in terms of the He-normal and He-rich subpopulations that had been previously identified along the cluster main sequence. The blue WDCS is populated by the evolved stars of the He-normal component (~ 0.55 $M_\odot$ CO-core DA objects) while the red WDCS hosts the end-products of the He-rich population (~ 0.46 $M_\odot$ objects, ~ 10% CO-core and ~ 90% He-core WDs). The He-core WDs correspond to He-rich stars that missed the central He-ignition, and we estimate their fraction by analyzing the population ratios along the cluster horizontal branch.

Accepted for publication in ApJ Letters
Available from arXiv:1305.0265

Triggering collapse of the presolar dense cloud core and injecting short-lived radioisotopes with a shock wave. II. Varied shock wave and cloud core parameters

Alan P. Boss[1] *and Sandra A. Keiser*[1]

[1]DTM, Carnegie Institution, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA

A variety of stellar sources have been proposed for the origin of the short-lived radioisotopes that existed at the time of the formation of the earliest Solar System solids, including Type II supernovæ, AGB and super-AGB stars, and Wolf–Rayet star winds. Our previous adaptive mesh hydrodynamics models with the FLASH2.5 code have shown which combinations of shock wave parameters are able to simultaneously trigger the gravitational collapse of a target dense cloud core and inject significant amounts of shock wave gas and dust, showing that thin supernova shocks may be uniquely suited for the task. However, recent meteoritical studies have weakened the case for a direct supernova injection to the presolar cloud, motivating us to re-examine a wider range of shock wave and cloud core parameters, including rotation, in order to better estimate the injection efficiencies for a variety of stellar sources. We find that supernova shocks remain as the most promising stellar source, though planetary nebulæ resulting from AGB star evolution cannot be conclusively ruled out. Wolf–Rayet star winds, however, are likely to lead to cloud core shredding, rather than to collapse. Injection efficiencies can be increased when the cloud is rotating about an axis aligned with the direction of the shock wave, by as much as a factor of ~ 10. The amount of gas and dust accreted from the post-shock wind can exceed that injected from the shock wave, with implications for the isotopic abundances expected for a supernova source.

Accepted for publication in Astrophysical Journal
Available from arXiv:1305.0249
and from http://www.dtm.ciw.edu/users/boss/ftp/triggerii.pdf

Metal-poor stars observed with the Magellan telescope I. Constraints on progenitor mass and metallicity of AGB stars undergoing *s*-process nucleosynthesis

Vinicius M. Placco[1,2]*, Anna Frebel*[3]*, Timothy C. Beers*[2]*, Amanda I. Karakas*[4]*, Catherine R. Kennedy*[4]*, Silvia Rossi*[1]*, Norbert Christlieb*[5] *and Richard J. Stancliffe*[6]

[1]Instituto de Astronomía, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, São Paulo, SP 05508-900, Brazil

[2]National Optical Astronomy Observatory, Tucson, AZ 85719, USA

[3]Massachussetts Institute of Technology and Kavli Institute for Astrophysics and Space Research, 77 Massachusetts Avenue, Cambridge, MA, 02139, USA

[4]Research School of Astronomy and Astrophysics, The Australian National University, Cotter Road, Weston, ACT, 2611, Australia

[5]Zentrum für Astronomie der Universität Heidelberg, Landessternwarte, Königstuhl 12, 69117, Heidelberg, Germany

[6]Argelander-Institut für Astronomie der Universität Bonn, Auf dem Hügel 71, 53121, Bonn, Germany

We present a comprehensive abundance analysis of two newly-discovered carbon-enhanced metal-poor (CEMP) stars. HE 2138−3336 is a *s*-process-rich star with [Fe/H] = −2.79, and has the highest [Pb/Fe] abundance ratio measured thus far, if NLTE corrections are included ([Pb/Fe] = +3.84). HE 2258−6358, with [Fe/H] = −2.67, exhibits enrichments in both *s*- and *r*-process elements. These stars were selected from a sample of candidate metal-poor stars from the Hamburg/ESO objective-prism survey, and followed up with medium-resolution ($R \sim 2,000$) spectroscopy with Gemini/GMOS. We report here on derived abundances (or limits) for a total of 34 elements in each star, based on high-resolution ($R \sim 30,000$) spectroscopy obtained with Magellan–Clay/MIKE. Our results are compared to predictions from new theoretical AGB nucleosynthesis models of 1.3 $M_\odot$ with [Fe/H] = −2.5 and −2.8, as well as to a set of AGB models of 1.0 to 6.0 $M_\odot$ at [Fe/H] = −2.3. The agreement with the model predictions suggests that the neutron-capture material in HE 2138−3336 originated from mass transfer from a binary companion star that previously went through the AGB phase, whereas for HE 2258−6358, an additional process has to be taken into account to explain its abundance pattern. We find that a narrow range of progenitor masses ($1.0 \leq M(\mathrm{M}_\odot) \leq 1.3$) and metallicities ($-2.8 \leq$

[Fe/H] ≤ -2.5) yield the best agreement with our observed elemental abundance patterns.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1304.7869

On the internal pollution mechanisms in the globular cluster NGC 6121 (M 4): heavy-element abundances and AGB models

Valentina D'Orazi[1,2], *Simon W. Campbell*[2], *Maria Lugaro*[2], *John C. Lattanzio*[2], *Marco Pignatari*[3] *and Eugenio Carretta*[4]

[1]Dept. of Physics and Astronomy, Macquarie University, Australia
[2]Monash Centre for Astrophysics, Monash University, Australia
[3]Department of Physics, Basel University, Switzerland
[4]INAF – Osservatorio Astronomico di Bologna, Italy

