THE AGB NEWSLETTER

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

Official publication of the IAU Working Group on Red Giants and Supergiants

No. 283 — 3 February 2021

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 283rd issue of the AGB Newsletter, with a variety of interesting topics.

No fewer than four meetings are being announced, all virtual. In June and July there is a School for research students on fluid dynamics of stars. At the start of July there is a special session at the European Astronomical Society annual congress on red supergiants. The other two meetings concern red giants and supergiants in general, the first of which takes place in April and the second one in June – the latter is a meeting our Working Group and IAU Commission G3 ("Stellar Evolution") are organising with the aim of writing a White Paper. Each of these meetings offers great opportunities, especially for junior scientists and also for those who might find it difficult to attend in-situ meetings at the best of times.

Some of us might wish they were still looking for an exciting postdoctoral position, as several have come up in Sweden in a fantastic team – do check out the advertisement.

Last month's Food for Thought addressed the relation between convection and pulsation. To push this a bit further, this month's Food for Thought carries on from that question. We eagerly await your input!

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

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

Food for Thought

This month's thought-provoking statement is:

How does convection affect pulsation, and vice versa?

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

Refereed Journal Papers

Magnesium and silicon in interstellar dust: X-ray overview

Daniele Rogantini[1,2,3], *Elisa Costantini*[1,2], *Sascha Zeegers*[1,4], *Missagh Mehdipour*[1], *Ioanna Psaradaki*[1,2], *Ton Raassen*[1,2], *Cor de Vries*[1] *and Rens Waters*[1,2]

[1]SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584, CA Utrecht, The Netherlands

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

[3]MIT Kavli Institute for Astrophysics and Space Research, Cambridge, MA 02139, USA

[4]Academia Sinica Institute of Astronomy and Astrophysics, 11F of AS/NTU Astronomy–Mathematics Building, No. 1, Section 4, Roosevelt Rd., Taipei10617, Taiwan

The dense Galactic environment is a large reservoir of interstellar dust. Therefore, this region represents a perfect laboratory to study the properties of cosmic dust grains. X-rays are the most direct way to detect the interaction of light with dust present in these dense environments. The interaction between the radiation and the interstellar matter imprints specific absorption features on the X-ray spectrum. We study them with the aim of defining the chemical composition, the crystallinity, and structure of the dust grains that populate the inner regions of the Galaxy. We investigated the magnesium and the silicon K-edges detected in the *Chandra*/HETG spectra of eight bright X-ray binaries, distributed in the neighbourhood of the Galactic centre. We modelled the two spectral features using accurate extinction cross-sections of silicates, which we measured at the synchrotron facility Soleil, France. Near the Galactic centre, magnesium and silicon show abundances similar to the solar ones and they are highly depleted from the gas phase ($\delta_{\rm Mg} > 0.90$ and $\delta_{\rm Si} > 0.96$). We find that amorphous olivine with a composition of $MgFeSiO_4$ is the most representative compound along all lines of sight according to our fits. The contribution of Mg-rich silicates and quartz is low (less than 10%). On average we observe a percentage of crystalline dust equal to 11%. For the extragalactic source LMC X-1, we find a preference for forsterite, a magnesium-rich olivine. Along this line of sight we also observe an under-abundance of silicon $A_{\rm Si}/A_{\rm LMC} = 0.5 \pm 0.2$.

Published in Astronomy & Astrophysics, 641, A149 (2020)
Available from https://arxiv.org/abs/2007.03329
and from https://ui.adsabs.harvard.edu/abs/2020A%26A...641A.149R/abstract

ExoMol line lists – XXXIX. Ro-vibrational molecular line list for CO_2

S.N. Yurchenko[1], *Thomas M. Mellor*[1], *Richard S. Freedman*[2,3] *and J. Tennyson*[1]

[1]Department of Physics and Astronomy, University College London, Gower Street, WC1E 6BT London, UK

[2]NASA Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035-1000, USA

[3]SETI Institute, Mountain View, CA, USA

A new hot line list for the main isotopologue of CO_2 is presented. The line list consists of almost 2.5 billion transitions between 3.5million rotation-vibration states of CO_2 in its ground electronic state, covering the wavenumber range 0–20 000 cm^{-1} ($\lambda > 0.5$ μm) with the upper and lower energy thresholds of 36 000 cm^{-1} and 16 000 cm^{-1}, respectively. The ro-vibrational energies and wavefunctions are computed variationally using the accurate empirical potential energy surface Ames-2. The rovibrational transition probabilities in the form of Einstein coefficients are computed using an accurate ab initio dipole moment surface with variational program TROVE. A new implementation of TROVE which uses an exact nuclear-motion kinetic energy operator is employed. Comparisons with the existing hot line lists are presented. The line list should be useful for atmospheric retrievals of exoplanets and cool stars. The UCL-4000 line list is available from the CDS and ExoMol data bases.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2007.02122
and from https://doi.org/10.1093/mnras/staa1874

Infrared spectra of pyroxenes (crystalline chain silicates) at room temperature

J.E. Bowey[1], *A.M. Hofmeister*[2] *and E. Keppel*[2]

[1]School of Physics and Astronomy, Cardiff University, Queen's Buildings, The Parade, Cardiff CF24 3AA, Wales

[2]Department of Earth and Planetary Sciences, Washington University, 1 Brookings Drive, St. Louis MO 63130, USA

Crystals of pyroxene are common in meteorites but few compositions have been recognized in astronomical environments due to the limited chemistries included in laboratory studies. We present quantitative room-temperature spectra of 17 Mg-, Fe- and Ca-bearing ortho- and clinopyroxenes, and a Ca-pyroxenoid in order to discern trends indicative of crystal structure and a wide range of composition. Data are produced using a Diamond Anvil Cell: our band strengths are up to 6 times higher than those measured in KBr or polyethylene dispersions, which include variations in path length (from grain size) and surface reflections that are not addressed in data processing. Pyroxenes have varied spectra: only two bands, at 10.22 μm and 15.34 μm in enstatite (En_{99}), are common to all. Peak-wavelengths generally increase as Mg is replaced by Ca or Fe. However, two bands in MgFe-pyroxenes shift to shorter wavelengths as the Fe component increases from 0 to 60 per cent. A high-intensity band shifts from 11.6 μm to 11.2 μm and remains at 11.2 μm as Fe increases to 100 per cent; it resembles an astronomical feature normally identified with olivine or forsterite. The distinctive pyroxene bands between 13 and 16 μm show promise for their identification in Mid-Infrared-Instrument (MIRI) spectra obtained with the *James Webb* Space Telescope (JWST). The many pyroxene bands between 40 and 80 μm could be diagnositic of silicate mineralogy if data were obtained with the proposed Space Infrared Telescope for Cosmology and Astrophysics (SPICA). Our data indicate that comparison between room-temperature laboratory bands for enstatite and cold ~ 10 K astronomical dust features at wavelengths $\gtrsim 28$ μm can result in the identification of (Mg,Fe)-pyroxenes that contain 7–15 per cent less Fe than their true values because some temperature shifts mimic some compositional shifts. Therefore some astronomical silicates may contain more Fe, and less Mg, than previously thought.

Published in MNRAS
Available from https://arxiv.org/abs/2007.13557
and from https://doi.org/10.1093/mnras/staa2227

Modelling R Coronæ Borealis stars: effects of He-burning shell temperature and metallicity

Courtney L. Crawford[1], *Geoffrey C. Clayton*[1], *Bradley Munson*[1], *Emmanouil Chatzopoulos*[1] *and Juhan Frank*[1]

[1]Louisiana State University, Baton Rouge, LA 70803, USA

The R Coronæ Borealis (RCB) stars are extremely hydrogen-deficient carbon stars that produce large amounts of dust, causing sudden deep declines in brightness. They are believed to be formed primarily through white dwarf mergers. In this paper, we use MESA to investigate how post-merger objects with a range of initial He-burning shell temperatures from 2.1–5.4 $\times 10^8$ K with solar and subsolar metallicities evolve into RCB stars. The most successful model of these has subsolar metallicity and an initial temperature near 3×10^8 K. We find a strong dependence on initial He-burning shell temperature for surface abundances of elements involved in the CNO cycle, as well as differences in effective temperature and radius of RCBs. Elements involved in nucleosynthesis present around 1 dex diminished surface abundances in the 10 per cent solar metallicity models, with the exception of carbon and lithium that are discussed in detail. Models with subsolar metallicities also exhibit longer lifetimes than their solar counterparts. Additionally, we find that convective mixing of the burned material occurs only in the first few years of post-merger evolution, after which the surface abundances are constant during and after the RCB phase, providing evidence for why these stars show a strong enhancement of partial He-burning products.

Published in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2007.03076

The pulsational properties of ultra-massive DB white dwarfs with carbon–oxygen cores coming from single-star evolution

Alejandro H. Córsico[1,2], *Leandro G. Althaus*[1,2], *Pilar Gil Pons*[3] *and Santiago Torres*[3,4]

[1]Grupo de Evolución Estelar y Pulsaciones. Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata,Paseo del Bosque s/n, 1900 La Plata, Argentina

[2]Instituto de Astrofísica La Plata, IALP (CCT La Plata), CONICET–UNLP, Argentina

[3]Departament de Física, Universitat Politècnica de Catalunya, c/Esteve Terrades 5, 08860 Castelldefels, Spain

[4]Institute for Space Studies of Catalonia, c/Gran Capita 2–4, Edif. Nexus 104, 08034 Barcelona, Spain

Ultra-massive white dwarfs are relevant for many reasons: their role as type Ia supernova progenitors, the occurrence of physical processes in the asymptotic giant branch phase, the existence of high-field magnetic white dwarfs, and the occurrence of double white dwarf mergers. Some hydrogen-rich ultra-massive white dwarfs are pulsating stars and, as such, they offer the possibility of studying their interiors through asteroseismology. On the other hand, pulsating helium-rich ultra-massive white dwarfs could be even more attractive objects for asteroseismology if they were found, as they should be hotter and less crystallized than pulsating hydrogen-rich white dwarfs, something that would pave the way for probing their deep interiors. We explore the pulsational properties of ultra-massive helium-rich white dwarfs with carbon–oxygen and oxygen–neon cores resulting from single stellar evolution. Our goal is to provide a theoretical basis that could eventually help to discern the core composition of ultra-massive white dwarfs and the scenario of their formation through asteroseismology, anticipating the possible future detection of pulsations in these types of stars. We focus on three scenarios for the formation of ultra-massive white dwarfs. First, we consider stellar models coming from two recently proposed single-star evolution scenarios for the formation of ultra-massive white dwarfs with carbon-oxygen cores that involve the rotation of the degenerate core after core helium burning and reduced mass-loss rates in massive asymptotic giant branch stars. Finally, we contemplate ultra-massive oxygen–neon core white-dwarf models resulting from standard single-star evolution. We compute the adiabatic pulsation gravity-mode periods for models in a range of effective temperatures, embracing the instability strip of average-mass pulsating helium-rich white dwarfs, and we compare the characteristics of the mode-trapping properties for models of different formation scenarios through the analysis of the period spacing. Given that the white dwarf models coming from the three scenarios considered are characterized by distinct core chemical profiles, we find that their pulsation properties are also different, thus leading to distinctive signatures in the period-spacing and mode-trapping properties. Our results indicate that in the case of an eventual detection of pulsating ultra-massive helium-rich white dwarfs, it would be possible to derive valuable information encrypted in the core of these stars in connection with the origin of such exotic objects. This is of the utmost importance regarding recent evidence for the existence of a population of ultra-massive white dwarfs with carbon–oxygen cores. There will soon be many opportunities to detect pulsations in these stars through observations collected with ongoing space missions.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2012.10953

A new instability domain of CNO-flashing low-mass He-core stars on their early white-dwarf cooling branches

Leila M. Calcaferro[1,2], *Alejandro H. Córsico*[1,2], *Leandro G. Althaus*[1,2] *and Keaton J. Bell*[3,4]

[1]Grupo de Evolución Estelar y Pulsaciones. Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina

[2]Instituto de Astrofísica La Plata, IALP (CCT La Plata), CONICET–UNLP, Argentina

[3]DIRAC Institute, Department of Astronomy, University of Washington, Seattle, WA-98195, USA

[4]NSF Astronomy and Astrophysics Postdoctoral Fellow and DIRAC Fellow

Before reaching their quiescent terminal white-dwarf cooling branch, some low-mass helium-core white dwarf stellar models experience a number of nuclear flashes which greatly reduce their hydrogen envelopes. Just before the occurrence of each flash, stable hydrogen burning may be able to drive global pulsations that could be relevant to shed some light on the internal structure of these stars through asteroseismology, similar to what happens with other classes of pulsating white dwarfs. We present a pulsational stability analysis applied to low-mass helium-core stars on their early white-dwarf cooling branches going through CNO flashes in order to study the possibility that the ε mechanism is able to excite gravity-mode pulsations. We assess the ranges of unstable periods and the corresponding instability domain

in the $\log g$–$T_{\rm eff}$ plane. We carried out a nonadiabatic pulsation analysis for low-mass helium-core white-dwarf models with stellar masses between 0.2025 and 0.3630 $M_\odot$ going through CNO flashes during their early cooling phases. We found that the ε mechanism due to stable hydrogen burning can excite low-order ($\ell = 1, 2$) gravity modes with periods between $\sim$ 80 and 500 s, for stars with $0.2025 \lesssim M_\star/M_\odot \lesssim 0.3630$ located in an extended region of the $\log g$–$T_{\rm eff}$ diagram with effective temperature and surface gravity in the ranges $15\,000 \lesssim T_{\rm eff} \lesssim 38\,000$ K and $5.8 \lesssim \log g \lesssim 7.1$, respectively. For the sequences that experience multiple CNO flashes, we found that with every consecutive flash, the region of instability becomes wider, and the modes, more strongly excited. The magnitudes of the rate of period change for these modes are in the range $\sim 10^{-10}$–10^{-11} [s/s]. Since the timescales required for these modes to reach amplitudes large enough to be observable are shorter than their corresponding evolutionary timescales, the detection of pulsations in these stars is feasible. Given the current problems in distinguishing some stars that are populating the same region of the $\log g$–$T_{\rm eff}$ plane, the eventual detection of short-period pulsations may help in the classification of such stars. Furthermore, if a low-mass white dwarf star were found to pulsate with low-order gravity modes in this region of instability, it would confirm our result that such pulsations can be driven by the ε mechanism. In addition, confirming a rapid rate of period change in these pulsations would support that these stars actually experience CNO flashes, as predicted by evolutionary calculations.

Accepted for publication in Astronomy and Astrophysics

Near-infrared and optical observations of type Ic SN 2020oi and broad-lined Ic SN 2020bvc: carbon monoxide, dust and high-velocity supernova ejecta

J. Rho[1], *A. Evans*[2], *T.R. Geballe*[3], *D.P.K. Banerjee*[4], *P. Höflich*[5], *M. Shahbandeh*[5], *S. Valenti*[6], *S.-C. Yoon*[7], *H. Jin*[7], *M. Williamson*[8], *M. Modjaz*[8], *D. Hiramatsu*[9,10], *D.A. Howell*[9,10], *C. Pellegrino*[9,10], *J. Vinkó*[11,12,13], *R. Cartier*[14], *J. Burke*[9,10], *C. McCully*[9,10], *H. An*[15], *H. Cha*[15], *T. Pritchard*[8], *X. Wang*[16,17], *J. Andrews*[18], *L. Galbany*[19], *S. Van Dyk*[20], *M.L. Graham*[21], *S. Blinnikov*[22,23,24], *V. Joshi*[4], *A. Pál*[11,13,25], *L. Kriskovics*[11,13], *A. Ordash*[11], *R. Szakats*[11], *K. Vida*[11,13], *Z. Chen*[16], *X. Li*[16], *J. Zhang*[26] *and S. Yan*[16]