Globular clusters display significant variations in their light-element content, pointing to the existence of a second stellar generation formed from the ejecta of an earlier generation. The nature of these internal polluters is still a matter of debate: the two most popular scenarios indicate intermediate-mass AGB stars and fast rotating massive stars. Abundances determination for some key elements can help distinguish between these competitor candidates. We present in this paper Y abundances for a sample of 103 red giant branch stars in NGC 6121. Within measurement errors, we find that the [Y/Fe] is constant in this cluster contrary to a recent suggestion. For a subsample of six stars we also find [Rb/Fe] to be constant, consistent with previous studies showing no variation in other *s*-process elements. We also present a new set of stellar yields for intermediate-mass AGB stellar models of 5 and 6 $M_\odot$, including heavy element *s*-process abundances. The uncertainties on the mass-loss rate, the mixing-length parameter, and the nuclear reaction rates have a major impact on the stellar abundances. Within the IM-AGB pollution scenario, the constant abundance of heavy elements inside the cluster requires a marginal *s*-process efficiency in IM-AGB stars. Such a constrain could still be satisfied by the present models assuming a stronger mass-loss rate. The uncertainties mentioned above are limiting the predictive power of intermediate-mass AGB models. For these reasons, at the moment we are not able to clearly rule out their role as main polluters of the second population stars in globular clusters.

Accepted for publication in MNRAS
Available from arXiv:1304.7009

Cumulative physical uncertainty in modern stellar models II. The dependence on the chemical composition

Giada Valle[1,2], *Matteo Dell'Omodarme*[1], *Pier Giorgio Prada Moroni*[1,2] *and Scilla Degl'Innocenti*[1,2]

[1]Dipartimento di Fisica "Enrico Fermi", Università di Pisa, Largo B. Pontecorvo 3, Italy
[2]INFN, Sezione di Pisa, Largo B. Pontecorvo 3, I-56127, Italy

We extend our work on the effects of the uncertainties on the main input physics for the evolution of low-mass stars. We analyse the dependence of the cumulative physical uncertainty affecting stellar tracks on the chemical composition. We calculated more than 6000 stellar tracks and isochrones, with metallicity ranging from $Z = 0.0001$ to 0.02, by changing the following physical inputs within their current range of uncertainty: ^{1}H(p,ν e^{+})^{2}H, ^{14}N(p,γ)^{15}O and triple-α reaction rates, radiative and conductive opacities, neutrino energy losses, and microscopic diffusion velocities. The analysis was performed using a latin hypercube sampling design. We examine in a statistical way the dependence on the variation of the physical inputs of the turn-off (TO) luminosity, the central hydrogen exhaustion time ($t_{\rm H}$), the luminosity and the helium core mass at the red-giant branch (RGB) tip, and the zero age horizontal branch (ZAHB) luminosity in the RR Lyræ region. For the stellar tracks, an increase from $Z = 0.0001$ to $Z = 0.02$ produces

a cumulative physical uncertainty in TO luminosity from 0.028 dex to 0.017 dex, while the global uncertainty on $t_{\rm H}$ increases from 0.42 Gyr to 1.08 Gyr. For the RGB tip, the cumulative uncertainty on the luminosity is almost constant at 0.03 dex, whereas the one the helium core mass decreases from 0.0055 $M_\odot$ to 0.0035 $M_\odot$. The dependence of the ZAHB luminosity error is not monotonic with Z, and it varies from a minimum of 0.036 dex at $Z = 0.0005$ to a maximum of 0.047 dex at $Z = 0.0001$. Regarding stellar isochrones of 12 Gyr, the cumulative physical uncertainty on the predicted TO luminosity and mass increases respectively from 0.012 dex to 0.014 dex and from 0.0136 $M_\odot$ to 0.0186 $M_\odot$. Consequently, for ages typical of galactic globular clusters, the uncertainty on the age inferred from the TO luminosity increases from 325 Myr to 415 Myr.

Accepted for publication in Astronomy and Astrophysics
Available from arXiv:1304.7658

Cumulative physical uncertainty in modern stellar models I. The case of low-mass stars

Giada Valle[1,2], Matteo Dell'Omodarme[1], Pier Giorgio Prada Moroni[1,2] and Scilla Degl'Innocenti[1,2]

[1]Dipartimento di Fisica "Enrico Fermi", Università di Pisa, Largo B. Pontecorvo 3, Italy
[2]INFN, Sezione di Pisa, Largo B. Pontecorvo 3, I-56127, Italy

Using our updated stellar evolutionary code, we quantitatively evaluate the effects of the uncertainties in the main physical inputs on the evolutionary characteristics of low mass stars from the main sequence to the zero age horizontal branch (ZAHB). We calculated more than 3000 stellar tracks and isochrones, with updated solar mixture, by changing the following physical inputs within their current range of uncertainty: ^{1}H(p,ν e^{+})^{2}H, ^{14}N(p,γ)^{15}O, and triple-α reaction rates, radiative and conductive opacities, neutrino energy losses, and microscopic diffusion velocities. We performed a systematic variation on a fixed grid, in a way to obtain a full crossing of the perturbed input values. The effect of the variations of the chosen physical inputs on relevant stellar evolutionary features, such as the turn-off luminosity, the central hydrogen exhaustion time, the red-giant branch (RGB) tip luminosity, the helium core mass, and the ZAHB luminosity in the RR Lyræ region are statistically analyzed. For a 0.9 $M_\odot$ model, the cumulative uncertainty on the turn-off, the RGB tip, and the ZAHB luminosities accounts for $\pm$0.02 dex, $\pm$0.03 dex, and $\pm$0.045 dex respectively, while the central hydrogen exhaustion time varies of about $\pm$0.7 Gyr. The most relevant effect is due to the radiative opacities uncertainty; for the later evolutionary stages the second most important effect is due to the triple-α reaction rate uncertainty. For an isochrone of 12 Gyr, we find that the isochrone turn-off log luminosity varies of $\pm$0.013 dex, the mass at the isochrone turn-off varies of $\pm$0.015 $M_\odot$, and the difference between ZAHB and turn-off log-luminosity varies of $\pm$0.05 dex. The effect of the physical uncertainty affecting the age inferred from turn-off luminosity and from the vertical method are of $\pm$0.375 Gyr and $\pm$1.25 Gyr respectively.

Published in Astronomy and Astrophysics, 549, A50
Available from arXiv:1211.0706

Mapping the central region of the PPN CRL 618 at sub-arcsecond resolution at 350 GHz

Chin-Fei Lee[1], Chun-Hui Yang[1], Raghvendra Sahai[2] and Carmen Sánchez Contreras[3]

[1]ASIAA, Taiwan
[2]JPL/NASA, USA
[3]CSIC–INTA, Spain

CRL 618 is a well-studied pre-planetary nebula. We have mapped its central region in continuum and molecular lines with the SubMillimeter Array at 350 GHz at $\sim$ 0.″3 to 0.″5 resolutions. Two components are seen in 350 GHz continuum: (1) a compact emission at the center tracing the dense inner part of the H II region previously detected in 23 GHz continuum and it may trace a fast ionized wind at the base, and (2) an extended thermal dust emission surrounding the H II region, tracing the dense core previously detected in HC_3N at the center of the circumstellar envelope. The dense core is dusty and may contain mm-sized dust grains. It may have a density enhancement in the equatorial plane. It is also detected in carbon chain molecules HC_3N and HCN, and their isotopologues, with higher excitation lines tracing closer to the central star. It is also detected in C_2H_3CN toward the innermost part. Most of the emission detected here arises within ~ 630 au ($\sim 0\farcs7$) from the central star. A simple radiative transfer model is used to derive the kinematics, physical conditions, and the chemical abundances in the dense core. The dense core is expanding and accelerating, with the velocity increasing roughly linearly from ~ 3 km s^{-1} in the innermost part to ~ 16 km s^{-1} at 630 au. The mass-loss rate in the dense core is extremely high with a value of $\sim 1.15\times10^{-3}$ M$_\odot$ yr^{-1}. The dense core has a mass of ~ 0.47 M$_\odot$ and a dynamical age of ~ 400 yr. It could result from a recent enhanced heavy mass-loss episode that ends the AGB phase. The isotopic ratios of $^{12}C/^{13}C$ and $^{14}N/^{15}N$ are 9 ± 4 and 150 ± 50, respectively, both lower than the solar values.

Accepted for publication in ApJ
Available from arXiv:1305.1731

Two barium stars in the Galactic Bulge

Thomas Lebzelter[1], Stefan Uttenthaler[1], Oscar Straniero[2] and Bernhard Aringer[1]

[1]University of Vienna, Department of Astrophysics, Austria
[2]INAF – Osservatorio Astronomico di Collurania, Italy

Barium stars conserve important information on the *s*-process and the third dredge-up in intermediate mass stars. Their discovery in various environments is therefore of great help to test nucleosynthesis and mixing models. Our aim is to analyse two stars with a very strong barium line detected in a large survey of red giants in the Galactic Bulge. Abundance analysis was done comparing synthetic model spectra based on the COMARCS code with our medium resolution spectra. Abundances of Ba, La, Y, and Fe were determined. Beside the two main targets, the analysis was also applied to two comparison stars. We confirm that both stars are barium stars. They are the first ones of this kind identified in the Galactic Bulge. Their barium excesses are among the largest values found up to now. The elemental abundances are compared with current nucleosynthesis and mixing models. Furthermore, we estimate a frequency of barium stars in the Galactic Bulge of about 1%, which is identical to the value for Disc stars.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1305.2298

Seed particle formation for silicate dust condensation by SiO nucleation

H.-P. Gail[1], S. Wetzel[2], A. Pucci [2] and A. Tamanai[2]

[1]Institute for Theoretical Astrophysics, Heidelberg, Germany
[2]Kirchhoff Institute for Physics, Heidelberg, Germany

Clustering of the abundant SiO molecules has been discussed as a possible mechanism of seed particle formation for silicate dust in stellar outflows with an oxygen rich element mixture. Previous results indicated that condensation temperatures based on this mechanism are significant lower than what is really observed. This negative result strongly rests on experimental data on vapour pressure of SiO. New determinations show the older data to be seriously in error. Here we aim to check with improved data the possibility that SiO nucleation triggers the cosmic silicate dust formation. First we present results of our measurements of vapour pressure of solid SiO. Second, we use the improved vapour pressure data to re-calibrate existing experimental data on SiO nucleation from the literature. Third, we use the re-calibrated data on SiO nucleation in a simple model for dust-driven winds to determine the condensation temperature of silicate in stellar outflows from AGB stars. We show that onset of nucleation under circumstellar

conditions commences at higher temperature than was previously found. Calculated condensation temperatures are still by about 100 K lower than observed ones, but this may be due to the greenhouse effect of silicate dust temperatures. The assumption that the onset of silicate dust formation in late-type M stars is triggered by cluster formation of SiO is compatible with dust condensation temperatures derived from IR observations.

Submitted to Astronomy and Astrophysics
Available from arXiv:1305.2879

Water vapor excitation in dusty AGB envelopes. A PACS view of OH 127.8+0.0

R. Lombært[1], *L. Decin*[1,2], *A. de Koter*[1,2,3], *J.A.D.L. Blommært*[1,4], *P. Royer*[1], *E. De Beck*[1,5], *B.L. de Vries*[1], *T. Khouri*[2] *and M. Min*[2,3]

[1]Instituut voor Sterrenkunde, KU Leuven, Celestijnenlaan 200D B-2401, 3001 Leuven, Belgium

[2]Astronomical Institute "Anton Pannekoek", University of Amsterdam, P.O. Box 94249, 1090 GE Amsterdam, The Netherlands

[3]Astronomical Institute Utrecht, University Utrecht, P.O. Box 80000, 3508 TA Utrecht, The Netherlands

[4]Department of Physics and Astrophysics, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

[5]Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

AGB stars lose a large percentage of their mass in a dust-driven wind. This creates a circumstellar envelope, which can be studied through thermal dust emission and molecular emission lines. In the case of high mass-loss rates, this study is complicated by the high optical depths and the intricate coupling between gas and dust radiative transfer characteristics. An important aspect of the physics of gas-dust interactions is the strong influence of dust on the excitation of several molecules, including water.