[1]SETI Institute, 189 Bernardo Ave., Ste. 200, Mountain View, CA 94043, USA

[2]Astrophysics Group, Keele University, Keele, Staffordshire, ST5 5BG, UK

[3]Gemini Observatory/NSF's National Optical–Infrared Astronomy Research Laboratory, 670 N. Aohoku Place, Hilo, HI, 96720, USA

[4]Physical Research Laboratory, Navrangpura, Ahmedabad, Gujarat 380009, India

[5]Florida State University, Tallahassee, FL 32309, USA

[6]Department of Physics, University of California, Davis, CA 95616, USA

[7]Department of Physics and Astronomy, Seoul National University, Gwanak-ro 1, Gwanak-gu, Seoul, 08826, South Korea

[8]Center for Cosmology and Particle Physics, New York University, 726 Broadway, NY, NY 11201, USA

[9]Las Cumbres Observatory, 6740 Cortona Drive, Suite 102, Goleta, CA 93117-5575, USA

[10]Department of Physics, University of California, Santa Barbara, CA 93106-9530, USA

[11]CSFK Konkoly Observatory, Konkoly-Thege M. ut 15–17, Budapest, 1121, Hungary

[12]Department of Optics and Quantum Electronics, University of Szeged, Dóm tór 9, Szeged, 6720 Hungary

[13]ELTE Eötvös Loránd University, Institute of Physics, Pázmany Péter sétány 1/A, Budapest, 1117, Hungary

[14]CTIO, NSF's National Optical-Infrared Astronomy Research Laboratory, Casilla 603, La Serena, Chile

[15]Department of Astronomy and Space Science, Chungbuk National University, Cheongju, 28644, South Korea

[16]Physics Department, Tsinghua University, Beijing, 100084, China

[17]Beijing Planetarium, Beijing Academy of Science and Technology, Beijing, 100089, China

[18]Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

[19]Departamento de Física Teórica y del Cosmos, Universidad de Granada, E-18071 Granada, Spain

[20]Caltech/IPAC, Mailcode 100-22, Pasadena, CA 91125, USA

[21]DiRAC Institute, Department of Astronomy, University of Washington, Box 351580, U.W., Seattle WA 98195, USA

[22]NRC Kurchatov Institute – ITEP, Moscow, 117218, Russia

[23]Sternberg Astronomical Institute (SAI) of Lomonosov Moscow State University, Moscow, 117218, Russia

[24]Dukhov Automatics Research Institute (VNIIA), Moscow, 127055, Russia

[25]ELTE Eötvös Loränd University, Department of Astronomy, Pázmány Péter sťný 1/A, Budapest, 1117, Hungary

[26]Yunnan Observatories, Chinese Academy of Sciences, Kunming, 650216, China

We present near-infrared and optical observations of the type Ic Supernova (SN) 2020oi in the galaxy M 100 and

the broad-lined type Ic SN 2020bvc in UGC 9379, using Gemini, LCO, SOAR, and other ground-based telescopes. The near-IR spectrum of SN 2020oi at day 63 since the explosion shows strong CO emissions and a rising K-band continuum, which is the first unambiguous dust detection from a type Ic SN. Non-LTE CO modeling shows that CO is still optically thick, and that the lower limit to the CO mass is 10^{-3} $M_\odot$. The dust temperature is 810 K, and the dust mass is $\sim 10^{-5}$ $M_\odot$. We explore the possibilities that the dust is freshly formed in the ejecta, heated dust in the pre-existing circumstellar medium, and an infrared echo. The light curves of SN 2020oi are consistent with a STELLA model with canonical explosion energy, 0.07 $M_\odot$ Ni mass, and 0.7 $M_\odot$ ejecta mass. A model of high explosion energy of 10^{52} erg, 0.4 $M_\odot$ Ni mass, 6.5 $M_\odot$ ejecta mass with the circumstellar matter, reproduces the double-peaked light curves of SN 2020bvc. We observe temporal changes of absorption features of the IR Ca II triplet, S I at 1.043 μm, and Fe II at 5169 Å. The blue-shifted lines indicate high velocities, up to 60,000 km s^{-1} for SN 2020bvc and 20,000 km s^{-1} for SN 2020oi, and the expansion velocity rapidly declines before the optical maximum. We present modeled spectral signatures and diagnostics of CO and SiO molecular bands between 1.4 and 10 μm.

Accepted for publication in The Astrophysical Journal
Available from https://arxiv.org/abs/2010.00662

86-GHz SiO masers in Galactic centre OH/IR stars

Maria Messineo[1,3], *Lorant O. Sjouwerman*[2], *Harm J. Habing*[3] *and Alain Omont*[4]

[1]University of Science and Technology of China, China
[2]National Radio Astronomy Observatory, USA
[3]Leiden Observatory, The Netherlands
[4]Institut d'Astrophysique de Paris, France

We present results on a search for 86.243-GHz SiO ($J = 2$–1, $v = 1$) maser emission toward 67 OH/IR stars located near the Galactic centre. We detected 32 spectral peaks, of which 28 correspond to SiO maser lines arising from the envelopes of these OH/IR stars. In OH/IR stars, we obtained an SiO maser detection rate of about 40%. We serendipitously detected two other lines from OH/IR stars at $\sim$ 86.18 GHz, which could be due to a CCS-molecule transition at 86.181 GHz or probably to a highly excited OH molecular transition at 86.178 GHz. The detection rate of 86-GHz maser emission is found to be about 60% for sources with the Midcourse Space Experiment (MSX) $(A-E) < 2.5$ mag; but it drops to 25% for the reddest OH/IR stars with MSX $(A-E) > 2.5$ mag. This supports the hypothesis by Messineo (2002, A&A, 393, 115) that the SiO masers are primarily found in relatively thinner circumstellar material.

Published in Publ. Astron. Soc. Japan
Available from https://arxiv.org/abs/2007.03398

The luminosity evolution of nova shells – I. A new analysis of old data

C. Tappert[1], *N. Vogt*[1], *A. Aderoclite*[2], *L. Schmidtobreick*[3], *M. Vučković*[1] *and L.L. Becegato*[2]

[1]Instituto de Física y Astronomía, Universidad de Valparaíso, Chile
[2]Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, São Paulo, Brazil
[3]European Southern Observatory, Santiago, Vitacura, Chile

Over the last decade, nova shells have been discovered around a small number of cataclysmic variables that had not been known to be post-novæ, while other searches around much larger samples have been mostly unsuccessful. This raises the question about how long such shells are detectable after the eruption and whether this time limit depends on the characteristics of the nova. So far, there has been only one comprehensive study of the luminosity evolution of nova shells, undertaken almost two decades ago. Here, we present a re-analysis of the Hα and [O III] flux data from that study, determining the luminosities while also taking into account newly available distances and extinction values, and including additional luminosity data of "ancient" nova shells. We compare the long-term behaviour with respect to nova speed class and light curve type. We find that, in general, the luminosity as a function of time can be described as consisting of three phases: an initial shallow logarithmic decline or constant behaviour, followed by a logarithmic main

decline phase, with a possible return to a shallow decline or constancy at very late stages. The luminosity evolution in the first two phases is likely to be dominated by the expansion of the shell and the corresponding changes in volume and density, while for the older nova shells, the interaction with the interstellar medium comes into play. The slope of the main decline is very similar for almost all groups for a given emission line, but it is significantly steeper for [O III], compared to Hα, which we attribute to the more efficient cooling provided by the forbidden lines. The recurrent novae are among the notable exceptions, along with the plateau light curve type novæ and the nova V838 Her. We speculate that this is due to the presence of denser material, possibly in the form of remnants from previous nova eruptions, or of planetary nebulæ, which might also explain some of the brighter ancient nova shells. While there is no significant difference in the formal quality of the fits to the decline when grouped according to light curve type or to speed class, the former presents less systematic scatter. It is also found to be advantageous in identifying points that would otherwise distort the general behaviour. As a by-product of our study, we revised the identification of all novæ included in our investigation with sources in the Gaia Data Release 2 catalogue.

Published in Astronomy & Astrophysica, 641, A122 (2020)
Available from https://arxiv.org/abs/2007.10940

The five axes of the Turtle: symmetry and asymmetry in NGC 6210

William J. Henney[1], *J.A. López*[2], *Ma.T. García-Díaz*[2] *and M.G. Richer*[2]

[1]Instituto de Radioastronomía y Astrofísica, UNAM, Morelia, México
[2]Instituto de Astronomía, UNAM, Ensenada, México

We carry out a comprehensive kinematic and morphological study of the asymmetrical planetary nebula: NGC 6210, known as the Turtle. The nebula's spectacularly chaotic appearance has led to proposals that it was shaped by mass transfer in a triple star system. We study the three-dimensional structure and kinematics of its shells, lobes, knots, and haloes by combining radial velocity mapping from multiple long-slit spectra with proper motion measurements from multi-epoch imaging. We find that the nebula has five distinct ejection axes. The first is the axis of the bipolar, wind-blown inner shell, while the second is the axis of the lop-sided, elliptical, fainter, but more massive intermediate shell. A further two axes are bipolar flows that form the point symmetric, high-ionization outer lobes, all with inclinations close to the plane of the sky. The final axis, which is inclined close to the line of sight, traces collimated outflows of low-ionization knots. We detect major changes in outflow direction. during the planetary nebula phase, starting at or before the initial ionization of the nebula 3500 years ago. Most notably, the majority of redshifted low-ionization knots have kinematic ages greater than 2000 years, whereas the majority of blueshifted knots have ages younger than 2000 years. Such a sudden and permanent 180° flip in the ejection axis at a relatively late stage in the nebular evolution is a challenge to models of planetary nebula formation and shaping.

Published in MNRAS
Available from https://arxiv.org/abs/2012.14893
and from https://doi.org/10.1093/mnras/staa4014

Common-envelope evolution with an asymptotic giant branch star

C. Sand[1], *S.T. Ohlmann*[2], *F.R.N. Schneider*[3,1], *R. Pakmor*[4] *and F.K. Röpke*[1,5]

[1]Heidelberger Institut für Theoretische Studien, Schloß-Wolfsbrunnenweg 35, 69118 Heidelberg, Germany
[2]Max Planck Computing and Data Facility, Gießenbachstr. 2, 85748 Garching bei München, Germany
[3]Zentrum für Astronomie der Universität Heidelberg, Astronomisches Rechen-Institut, Mönchhofstr. 12–14, 69120 Heidelberg, Germany
[4]Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Str. 1, 85748 Garching bei München, Germany
[5]Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Philosophenweg 12, 69120 Heidelberg, Germany

Common-envelope phases are decisive for the evolution of many binary systems. Cases with asymptotic giant branch (AGB) primary stars are of particular interest because they are thought to be progenitors of various astrophysical transients. In three-dimensional hydrodynamic simulations with the moving-mesh code AREPO, we study the common-envelope evolution of a 1.0 $M_\odot$ early-AGB star with companions of different masses. Although the stellar envelope of an AGB star is less tightly bound than that of a red giant, we find that the release of orbital energy of the core binary is insufficient to eject more than about twenty percent of the envelope mass. Ionization energy that is released in the expanding envelope, however, can lead to complete envelope ejection. Because recombination proceeds largely at high optical depths in our simulations, it is likely that this effect indeed plays a significant role in the considered systems. The efficiency of mass loss and the final orbital separation of the core binary system depend on the mass ratio between the companion and the primary star. Our results suggest a linear relation between the ratio of final to initial orbital separation and this parameter.

Published in A&A, 644, A60 (2020)
Available from https://arxiv.org/abs/2007.11000
and from https://doi.org/10.1051/0004-6361/202038992

Evolved massive stars at low metallicity – IV. Using 1.6 μm "H-bump" to identify red supergiant stars: a case study of NGC 6822

Ming Yang[1], *Alceste Z. Bonanos*[1], *Biwei Jiang*[2], *Man I Lam*[3], *Jian Gao*[2], *Panagiotis Gavras*[4], *Grigoris Maravelias*[1,5], *Shu Wang*[6], *Xiao-Dian Chen*[6], *Frank Tramper*[1], *Yi Ren*[2] *and Zoi T. Spetsieri*[1]

[1]IAASARS, National Observatory of Athens, Vas. Pavlou and I. Metaxa, Penteli 15236, Greece
[2]Department of Astronomy, Beijing Normal University, Beijing 100875, China
[3]Key Laboratory of Space Astronomy and Technology, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China
[4]Rhea Group for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
[5]Institute of Astrophysics, Foundation for Research and Technology–Hellas, Heraklion 71110, Greece
[6]CAS Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Datun Road 20A, Beijing 100101, China

We present a case study of using a novel method to identify red supergiant (RSG) candidates in NGC 6822, based on their 1.6 μm "H-bump". We collected 32 bands of photometric data for NGC 6822 ranging from optical to mid-infrared (MIR), derived from Gaia, PS1, LGGS, VHS, UKIRT, IRSF, HAWK-I, *Spitzer*, and WISE. By using the theoretical spectra from MARCS, we demonstrate that there is a prominent difference around 1.6 μm ("H-bump") between low-surface-gravity (LSG) and high-surface-gravity (HSG) targets. Taking advantage of this feature, we identify efficient color–color diagrams (CCDs) of rzH ($r-z$ versus $z-H$) and rzK ($r-z$ versus $z-K$) to separate HSG (mostly foreground dwarfs) and LSG targets (mainly background red giant stars (RGs), asymptotic giant branch stars (AGBs), and RSGs) from crossmatching of optical and near-infrared (NIR) data. Moreover, synthetic photometry from ATLAS9 also give similar results. Further separating RSG candidates from the rest of the LSG candidates as determined by the "H-bump" method is done by using semi-empirical criteria on NIR color–magnitude diagrams (CMDs), where both the theoretic cuts and morphology of the RSG population are considered and resulted in 323 RSG candidates. Meanwhile, the simulation of foreground stars from Besançon models also indicates that our selection criteria is largely free from the contamination of Galactic giants. In addition to the "H-bump" method, we also use the traditional BVR method ($B-V$ versus $V-R$) as a comparison and/or supplement, by applying a slightly aggressive cut to select as much as possible RSG candidates (358 targets). Furthermore, the Gaia astrometric solution is used to constrain the sample, where 181 and 193 targets were selected from the "H-bump" and BVR method, respectively. The percentages of selected targets in both methods are similar as $\sim 60\%$, indicating the comparable accuracy of the two methods. In total, there are 234 RSG candidates after combining targets from both methods with 140 ($\sim 60\%$) of them in common. The final RSG candidates are in the expected locations on the MIR CMDs with $[3.6]-[4.5] \lesssim 0$ mag and $J-[8.0] \approx 1.0$ mag. The spatial distribution is also coincident with the far-ultraviolet-selected star formation regions, suggesting the selection is reasonable and reliable. We indicate that our method also can be used to identify other LSG targets like RGs and AGBs, as well as applied to most of the nearby galaxies by utilizing the recent large-scale ground-based surveys. Future ground and space facilities may promote its application beyond the Local Group.