The dust and gas content of the envelope surrounding the high mass-loss rate OH/IR star OH 127.8+0.0, as traced by *Herschel* observations, is studied, with a focus on the water content and the dust-to-gas ratio. We report detecting a large number of water vapor emission lines up to $J = 9$ in the *Herschel* data, for which we present the measured line strengths.

The treatments of both gas and dust species are combined using two numerical radiative transfer codes. The method is illustrated for both low and high mass-loss-rate sources. Specifically, we discuss different ways of assessing the dust-to-gas ratio: 1) from the dust thermal emission spectrum and the CO molecular gas line strengths, 2) from the momentum transfer from dust to gas and the measured gas terminal velocity, and 3) from the determination of the required amount of dust to reproduce water lines for a given water vapor abundance. These three diagnostics probe different zones of the outflow, for the first time allowing an investigation of a possible radial dependence of the dust-to-gas ratio.

We modeled the infrared continuum and the CO and water emission lines in OH 127.8+0.0 simultaneously. We find a dust-mass-loss rate of $(0.5 \pm 0.1) \times 10^{-6}$ $M_\odot$ yr^{-1} and a water ice fraction of 16% ±2% with a crystalline-to-amorphous ratio of 0.8 ± 0.2. The gas temperature structure is modeled with a power law, leading to a constant gas-mass-loss rate between 2×10^{-5} $M_\odot$ yr^{-1}, and 1×10^{-4} $M_\odot$ yr^{-1}, depending on the temperature profile. In addition, a change in mass-loss rate is needed to explain the $J = 1$–0 and $J = 2$–1 CO lines formed in the outer wind, where the older mass-loss rate is estimated to be 1×10^{-7} $M_\odot$ yr^{-1}. The dust-to-gas ratio found with method 1) is 0.01, accurate to within a factor of three; method 2) yields a lower limit of 0.0005; and method 3) results in an upper limit of 0.005. The water ice fraction leads to a minimum required water vapor abundance with respect to H_2 of $(1.7 \pm 0.2) \times 10^{-4}$. Finally, we report detecting 1612 MHz OH maser pumping channels in the far-infrared at 79.1, 98.7, and 162.9 μm.

Abundance predictions for a stellar atmosphere in local thermodynamic equilibrium yield a twice higher water vapor abundance ($\sim 3 \times 10^{-4}$), suggesting a 50% freeze-out. This is considerably higher than current freeze-out predictions. Regarding the dust-to-gas ratio, methods 2) and 3) probe a deeper part of the envelope, while method 1) is sensitive to the outermost regions. The latter diagnostic yields a significantly higher dust-to-gas ratio than do the two other probes. We offer several potential explanations for this behavior: a clumpy outflow, a variable mass loss, or a continued dust growth.

Accepted for publication in Astronomy & Astrophysics

Symbiotic stars and other Hα emission line stars towards the Galactic Bulge

Brent Miszalski[1,2], *Joanna Mikołajewska*[3] *and Andrzej Udalski*[4]

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

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

[3]Nicolaus Copernicus Astronomical Centre, Bartycka 18, 00716 Warsaw, Poland

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

Symbiotic stars are interacting binaries with the longest orbital periods and their multi-component structure makes them rich astrophysical laboratories. The accretion of a high mass loss rate red giant wind on to a white dwarf (WD) makes them promising Type Ia supernovæ (SNe Ia) progenitors. Systematic surveys for new Galactic symbiotic stars are critical to identify new promising SNe Ia progenitors (e.g., RS Oph) and to better estimate the total population size to compare against SNe Ia rates. Central to the latter objective is building a complete census of symbiotic stars towards the Galactic Bulge. Here we report on the results of a systematic survey of Hα emission line stars covering 35 deg^2. It is distinguished by the combination of deep optical spectroscopy and long-term lightcurves that improve the certainty of our classifications. A total of 20 bona-fide symbiotic stars are found (13 S-types, 6 D-types and 1 D′-type), 35% of which show the symbiotic specific Raman-scattered O VI emission bands, as well as 15 possible symbiotic stars that require further study (6 S-types and 9 D-types). Lightcurves show a diverse range of variability including stellar pulsations (semi-regular and Mira), orbital variations and slow changes due to dust. Orbital periods are determined for 5 S-types and Mira pulsation periods for 3 D-types. The most significant D-type found is H 1-45 and its carbon Mira with a pulsation period of 408.6 days, corresponding to an estimated period–luminosity relation distance of $\sim 6.2 \pm 1.4$ kpc and $M_{\mathrm{K}} = -8.06 \pm 0.12$ mag. If H 1-45 belongs to the Galactic Bulge, then it would be the first bona-fide luminous carbon star to be identified in the Galactic Bulge population. The lack of luminous carbon stars in the Bulge is a longstanding unsolved problem. A possible explanation for H 1-45 may be that the carbon enhancement was accreted from the progenitor of the WD companion. A wide variety of unusual emission line stars were also identified. These include central stars of PNe (one [WC10–11] Wolf–Rayet and 5 with high density cores), 2 novæ, 2 WN6 Wolf–Rayet stars, 2 possible Be stars, a B[e] star with a bipolar outflow, an ultracompact H II region and a dMe flare star. Dust obscuration events were found in two central stars of PNe, increasing the known cases to 5, as well as one WN6 star. There is considerable scope to uncover several more symbiotic stars towards the Bulge, many of which are currently misclassified as PNe, provided that deep spectroscopy is combined with optical and near-infrared lightcurves.