Accepted for publication in A&A
Available from https://arxiv.org/abs/2101.08689

How Jupiters save or destroy inner Neptunes around evolved stars

María Paula Ronco[1,2], Matthias R. Schreiber[3,2], Cristian A. Giuppone[4], Dimitri Veras[5,6], Jorge Cuadra[7,2] and Octavio M. Guilera[8,1,2]

[1]Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, Macul, Santiago, 8970117 , Chile
[2]Núcleo Milenio de Formación Planetaria
[3]Instituto de Física y Astronomía, Universidad de Valparaíso, Valparaíso, Chile
[4]Universidad Nacional de Córdoba, Observatorio Astronómico – IATE, Laprida 854, 5000 Córdoba, Argentina
[5]Centre for Exoplanets and Habitability, University of Warwick, Coventry CV4 7AL, UK
[6]Department of Physics, University of Warwick, Coventry CV4 7AL, UK
[7]Departamento de Ciencias, Facultad de Artes Liberales, Universidad Adolfo Ibáñez, Avenida Padre Hurtado 750, Viña del Mar, Chile
[8]Instituto de Astrofísica de La Plata, CONICET–UNLP, La Plata, Argentina

In about 6 Giga years our Sun will evolve into a red giant and finally end its life as a white dwarf. This stellar metamorphosis will occur to virtually all known host stars of exo-planetary systems and is therefore crucial for their final fate. It is clear that the innermost planets will be engulfed and evaporated during the giant phase and that planets located farther out will survive. However, the destiny of planets in-between, at $\sim$ 1–10 au, has not yet been investigated with a multi-planet tidal treatment. We here combine for the first time multi-planet interactions, stellar evolution, and tidal effects in an N-body code to study the evolution of a Neptune–Jupiter planetary system. We report that the fate of the Neptune-mass planet, located closer to the star than the Jupiter-mass planet, can be very different from the fate of a single Neptune. The simultaneous effects of gravitational interactions, mass loss and tides can drive the planetary system towards mean motion resonances. Crossing these resonances affects particularly the eccentricity of the Neptune and thereby also its fate, which can be engulfment, collision with the Jupiter-mass planet, ejection from the system, or survival at a larger separation.

Published in The Astrophysical Journal Letters
Available from https://arxiv.org/abs/2007.04337
and from 10.3847/2041-8213/aba35f

Discovery of five new Galactic symbiotic stars in the VPHAS+ survey

Stavros Akras[1,2], Denise R. Gonçalves[3], Alvaro Alvarez-Candal[4] and Claudio B. Pereira[4]

[1]Instituto de Matemática, Estatística e Física, Universidade Federal do Rio Grande, Rio Grande 96203-900, Brazil
[2]Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, GR 15236 Penteli, Greece
[3]Observatório do Valongo, Universidade Federal do Rio de Janeiro, Ladeira Pedro Antonio 43, 20080-090 Rio de Janeiro, Brazil
[4]Observatório Nacional/MCTIC, Rua Gen. José Cristino, 77, 20921-400 Rio de Janeiro, Brazil

We report the validation of a recently proposed infrared selection criterion for symbiotic stars (SySts). Spectroscopic data were obtained for seven candidates, selected from the SySt candidates of Akras et al. (2019, MNRAS, 483, 5077) by employing the new supplementary infrared selection criterion for SySts in the VST/OmegaCAM Photometric H-Alpha Survey (VPHAS+). Five of them turned out to be genuine SySts after the detection of Hα, He II and [O III] emission lines as well as TiO molecular bands. The characteristic O VI Raman-scattered line is also detected in one of these SySts. According to their infrared colours and optical spectra, all five newly discovered SySts are classified as S-type. The high rate of true SySts detections of this work demonstrates that the combination of the Hα-emission and the new infrared criterion improves the selection of target lists for follow-up observations by minimizing the number of contaminants and optimizing the observing time.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2101.08806

The Isaac Newton Telescope monitoring survey of Local Group dwarf galaxies – IV. The star formation history of Andromeda VII derived from long period variable stars

Mahdieh Navabi[1], *Elham Saremi*[1], *Atefeh Javadi*[2,1], *Majedeh Noori*[3], *Jacco Th. van Loon*[4], *Habib G. Khosroshahi*[1,5], *Iain McDonald*[6,7], *Mina Alizadeh*[3], *Arash Danesh*[5], *Ghassem Gozaliasl*[8,9,10], *Alireza Molaeinezhad*[11,12], *Tahere Parto*[1,13] *and Mojtaba Raouf*[14]

[1]School of Astronomy, Institute for Research in Fundamental Sciences (IPM), P.O. Box 1956836613, Tehran, Iran

[2]Department of Physics, Sharif University of Technology, P.O. Box 11155-9161, Tehran, Iran

[3]Department of Physics, University of Zanjan, University Blvd., P.O. Box: 45371-38791, Zanjan, Iran

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

[5]Iranian National Observatory, Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

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

[7]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK

[8]Finnish Centre for Astronomy with ESO (FINCA), Quantum,University of Turku, Vesilinnantie 5, 20014 Turku, Finland

[9]Department of Physics, University of Helsinki, P.O. Box 64, 00014 Helsinki, Finland

[10]Helsinki Institute of Physics, University of Helsinki, P.O. Box 64, 00014 Helsinki, Finland

[11]Department of Physics, University of Oxford, Keble Road, OX1 3RH Oxford, UK

[12]Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK

[13]Physics Department, Alzahra University, Vanak, 1993891176, Tehran, Iran

[14]Korea Astronomy and Space Science Institute, 776 Daedeokdae-ro, Yuseong-gu, Daejeon 34055, South Korea

We have examined the star formation history (SFH) of Andromeda VII (And VII), the brightest and most massive dwarf spheroidal (dSph) satellite of the Andromeda galaxy (M 31). Although M 31 is surrounded by several dSph companions with old stellar populations and low metallicity, it has a metal-rich stellar halo with an age of 6–8 Gyr. This indicates that any evolutionary association between the stellar halo of M 31 and its dSph system is frail. Therefore, the question is whether And VII (a high-metallicity dSph located ~ 220 kpc from M 31), can be associated with M 31's young, metal-rich halo. Here, we perform the first reconstruction of the SFH of And VII employing long-period variable (LPV) stars. As the most-evolved asymptotic giant branch (AGB) and red supergiant (RSG) stars, the birth mass of LPVs can be determined by connecting their near-infrared photometry to theoretical evolutionary tracks. We found 55 LPV candidates within two half-light radii, using multi-epoch imaging with the Isaac Newton Telescope in the i and V bands. Based on their birth mass function, the star-formation rate (SFR) of And VII was obtained as a function of cosmic time. The main epoch of star formation occurred ~ 6.2 Gyr ago with a SFR of 0.006 ± 0.002 $M_\odot$ yr^{-1}. Over the past 6 Gyr, we find slow star formation, which continued until 500 Myr ago with a SFR $\sim 0.0005 \pm 0.0002$ $M_\odot$ yr^{-1}. We determined And VII's stellar mass $M = (13.3 \pm 5.3) \times 10^6$ $M_\odot$ within a half-light radius $r = 3.8 \pm 0.3$ arcmin and metallicity $Z = 0.0007$, and also derived its distance modulus of $\mu = 24.38$ mag.

Accepted for publication in ApJ
Available from https://arxiv.org/abs/2101.09900

Mixing uncertainties in low-metallicity AGB stars: the impact on stellar structure and nucleosynthesis

Umberto Battino[1,5], *Claudia Lederer-Woods*[1,5], *Borbála Cseh*[2], *Pavel Denissenkov*[3,4,5] *and Falk Herwig*[3,4,5]

[1]School of Physics and Astronomy, University of Edinburgh, Edinburgh EH9 3FD, UK

[2]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Eötvös Loránd Research Network, Budapest, Hungary

[3]Department of Physics & Astronomy, University of Victoria, Victoria, BC V8P 5C2, Canada

[4]Joint Institute for Nuclear Astrophysics, Center for the Evolution of the Elements, Michigan State University, USA

[5]The NuGrid Collaboration, http://www.nugridstars.org

The slow neutron-capture process (s-process) efficiency in low-mass AGB stars ($1.5 < M/M_\odot < 3$) critically depends on how mixing processes in stellar interiors are handled, which is still affected by considerable uncertainties. In this work, we compute the evolution and nucleosynthesis of low-mass AGB stars at low metallicities using the MESA stellar evolution code. The combined data set includes models with initial masses $M\mathrm{ini}/\mathrm{M}_\odot = 2$ and 3 for initial metallicities $Z = 0.001$ and 0.002. The nucleosynthesis was calculated for all relevant isotopes by post-processing with the NuGrid MPPNP code. Using these models, we show the impact of the uncertainties affecting the main mixing processes on heavy element nucleosynthesis, such as convection and mixing at convective boundaries. We finally compare our theoretical predictions with observed surface abundances on low-metallicity stars. We find that mixing at the interface between the He-intershell and the CO-core has a critical impact on the s-process at low metallicities, and its importance is comparable to con- vective boundary mixing processes under the convective envelope, which determine the formation and size of the ^{13}C-pocket. Additionally, our results indicate that models with very low to no mixing below the He-intershell during thermal pulses, and with a ^{13}C-pocket size of at least $\sim 3 \times 10^{-4}$ $\mathrm{M}_\odot$, are strongly favored in reproducing observations. Online access to complete yield data tables is also provided.

Published in MDPI Universe
Available from https://www.mdpi.com/2218-1997/7/2/25

Evidence of increased macroturbulence for Betelgeuse during Great Dimming

Laimons Začs[1] *and Kārlis Puķītis*[1]

[1]Laser Center, Faculty of Physics, Mathematics and Optometry, University of Latvia, Raiņa bulvāris 19, LV-1586 Rīga, Latvia

We compared high-resolution spectra of Betelgeuse observed before and during the Great Dimming. Atomic lines are shallow and broad during the Great Dimming presumably because of molecular veiling and increased macroturbulence, $\nu_{\mathrm{macro}} \gtrsim 23$ km s^{-1}. The best fit for TiO bands was found for the MARCS model atmosphere with $T_{\mathrm{eff}} = 3500$ K.

Published in Research Notes of the AAS
Available from https://iopscience.iop.org/article/10.3847/2515-5172/abdaac

Asteroseismology of luminous red giants with *Kepler* – II. Dependence of mass-loss on pulsations and radiation

Jie Yu[1], *Saskia Hekker*[2,3], *Timothy R. Bedding*[4,5], *Dennis Stello*[4,5,6], *Daniel Huber*[7], *Laurent Gizon*[1,8,9], *Shourya Khanna*[10] *and Shaolan Bi*[11]

[1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, D-37077 Göttingen, Germany
[2]Heidelberg Institute for Theoretical Studies (HITS), Schloß-Wolfsbrunnenweg 35, D-69118 Heidelberg, Germany; Zentrum für Astronomie der Universtät Heidelberg, Landessternwarte, Königstuhl 12, D-69117, Heidelberg, Germany
[3]Zentrum für Astronomie der Universtät Heidelberg, Landessternwarte, Königstuhl 12, D-69117, Heidelberg, Germany
[4]Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia
[5]Stellar Astrophysics Centre, Department of Physics and Astronomy, Århus University, Ny Munkegade 120, DK 8000 Århus C, Denmark
[6]School of Physics, University of New South Wales, NSW 2052, Australia
[7]Institute for Astronomy, University of Hawai'i, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[8]Institut für Astrophysik, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany
[9]Center for Space Science, NYUAD Institute, New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, UAE
[10]Kapteyn Astronomical Institute, University of Groningen, Groningen, 9700 AV, The Netherlands
[11]Department of Astronomy, Beijing Normal University, Beijing 100875, China

Mass-loss by red giants is an important process to understand the final stages of stellar evolution and the chemical enrichment of the interstellar medium. Mass-loss rates are thought to be controlled by pulsation-enhanced dust-driven outflows. Here, we investigate the relationships between mass-loss, pulsations, and radiation, using 3213 luminous *Kepler* red giants and 13 5000 ASAS-SN semiregulars and Miras. Mass-loss rates are traced by infrared colours using 2MASS and Wide-field Infrared Survey Explorer (WISE) and by observed-to-model WISE fluxes, and are also estimated using dust mass-loss rates from literature assuming a typical gas-to-dust mass ratio of 400. To specify the pulsations, we extract the period and height of the highest peak in the power spectrum of oscillation. Absolute magnitudes are obtained from the 2MASS K_s band and the Gaia DR2 parallaxes. Our results follow. (i) Substantial mass-loss sets in at pulsation periods above ~ 60 and ~ 100 d, corresponding to Asymptotic-Giant-Branch stars at the base of the period–luminosity sequences C′ and C. (ii) The mass-loss rate starts to rapidly increase in semiregulars for which the luminosity is just above the red-giant-branch tip and gradually plateaus to a level similar to that of Miras. (iii) The mass-loss rates in Miras do not depend on luminosity, consistent with pulsation-enhanced dust-driven winds. (iv) The accumulated mass-loss on the red giant branch consistent with asteroseismic predictions reduces the masses of red-clump stars by 6.3 per cent, less than the typical uncertainty on their asteroseismic masses. Thus mass-loss is currently not a limitation of stellar age estimates for Galactic archæology studies.

Published in MNRAS
Available from https://arxiv.org/abs/2012.12414
and from https://ui.adsabs.harvard.edu/abs/2021MNRAS.501.5135Y/abstract

Morpho-kinematics of the circumstellar envelope of AGB star R Dor: a global view

P.T. Nhung[1], *D.T. Hoai*[1], *P. Tuan-Anh*[1], *P. Darriulat*[1], *P.N. Diep*[1], *N.B. Ngoc*[1], *N.T. Phuong*[1] *and T.T. Thai*[1]

[1]Department of Astrophysics, Vietnam National Space Center (VNSC), Vietnam Academy of Science and Technology (VAST), 18 Hoang Quoc Viet, Cau Giay, Ha Noi, Vietnam

We analyse new ALMA observations of the ^{29}SiO ($v = 0$, $J = 8$–7) and SO_2 ($v = 0$, $34_{3,31}$–$34_{2,32}$) line emissions of the circumstellar envelope (CSE) of oxygen-rich AGB star R Dor. They cover distances below ~ 30 au from the star providing a link between earlier observations and clarifying some open issues. The main conclusions are: 1) Rotation is confined below ~ 15 au from the star, with velocity reaching a maximum below 10 au and morphology showing no significant disc-like flattening. 2) In the south–eastern quadrant, a large Doppler velocity gas stream is studied in more detail than previously possible and its possible association with an evaporating planetary companion is questioned. 3) A crude evaluation of the respective contributions of rotation, expansion and turbulence to the morpho-kinematics is presented. Significant line broadening occurs below ~ 12 au from the star and causes the presence of high Doppler velocity components near the line of sight pointing to the centre of the star. 4) Strong absorption of the continuum emission of the stellar disc and its immediate dusty environment is observed to extend beyond it in the form of self-absorption. The presence of a cold SiO layer extending up to some 60 au from the star is shown to be the cause. 5) Line emissions from SO, ^{28}SiO, CO and HCN molecules are used to probe the CSE up to some 100 au from the star and reveal the presence of two broad back-to-back outflows, the morphology of which is studied in finer detail than in earlier work.