Published in MNRAS
Available from arXiv:1305.4863
and from http://mnras.oxfordjournals.org/content/early/2013/05/21/mnras.stt673.abstract

Evolution of thermally pulsing asymptotic giant branch stars I. The COLIBRI code

Paola Marigo[1], *Alessandro Bressan*[2], *Ambra Nanni*[2], *Léo Girardi*[3] *and Maria Letizia Pumo*[1,3]

[1]Department of Physics and Astronomy G. Galilei, University of Padova, Vicolo dell'Osservatorio 3, I-35122 Padova, Italy

[2]Astrophysics Sector, SISSA, Via Bonomea 265, I-34136 Trieste, Italy

[3]Astronomical Observatory of Padova – INAF, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy

We present the COLIBRI code for computing the evolution of stars along the TP-AGB phase. Compared to purely synthetic TP-AGB codes, COLIBRI relaxes a significant part of their analytic formalism in favour of a detailed physics applied to a complete envelope model, in which the stellar structure equations are integrated from the atmosphere down to the bottom of the hydrogen-burning shell. This allows to predict self-consistently: (i) the effective temperature, and more generally the convective envelope and atmosphere structures, correctly coupled to the changes in the surface chemical abundances and gas opacities; (ii) sphericity effects in the atmospheres; (iii) the core mass–luminosity relation and its break-down due to hot bottom burning (HBB) in the most massive AGB stars, (iv) the HBB nucleosynthesis via the solution of a complete nuclear network, (pp chains, and the CNO, NeNa, MgAl cycles), including also the production of ^{7}Li via the Cameron–Fowler beryllium transport mechanism; (v) the chemical composition of the pulse-driven

convective zone; (vi) the onset and quenching of the third dredge-up, with a suitable temperature criterion. At the same time COLIBRI pioneers new techniques in the treatment of the physics of stellar interiors. It is the first evolutionary code ever to use accurate on-the-fly computation of the equation of state for roughly 800 atoms, ions, molecules, and of the Rosseland mean opacities throughout the deep envelope. Another distinguishing aspect of COLIBRI is its high computational speed. This feature is necessary for calibrating the uncertain parameters and processes that characterize the TP-AGB phase, a step of paramount importance for producing reliable stellar population synthesis models of galaxies up to high redshift. (abridged)

Submitted to MNRAS (incorporating minor revisions recommended by the referee)
Available from arXiv:1305.4485

Dust input from AGB stars in the Large Magellanic Cloud

Svitlana Zhukovska[1,2] *and Thomas Henning*[1]

[1]Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

[2]Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Überle-Straße 2, 69120 Heidelberg, Germany

Aims: The dust-forming population of AGB stars and their input to the interstellar dust budget of the Large Magellanic Cloud (LMC) are studied with evolutionary dust models with the main goals (1) to investigate how the amount and composition of dust from AGB stars vary over the galactic history; (2) to characterise the mass and metallicity distribution of the present population of AGB stars; (3) to quantify the contribution of AGB stars of different mass and metallicity to the present stardust population in the interstellar medium (ISM).
Methods: We used models of the stardust lifecycle in the ISM developed and tested for the solar neighbourhood. The first global spatially resolved reconstruction of the star formation history of the LMC from the Magellanic Clouds Photometric Survey was employed to calculate the stellar populations in the LMC.
Results: The dust input from AGB stars is dominated by carbon grains from stars with masses below 4 $M_\odot$ almost during the entire history of the LMC. The production of silicate, silicon carbide, and iron dust is delayed until the ISM is enriched to about half the present metallicity in the LMC. For the first time, theoretically calculated dust production rates of AGB stars are compared with those derived from infrared observations of AGB stars for the entire galaxy. We find good agreement within scatter of various observational estimates. We show that the majority of silicate and iron grains in the present stardust population originate from a small population of intermediate-mass stars consisting of only about 4% of the total number of stars, whereas in the solar neighbourhood they originate from low-mass stars. With models of the lifecycle of stardust grains in the ISM we confirm the strong discrepancy between dust input from stars and the existing interstellar dust mass in the LMC reported previously.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1305.3521

Barium and yttrium abundance in intermediate-age and old open clusters

T. Mishenina[1], *S. Korotin*[1], *G. Carraro*[2,3], *V.V. Kovtyukh*[1] *and I.A. Yegorova*[2]

[1]Astronomical Observatory of Odessa National University, and Isaac Newton Institute of Chile Odessa branch, Odessa, Ukraine

[2]European Southern Observatory, Chile

[3]Dipartimento di Fisica e Astronomia, Università di Padova, Italy

Barium is a neutron capture element, that, in open clusters, is frequently over-abundant with respect to the iron. A clear explanation for this is still missing. Additionally, its gradient across the Galactic Disk is poorly constrained. We measure the abundance of yttrium and barium using the synthetic spectrum method from UVES high-resolution

spectra of eight distant open clusters, namely Ruprecht 4, Ruprecht 7, Berkeley 25, Berkeley 73, Berkeley 75, NGC 6192, NGC 6404, and NGC 6583. The barium abundance was estimated using NLTE approximation. We confirm that barium is indeed over-abundant in most clusters, especially young clusters. Finally, we investigated the trend of yttrium and barium abundances as a function of distance in the Galaxy and ages. Several scenarios for the barium over-abundance are then discussed.

Submitted to Mon. Not. R. Astron. Soc.
Available from arXiv:1305.1909

Detection of X-rays from the jet-driving symbiotic star Hen 3-1341

Matthias Stute[1], *Gerardo J.M. Luna*[2,3], *Ignazio F. Pillitteri*[3] *and Jennifer L. Sokoloski*[4]

[1]Institute for Astronomy and Astrophysics, Section Computational Physics, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany
[2]Instituto de Astronomía y Física del Espacio (CONICET–UBA), Casilla de Correo 67, Suc. 28 (C1428ZAA), Ciudad Autónoma de Buenos Aires, Argentina
[3]Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS 15, Cambridge, MA, 02138, USA
[4]Columbia Astrophysics Laboratory, 550 W. 220th Street, 1027 Pupin Hall, Columbia University, New York, NY 10027, USA