Submitted to MNRAS
Available from https://arxiv.org/abs/2101.05455

The inner circumstellar dust of the red supergiant Antares as seen with VLT/SPHERE/ZIMPOL

Emily Cannon[1], *Miguel Montargès*[1], *Alex de Koter*[1,2], *Leen Decin*[1,3], *Michiel Min*[2,4], *Eric Lagadec*[5], *Pierre Kervella*[6], *Jon O. Sundqvist*[1] *and Hugues Sana*[1]

[1]Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D B2401, 3001 Leuven, Belgium

[2]Anton Pannekoek Institute of Astronomy, University of Amsterdam, 1090 GE Amsterdam, The Netherlands

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

[4]SRON Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

[5]Laboratoire Lagrange, UNSA, CNRS, Obs. de la Côte d'Azur, Bd. de l'Observatoire, 06304 Nice Cedex 4, France

[6]LESIA, Observatoire de Paris, Universitè PSL, CNRS, Sorbonne Universitè, Universitè de Paris, 5 Place Jules Janssen, 92195 Meudon, France

The processes by which red supergiants lose mass are not fully understood thus-far and their mass-loss rates lack theoretical constraints. The ambient surroundings of the nearby M0.5 Iab star Antares offers an ideal environment to obtain detailed empirical information on the outflow properties at its onset, and hence indirectly, on the mode(s) of mass loss. We present and analyse optical VLT/SPHERE/ZIMPOL polarimetric imaging with angular resolution down to 23 milli-arcsec, sufficient to spatially resolve both the stellar disk and its direct surroundings. We detect a conspicuous feature in polarised intensity that we identify as a clump containing dust, which we characterise through 3D radiative transfer modelling. The clump is positioned behind the plane of the sky, therefore has been released from the backside of the star, and its inner edge is only 0.3 stellar radii above the surface. The current dust mass in the clump is $1.3^{+0.2}_{-1.0} \times 10^{-8}$ $M_{\odot}$, though its proximity to the star implies that dust nucleation is probably still ongoing. The ejection of clumps of gas and dust makes a non-negligible contribution to the total mass lost from the star which could possibly be linked to localised surface activity such as convective motions or non-radial pulsations.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2101.02785

Analytic, dust-independent mass-loss rates for red supergiant winds initiated by turbulent pressure

N.D. Kee[1], *J.O. Sundqvist*[1], *L. Decin*[1], *A. de Koter*[1,2] *and H. Sana*[1]

[1]Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium
[2]Anton Pannekoek Institute, University of Amsterdam, Science Park 904, 1098XH Amsterdam, The Netherlands

Context: Red supergiants are observed to undergo vigorous mass-loss. However, to date, no theoretical model has succeeded in explaining the origins of these objects' winds. This strongly limits our understanding of red supergiant evolution and type II-P and II-L supernova progenitor properties.
Aims: We examine the role that vigorous atmospheric turbulence may play in initiating and determining the mass-loss rates of red supergiant stars.
Methods: We analytically and numerically solve the equations of conservation of mass and momentum, which we later couple to an atmospheric temperature structure, to obtain theoretically motivated mass-loss rates. We then compare these to state-of-the-art empirical mass-loss rate scaling formulae as well as observationally inferred mass-loss rates of red supergiants.
Results: We find that the pressure due to the characteristic turbulent velocities inferred for red supergiants is sufficient to explain the mass-loss rates of these objects in the absence of the normally employed opacity from circumstellar dust. Motivated by this initial success, we provide a first theoretical and fully analytic mass-loss rate prescription for red supergiants. We conclude by highlighting some intriguing possible implications of these rates for future studies of stellar evolution, especially in light of the lack of a direct dependence on metallicity.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2101.03070

Classification of Planetary Nebulæ through Deep Transfer Learning

Dayang N.F. Awang Iskandar[1], *Albert Zijlstra*[2], *Iain McDonald*[2,3], *Rosni Abdullah*[4], *Gary Fuller*[2], *Ahmad H. Fauzi*[1] *and Johari Abdullah*[1]

[1]Universiti Malaysia Sarawak, Malaysia
[2]The University of Manchester, UK
[3]The Open University, UK
[4]Universiti Sains Malaysia, Malaysia

This study investigate the effectiveness of using Deep Learning (DL) for the classification of planetary nebulæ (PNe). It focusses on distinguishing PNe from other types of objects, as well as their morphological classification. We adopted the deep transfer learning approach using three ImageNet pre-trained algorithms. This study was conducted using images from the Hong Kong/Australian Astronomical Observatory/Strasbourg Observatory Hα Planetary Nebula research platform database (HASH DB) and the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS). We found that the algorithm has high success in distinguishing True PNe from other types of objects even without any parameter tuning. The Matthews correlation coefficient is 0.9. Our analysis shows that DenseNet201 is the most effective DL algorithm. For the morphological classification, we found for three classes, Bipolar, Elliptical and Round, half of objects are correctly classified. Further improvement may require more data and/or training. We discuss the trade-offs and potential avenues for future work and conclude that deep transfer learning can be utilized to classify wide-field astronomical images.

Published in Galaxies, 8, 88 (2020)
Available from https://arxiv.org/abs/2101.12628

Probing 3D and NLTE models using APOGEE observations of globular cluster stars

T. Masseron[1,2], Y. Osorio[1,2], D.A. García-Hernández[1,2], C. Allende Prieto[1,2], O. Zamora[1,2] and Sz. Mészáros[3,4]

[1]Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain

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

[3]ELTE Eötvös Loránd University, Gothard Astrophysical Observatory, 9700 Szombathely, Szent Imre H. st. 112, Hungary

[4]MTA–ELTE Exoplanet Research Group

Hydrodynamical (or 3D) and non-local thermodynamic equilibrium (NLTE) effects are known to affect abundance analyses. However, there are very few observational abundance tests of 3D and NLTE models. We developed a new way of testing the abundance predictions of 3D and NLTE models, taking advantage of large spectroscopic survey data. We use a line-by-line analysis of the Apache Point Observatory Galactic Evolution Experiment (APOGEE) spectra (H band) with the Brussels Automatic Code for Characterizing High accUracy Spectra (bacchus). We compute line-by-line abundances of Mg, Si, Ca, and Fe for a large number of globular cluster K giants in the APOGEE survey. We compare this line-by-line analysis against NLTE and 3D predictions. While the 1D–NLTE models provide corrections in the right direction, there are quantitative discrepancies between different models. We observe a better agreement with the data for the models including reliable collisional cross-sections. The agreement between data and models is not always satisfactory when the 3D spectra are computed in LTE. However, we note that for a fair comparison, 3D corrections should be computed with self-consistently derived stellar parameters, and not on 1D models with identical stellar parameters. Finally, we focus on 3D and NLTE effects on Fe lines in the H band, where we observe a systematic difference in abundance relative to the value from the optical. Our results suggest that the metallicities obtained from the H band are more accurate in metal-poor giants. Current 1D–NLTE models provide reliable abundance corrections, but only when the atom data and collisional cross-sections are accurate and complete. Therefore, we call for more atomic data for NLTE calculations. In contrast, we show that 3D corrections in LTE conditions are often not accurate enough, thus confirming that 3D abundance corrections are only valid when NLTE is taken into account. Consequently, more extended self-consistent 3D–NLTE computations need to be made. The method we have developed for testing 3D and NLTE models could be extended to other lines and elements, and is particularly suited for large spectroscopic surveys.

Accepted for publication in A&A
Available from https://arxiv.org/abs/2101.11643

Job Advert

Postdoctoral positions on the Origin and Fate of Dust in the Universe

We invite applications for up to 3 postdoctoral positions, funded by the Wallenberg Foundation, in the research project: "The Origin and Fate of Dust in the Unviverse". The cross disciplinary project aims to advance our understanding of dust formation, destruction and growth throughout the Universe. It is a collaboration between astronomers and theoretical chemists at Chalmers University of Technology and Gothenburg University. More information on the project can be found at the project website: https://cosmic-dust.se

To join this collaboration, we seek ambitious, highly-qualified postdoctoral researchers with experience in observations and modeling of dust around, e.g., evolved stars, novæ, supermassive black holes and in the local and high-redshift interstellar medium.

The successful candidates will join a growing and vibrant research environment encompassing the Chalmers Division for Astronomy and Plasma Physics and the Onsala Space Observatory – host of the Swedish National Facility for Radio Astronomy which includes the Nordic ALMA Regional Center Node. In addition to the close collaboration with Gothenburg University, the postdocs will work with, and be embedded in, the internationally active research groups of Profs. Susanne Aalto (Galactic Nuclei; susanne.aalto@chalmers.se), Kirsten Knudsen (high-z; kirsten.knudsen@chalmers.se) and Wouter Vlemmings (evolved stars; wouter.vlemmings@chalmers.se).

The positions will be for 2 years with possible extension and come with funds for a laptop + travel funds for conferences. The application deadline is February 28$^{\text{th}}$. The preferred starting date is July/August 2021, but can be negotiated. Informal inquiries can be addressed to any of the three Chalmers PIs.

See also https://www.chalmers.se/en/about-chalmers/Working-at-Chalmers/Vacancies/Pages/default.aspx?rmpage=job&rmjob=9249

Announcements

EAS 2021 – SS22
The Great Dimming of Betelgeuse

The registration and abstract submission for the EAS 2021 virtual conference are now opened. We invite contributions to Special Session 22 on the Great Dimming of Betelgeuse. In Winter 2019–2020, the nearby red supergiant star Betelgeuse experienced an historic dimming, catching attention all over the world for an impending supernova. Since then several scenarios have been put forward in the literature, however no consensus has been so far reached. The aim of this special session is to stimulate discussions among the different teams studying the Great Dimming. The discussion will be framed in the broader context of the mass loss of red supergiant stars and how it affects their ultimate fate: the supernova explosion, and their destiny as neutron stars or black holes.

Miguel Montargès on behalf of the SOC

See also https://eas.unige.ch/EAS2021/session.jsp?id=SS22

Conference announcement:
DELVE: Death-throes of EvoLved stars, a Virtual Encounter

The chairs, on behalf of the SOC, would like to announce an upcoming online conference on the topic of evolved stars. DELVE: Death-throes of EvoLved stars, a Virtual Encounter will run April 12–16 with different time slots on different days to accomodate people working in different time zones across the world.

The scientific focus of the conference will be on the chemistry and physics of evolved stars, particularly AGB and RSG stars. We welcome contributions delving into any topic related to AGB or RSG stars, including observations, modelling and theory of the chemical or physical states of these stars and their circumstellar environments.

We will have talks over Zoom (uploaded to YouTube for asynchronous viewing) with coffee breaks and poster sessions taking place in the virtual space of Gather Town. Registration is open now and abstract submissions will close on 1 March. For more details visit our website: https://fys.kuleuven.be/ster/events/conferences/2021/delve

See also https://fys.kuleuven.be/ster/events/conferences/2021/delve

Kavli Summer Program in Astrophysics 2021
Fluid dynamics of the Sun and Stars

We are pleased to announce the Kavli Summer Program in Astrophysics 2021: Fluid dynamics of the Sun and Stars.

Applications for the 2021 Kavli Summer Program in Astrophysics are now open (deadline for students February 19$^{\text{th}}$).

The Kavli Summer Program in Astrophysics normally runs for six weeks every summer alternating between various institutions world-wide and UC Santa Cruz. It involves up to 15 established faculty and 15 graduate students, as well as additional postdoctoral and senior scientists who contribute to the supervision of the research students.

The 2021 Kavli Summer Program in Astrophysics will be an online program organized by the Max Planck Institute for Solar System Research in Göttingen, Germany, from 7 June to 16 July 2021, on the topic of Fluid dynamics of the Sun and Stars. The 2021 program (carried over from 2020) will be directed by Aaron Birch. The introductory lectures will be given by Aaron Birch, Matthew Browning, and Michel Rieutord.

The Kavli Summer Program in Astrophysics combines the concept of a long-term workshop with graduate student training through research projects. The six-week-long program begins with a one-week workshop on the topic of the year, with introductory lectures by invited faculty and short contributed presentations. In the five following weeks, the students are teamed with the senior participants and are expected to make significant progress on their selected research project. During that time, the program hosts one seminar per day, while the rest of the day is dedicated to research. The students are required to present their research project to all participants during the last two days of the program and are expected to publish the results with their collaborators, either in the form of a refereed paper or a conference proceeding, in the subsequent year.

We are currently accepting applications from Ph.D. students who started research on their thesis at least one year ago, as well as from supervisors (postdocs and faculty). Student applications are due February 19$^{\text{th}}$, and faculty and postdoc applications are reviewed on a rolling basis.

For the latest information and online application forms, please see https://kspa.soe.ucsc.edu/2020

See also https://kspa.soe.ucsc.edu/2020

GAPS 2021 – unsolved problems in red Giants And suPergiantS

14–18 June 2021

A virtual and free conference organised by the International Astronomical Union's Working Group on Red Giants and Supergiants under the auspices of Commission G3 "Stellar Evolution".

Rationale:

The Sun will become a red giant, yet many fundamental aspects of the structure and evolution of red giants are unknown – convection, mixing, pulsation, mass loss, and the way these processes are affected by rotation and magnetic fields, to name but a few.

Many of these problems are shared by more massive red supergiants, with implications for their demise as supernovæ. Poor understanding of the timescales of their evolution and their feedback (mechanical, chemical) has consequences also for galactic evolution models and when using either resolved populations of red giants and supergiants or the integrated light of galaxies to infer knowledge of the star formation history.

The IAU Working Group on Red Giants and Supergiants has set itself two objectives:

1 to identify the most important Physics problems pertaining to the evolution of red giants and supergiants and their interaction with their surroundings;

2 to make suggestions how to make progress in these areas.

Before finalising their report, we wish to dedicate a meeting to red giants and supergiants and how gaps in our understanding affect other fields of Astrophysics.

Format:

The meeting will have nine topics, and one wrap-up session, spread over five days. This means two sessions a day of one hour each. Each of the nine topics are introduced by a plenary speaker:

- Internal structure, mixing processes, and evolution
- Nucleosynthesis and meteoritic evidence
- Atmospheric and circumstellar structure, dust formation
- Instabilities
- Feedback (mass loss)
- End products (white dwarfs, neutron stars, black holes, planetary nebulæ)
- Interaction with stellar and planetary companions
- Importance for ISM chemistry and the role of laboratory astrophysics
- Diagnostics in nearby and distant galaxies

The meeting will end with a panel discussion with the panel composed of the plenary speakers and the discussion moderated by one of the scientific organizing committee (SOC) members. Slack will be used to moderate discussion, and a link will be sent to the participants before the conference starts. The SOC will endeavor to obtain a balanced mix of seniority, gender and geographical origin among the presenters and session chairs.

The sessions will take place on Zoom and live broadcasted and recorded via Youtube. Contributed prerecorded talks will also be made available via Youtube, ahead of the sessions.

We will post a report on arXiv shortly after the meeting and solicit further input from the community before we finalize the "White Paper".

We expect to then select a topic we have a reasonable chance of success to solve, to focus on and coordinate in the following triennium. In doing so we also wish to seek out and support new talent who have the promise to make key contributions to this objective.

Scientific Organizing Committee:

- Carolyn Doherty (Konkoly Observatory)
- Jan Eldridge (University of Auckland)
- Domingo Aníbal García-Hernández (Instituto de Astrofísica de Canarias)
- Josef Hron (University of Vienna, Institute for Astrophysics)
- Biwei Jiang (Beijing Normal University)
- Tomasz Kamiński (Nicolaus Copernicus Astronomical Center)
- John Lattanzio (Monash University)
- Emily Levesque (University of Washington)
- Maria Lugaro (Hungarian Academy of Sciences)
- Marcelo Miller Bertolami (Instituto de Astrofísica de La Plata)
- Keiichi Ohnaka (Universidad Católica del Norte)
- Gioia Rau (NASA GSFC) – co-Chair
- Jacco van Loon (Keele University) – co-Chair

Registration:

Registration is free but required in order to access the meeting and recordings. Registration is now open on the meeting website: https://gaps2021.wixsite.com/conference/registration-contribution The registration form allows you to propose a prerecorded contribution as well as propose a plenary talk to get a session started. We strongly encourage (relatively) junior scientists to propose a plenary talk as we wish to inject fresh ideas into our field of research.

Important dates:

- Now: registration is open, inviting proposals for a contributed recording or plenary talk.
- 28 February 2021: deadline for proposing a plenary talk.
- 15 May 2021: deadline for proposing a prerecorded contributed talk.
- 31 May 2021: registration closes.
- 14–18 June 2021: meeting sessions, the exact timings of which are not yet finalized; we aim to accommodate different time zones.

More information:

Website: https://gaps2021.wixsite.com/conference
E-mail: gaps2021.conference@gmail.com
Twitter: @GAPS2021

We are looking forward to a fruitful and inclusive meeting!

See also https://gaps2021.wixsite.com/conference