Context: Hen 3-1341 is a symbiotic binary system consisting of a white dwarf and a red giant star that is one of about ten symbiotics that show hints of jets. The bipolar jets have been detected through displaced components of emission lines during its outburst from 1998 to 2004. These components disappeared when Hen 3-1341 reached quiescence. On February 23, 2012, Hen 3-1341 started a new outburst with the emergence of new bipolar jets on March 3, 2012.
Aims: We observed Hen 3-1341 during quiescence with XMM–*Newton* in March 2010 with an effective exposure time of 46.8 ks and with Swift on March 8–11, 2012 as ToO observations with an effective exposure time of 10 ks in order to probe the interaction of the jet with the ambient medium and also the accretion onto the white dwarf.
Methods: We fitted the XMM–*Newton* X-ray spectra with XSPEC and examined the X-ray and UV light curves.
Results: We report the detection of X-ray emission during quiescence from Hen 3-1341 with XMM–*Newton*. The spectrum can be fitted with an absorbed one-temperature plasma or an absorbed blackbody. We did not detect Hen 3-1341 during our short Swift exposure. Neither periodic or aperiodic X-ray nor UV variability were found.
Conclusions: Our XMM–*Newton* data suggest that interaction of the residual jet with the interstellar medium might survive for a long time after outbursts and might be responsible for the observed X-ray emission during quiescence. Additional data are strongly needed to confirm these suggestions.

Accepted for publication in A & A
Available from arXiv:1305.3269

Impulsive ejection of gas in bipolar planetary nebulæ

Muhammad Akashi[1] *and Noam Soker*[1]

[1]Technion, Israel (IIT)

We simulate the formation of bipolar planetary nebulæ (PNe) through very short impulsive mass ejection events from binary systems, where the asymptotic giant branch (AGB) star ejects a mass shell that is accelerated by jets launched from a compact companion. The acceleration process takes place at very short distances from the binary system, such that the photon-diffusion time is long enough to prevent rapid cooling of the shocked jets' material. When the shocked jets' gas density is lower than the shell density the flow becomes Rayleigh–Taylor unstable and dense clumps are formed in the flow. At later times a PN with clumpy lobes that have a linear distance–velocity relation will be observed. This process might account for the formation of bipolar PNe with clumpy lobes, such as NGC 6302. The energy radiated during the months to years duration of such an event will appear as an intermediate-luminosity optical

transient (ILOT).

Submitted to MNRAS
Available from arXiv:1305.6264

Asteroseismic surface gravity for evolved stars

S. Hekker[1,2], Y. Elsworth[2], B. Mosser[3], T. Kallinger[4], Sarbani Basu[5], W.J. Chaplin[2] and D. Stello[6]

[1]Astronomical institute 'Anton Pannekoek', University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, The Netherlands
[2]University of Birmingham, School of Physics and Astronomy, Edgbaston, Birmingham B15 2TT, United Kingdom
[3]LESIA, UMR8109, Université Pierre et Marie Curie, Université Denis Diderot, Observatoire de Paris, 92195 Meudon Cedex, France
[4]Institute for Astronomy, University of Vienna, Türkenschanzstraße 17, A-1180 Vienna, Austria
[5]Department of Astronomy, Yale University, P.O. Box 208101, New Haven CT 06520-8101, USA
[6]Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia

Context: Asteroseismic surface gravity values can be of importance in determining spectroscopic stellar parameters. The independent $\log g$ value from asteroseismology can be used as a fixed value in the spectroscopic analysis to reduce uncertainties due to the fact that $\log g$ and effective temperature can not be determined independently from spectra. Since 2012, a combined analysis of seismically and spectroscopically derived stellar properties is ongoing for a large survey with SDSS/APOGEE and *Kepler*. Therefore, knowledge of any potential biases and uncertainties in asteroseismic $\log g$ values is now becoming important.
Aims: The seismic parameter needed to derive $\log g$ is the frequency of maximum oscillation power ($\nu_{\rm max}$). Here, we investigate the influence of $\nu_{\rm max}$ derived with different methods on the derived $\log g$ values. The large frequency separation between modes of the same degree and consecutive radial orders ($\Delta\nu$) is often used as an additional constraint for the determination of $\log(g)$. Additionally, we checked the influence of small corrections applied to $\Delta\nu$ on the derived values of $\log g$.
Methods: We use methods extensively described in the literature to determine $\nu_{\rm max}$ and $\Delta\nu$ together with seismic scaling relations and grid-based modeling to derive $\log g$.
Results: We find that different approaches to derive oscillation parameters give results for $\log g$ with small, but different, biases for red-clump and red-giant-branch stars. These biases are well within the quoted uncertainties of ~ 0.01 dex (cgs). Corrections suggested in the literature to the $\Delta\nu$ scaling relation have no significant effect on $\log g$. However somewhat unexpectedly, method specific solar reference values induce biases of the order of the uncertainties, which is not the case when canonical solar reference values are used.

Accepted for publication in A&A
Available from arXiv:1305.6586

Supernova explosions of super-asymptotic giant branch stars: multicolor light curves of electron-capture supernovæ

Nozomu Tominaga[1,2], Sergei I. Blinnikov[3,2] and Ken'ichi Nomoto[2,4]

[1]Department of Physics, Faculty of Science and Engineering, Konan University, 8-9-1 Okamoto, Kobe, Hyogo 658-8501, Japan
[2]Kavli Institute for the Physics and Mathematics of the Universe (WPI), The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan
[3]Institute for Theoretical and Experimental Physics (ITEP), Moscow 117218, Russia
[4]Department of Astronomy, School of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

An electron-capture supernova (ECSN) is a core-collapse supernova explosion of a super-asymptotic giant branch (SAGB) star with a main-sequence mass $M_{\rm ms} \sim 7$–$9.5\ {\rm M}_\odot$. The explosion takes place in accordance with core bounce and subsequent neutrino heating and is a unique example successfully produced by first-principle simulation. This allows us to derive a first self-consistent multicolor light curves of a core-collapse supernova. Adopting the explosion properties derived by the first-principle simulation, i.e., the low explosion energy of 1.5×10^{50} erg and the small ^{56}Ni mass of 2.5×10^{-3} $M_{\odot}$, we perform a multigroup radiation hydrodynamics calculation of ECSNe and present multicolor light curves of ECSNe of SAGB stars with various envelope mass and hydrogen abundance. We demonstrate that a shock breakout has peak luminosity of $L \sim 2 \times 10^{44}$ erg s^{-1} and can evaporate circumstellar dust up to $R \sim 10^{17}$ cm for a case of carbon dust, that plateau luminosity and plateau duration of ECSNe are $L \sim 10^{42}$ erg s^{-1} and $t \sim$ 60–100 days, respectively, and that a plateau is followed by a tail with a luminosity drop by ~ 4 mag. The ECSN shows a bright and short plateau that is as bright as typical Type II plateau supernovæ, and a faint tail that might be influenced by spin-down luminosity of a newborn pulsar. Furthermore, the theoretical models are compared with ECSN candidates: SN 1054 and SN 2008S. We find that SN 1054 shares the characteristics of the ECSNe. For SN 2008S, we find that its faint plateau requires a ECSN model with a significantly low explosion energy of $E \sim 10^{48}$ erg.

Accepted for publication in Astrophysical Journal Letters
Available from arXiv:1305.6813

Type Ia supernovæ inside planetary nebulæ: shaping by jets

Danny Tsebrenko[1] *and Noam Soker*[1]

[1]Technion, Israel

Using 3D numerical hydrodynamical simulations we show that jets launched prior to type Ia supernova (SN Ia) explosion in the core-degenerate (CD) scenario can account for the appearance of two opposite lobes ('Ears') along the symmetry axis of the SN remnant (SNR). In the double-degenerate (DD) and CD scenarios the merger of the two degenerate compact objects is very likely to lead to the formation of an accretion disk, that might launch two opposite jets. In the CD scenario these jets interact with the envelope ejected during the preceding common envelope phase. If explosion occurs shortly after the merger process, the exploding gas and the jets will collide with the ejected nebula, leading to SNR with axisymmetric components including 'Ears'. We also explore the possibility that the jets are launched by the companion white dwarf prior to its merger with the core. This last process is similar to the one where jets are launched in some pre-planetary nebulæ. The SNR 'Ears' in this case are formed by a spherical SN Ia explosion inside an elliptical planetary nebula-like object. We compare our numerical results with two SNRs – *Kepler* and G 299.2-2.9.

Submitted to
Available from arXiv:1305.1845

Conference Papers

A remarkable sample of new symbiotic stars towards the Galactic Bulge

Brent Miszalski[1,2], *Joanna Mikołajewska*[3] *and Andrzej Udalski*[4]

[1]South African Astronomical Observatory, P.O. Box 9, Observatory, 7935, South Africa
[2]Southern African Large Telescope Foundation, P.O. Box 9, Observatory, 7935, South Africa
[3]Nicolaus Copernicus Astronomical Centre, Bartycka 18, 00716 Warsaw, Poland
[4]Warsaw University Observatory, Al. Ujazdowskie 4, PL-00-478, Warsaw, Poland

Symbiotic stars are the longest orbital period interacting binaries, where nova-like outbursts are generated by the accretion of a high mass-loss rate red giant wind onto a white dwarf companion. Long-term photometric monitoring surveys such as OGLE and MACHO are ideal platforms to identify nova-like events in symbiotic stars, however there

are only a handful of known systems within the small footprint of these surveys. We introduce a systematic Hα emission line object survey for new symbiotic stars covering 35 deg^2 towards the Galactic Bulge that combines deep 2dF/AAΩ spectroscopy with OGLE and MACHO photometry. This powerful combination has uncovered nearly two dozen new symbiotic stars, more than a dozen probable symbiotic stars, and several other unusual Hα emission line stars. While we do not find any nova-like activity, the lightcurves do exhibit semi-regular and Mira pulsations, orbital variations and slower changes due to dust. Here we introduce a few of the new symbiotics, including H 1-45, only the fourth known carbon symbiotic Mira. This remarkable discovery may be the first luminous carbon star belonging to the Galactic Bulge, according to its period–luminosity relation distance of 6.2 ± 1.4 kpc, potentially shedding new light on the puzzling lack of luminous carbon stars in the Bulge. We also present two old novæ captured in the nebular phase, complementing other surveys to better characterise the old nova population.

Oral contribution, published in "Stella Novæ: Future and Past Decades", eds. P.A. Woudt & V.A.R.M. Ribeiro, ASP Conference Series
Available from arXiv:1305.4885

Red supergiant star studies with CO5BOLD and OPTIM3D

B. Plez[1] *and A. Chiavassa*[2]

[1]LUPM, Université Montpellier 2, CNRS, Montpellier, France
[2]Laboratoire Lagrange, Université Nice Sophia–Antipolis, CNRS, Observatoire de la Côte d'Azur, Nice, France

We describe recent work focused towards a better understanding of red supergiant stars using 3D radiative-hydrodynamics (RHD) simulations with CO5BOLD. A small number of simulations now exist that span up to seven years of stellar time, at various numerical resolutions. Our discussion concentrates on interferometric and spectroscopic observations. We point out a number of problems, in particular the line depth and line width that are not well reproduced by simulations. The most recent introduction of a non-grey treatment of the radiation field dramatically improved the match with observations, without solving all difficulties. We also review the newly revived effective temperature scale controversy, and argue that it will only be solved using 3D RHD models.

Oral contribution, published in "CO5BOLD workshop 2012", Memorie della SAIt Supplementi, Vol. 24, eds. E. Caffau & L. Sbordone
Available from arXiv:1305.6444
and from http://www.lsw.uni-heidelberg.de/co5bold/workshop/

Exploring the water and carbon monoxide shell around Betelgeuse with VLTI/AMBER

Miguel Montargès[1]*, Pierre Kervella*[1]*, Guy Perrin*[1] *and Keiichi Ohnaka*[2]

[1]LESIA, Observatoire de Paris, CNRS, UPMC, Université Paris-Diderot, 5 place Jules Janssen, 92195, Meudon, France
[2]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121, Bonn, Germany

We present the results of the analysis of our recent interferometric observations of Betelgeuse, using the AMBER instrument of the VLTI. Using the medium spectral resolution mode ($R \sim 1500$) we detected the presence of the water vapour and carbon monoxide (CO) molecules in the H and K bands. We also derived the photospheric angular diameter in the continuum. By analysing the depth of the molecular lines and the interferometric visibilities, we derived the column densities of the molecules, as well as the temperature and the size of the corresponding regions in the atmosphere of Betelgeuse (the MOLsphere) using a single shell model around the photosphere. Our results confirm the findings by Perrin et al. (2004) and Ohnaka et al. (2011) that the H_2O and CO molecules are distributed around Betelgeuse in a MOLsphere extending to approximately 1.3 times the star's photospheric radius.

Oral contribution, published in "The Physics of Red Supergiants: Recent Advances and Open Questions", Betelgeuse Workshop 2012, Paris, France
Available from arXiv:1305.6718

Job Advert

PhD position

The Instituut voor Sterrenkunde of Leuven University has a vacancy for a 4-year PhD position entitled: The circumstellar environment of evolved stars traced by molecules and dust species.

The Instituut voor Sterrenkunde (IvS) of Leuven University 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 which rely on data gathered with telescopes at international observatories and with space missions. The institute is also responsible for the organization of the Master in Astronomy & Astrophysics of the Faculty of Science at Leuven University.

With this vacancy, we are looking for a motivated PhD student to join the IvS to pursue a research program aiming at unraveling the importance of different molecules and dust species in the chemical and thermodynamical structure of the circumstellar envelope around evolved stars.

Short project description:

The project is embedded in a larger theoretical and observational effort at the IvS to study in detail the late stages of evolution of low and intermediate mass stars.

Evolved stars are important sources for the enrichment of the interstellar medium due to their dense outflows. These outflows are variable on many timescales and their physics and chemistry are not well understood. The IvS has access to unique ALMA, *Herschel*, ISO, IRAM and APEX data to study with unprecedented detail the role of different molecules and dust species in the stellar winds of evolved stars. E.g., *Herschel* gives us for the first time a full inventory of water both in the gas phase and in the form of solid water ice. Water plays a pivotal role in the physics and chemistry of the molecular envelopes that surround AGB stars. In December 2012, the first (cycle 0) ALMA interferometric observations were obtained. ALMA will provide the astronomical community with a unique instrument in terms of sensitivity and spatial resolution. The goal of the present PhD project is to study the role of different molecules (H_2O, CO, HCN, ...), their isotopologues and dust species in the chemical and thermodynamical structure of the envelopes of stars with a wide range in stellar wind properties. Deriving the isotope ratios will shed light on the role of nucleosynthesis and different dredge-up processes in the stellar core/atmosphere. From the ALMA observations, one can study the dust condensation regions and trace the dust distribution. Depending on the interest of the successful candidate, this PhD project can either have a more theoretical or a more observational accent.

The *Herschel* and ALMA observations, will be complemented with already obtained ground-based high-resolution sub-millimeter single-dish and interferometric data of several molecules excited in the stellar wind of AGB stars.

Profile

The candidate

- has a Master diploma in Astrophysics, Physics or Mathematics;
- has good knowledge of the English language.

Tasks

- The PhD student shall perform research in the framework of the defined PhD project;
- The PhD student shall take up a teaching assistance task of 4 hours per week in the Bachelor of Physics (Dutch) or in the Master of Astronomy & Astrophysics (English);

- The PhD student shall perform at least one observing run of two weeks per year for the pooled IvS programmes at the Mercator telescope of La Palma (Spain) as part of his/her PhD education and as part of this specific PhD project.

Contract

- Following the usual procedure at Leuven University, the initial contract runs over two years and will be prolonged with another two years after positive evaluation. The position starts preferentially on the 1^{st} of September 2013;
- Salary is according to the university regulations for PhD positions (roughly 1600 Euro per month net tax-free salary, depending on age and experience).

Applications

Send curriculum vitæ and a 1-page motivation letter, in PDF format, to

Prof. Leen Decin
Leen.Decin@ster.kuleuven.be

The candidates also must arrange for two letters of recommendation to be sent electronically to the same email address.

The application and recommendation letter deadline is 21^{st} June 2013. Only complete applications will be considered.

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

Announcements

SHAPE **version 5 software β release**

The new version of the morpho-kinematic 3D modeling software SHAPE will be released for beta testing an application on June 7, 2013. Since its last official release in 2010 a number new features and general improvements have been added. Among the new features are modules for hydrodynamic simulations, magnetic and gravitational fields, as well as many new tools to improve the 3D morpho-kinematic modeling easier and more accurate. SHAPE now includes the capability to do explicit radiative transfer for CO molecules (based on code originally developed by M. Santander-García) and several types of dust. Hopefully existing and new users help us to test the software on a variety of astrophysical problems in order to finish the final release in time for the APN VI conference in November. More details about this release of SHAPE can be found at: http://www.astrosen.unam.mx/shape/v5

Don't hesitate to contact us about any aspect concerning SHAPE.

Wolfgang Steffen (wsteffen@astro.unam.mx)
Nico Koning (nico.koning@ucalgary.ca)

See also http://www.astrosen.unam.mx/shape/v5

DDSCAT **7.3.0 for light scattering by irregular targets**

A new release of DDSCAT – DDSCAT 7.3.0 – is available. DDSCAT is a F90 code to calculate light scattering and absorption by irregular targets. This release supersedes DDSCAT 7.2.2 New features include the "Filtered Coupled Dipole" method as a user-selectable option, as well as the ability to efficiently calculate near-field E and B if desired by the user. The complete source code, UserGuide, and example calculations are available from http://code.google.com/p/ddscat/

See also http://adsabs.harvard.edu/abs/2013arXiv1305.6497D