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. 275 — 1 June 2020

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

Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

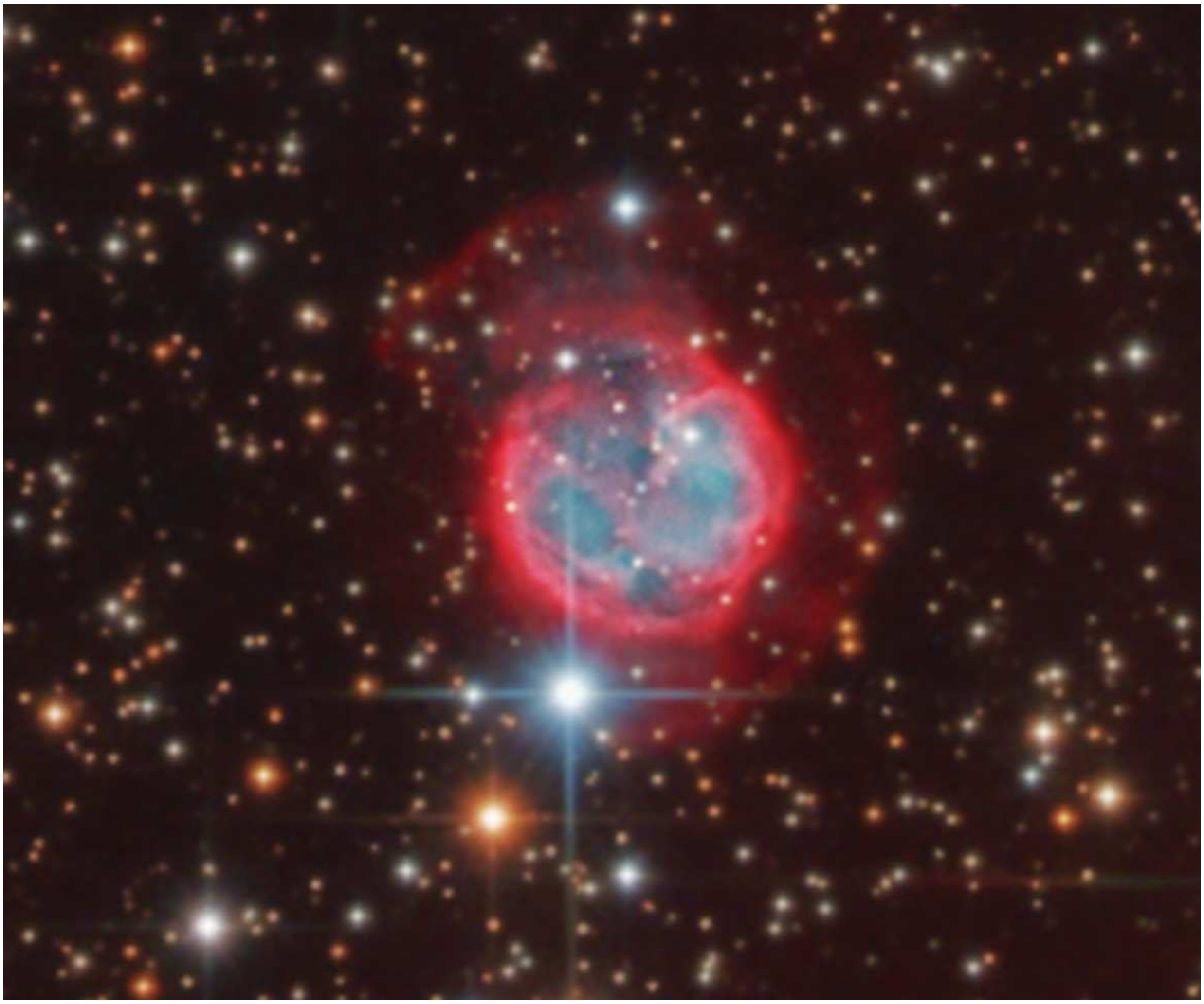

Figure 1: Planetary Nebula NGC 7048 imaged by Bernhard Hubl from Austria, with a 12″ Newtonian telescope – http://www.astrophoton.com/NGC7048.htm. Note the faint outer halo. (Suggestion by Sakib Rasool.)

Editorial

Dear Colleagues,

It is a pleasure to present you the 275th issue of the AGB Newsletter. The 'What am I thinking' item is returning with Marcelo Miller Bertolami offering a twist to what has been becoming somewhat of a paradigm.

It may not come as a surprise that last month's 'Food for Thought' ("Referees have too much, unchallenged power and editors/panels side with them") resulted in a couple of reactions:
"I agree. In too many cases the power of the referee leads to what I call 'Refereeing Harassment'. It is time that the physics community will start to pay attention not only to sexual harassment, but also to refereeing harassment. Sexual harassment has much more severe consequences. Nonetheless, refereeing harassment is much more common, can also harm the career of people, and it is very hard to deal with because of anonymity. Editors should go through a training to know how to deal with refereeing harassment, as much as there are workshops in working places on preventing sexual harassment. Much as in the past chairs of departments took the side of the professor that abused a student (not anymore for sexual harassments), Editors take the side of the referee.
We should think of other refereeing processes, in particular more open ones. One suggestion can be found here – section 3, and then section 3.2 in particular: https://arxiv.org/pdf/astro-ph/0508525.pdf"
...on the one hand, but on the other hand:
"As a blanket statement, this is definitely incorrect, and I think it does a disservice to those editors who take their jobs seriously. On the other hand, I suspect the point may be valid for some editors at some journals. To paraphrase Ethan Vishniac (AAS Journals Editor in Chief) who was my 'boss' for that job [science editor – ed.], the AAS doesn't hire Ph.D. scientists to just push emails around. AAS editors are fully expected to read the papers, think about the reports from the referees, relate those concerns to the authors, and also, do exactly the reverse as well: read the revised papers, think about the responses from the authors, and relate those points of view to the referees. We were repeatedly (often!) reminded that referees do not accept or reject papers; that role is the sole responsibility of the science editor. In reality, the job requires a level of science expertise, confidence, and diplomacy that not everyone has, or takes the time to exercise for every paper.
If you think that there is a problem with the editors at a journal, then make a statement – submit to a different journal."

Last month's edition advertised a fundraising initiative to support an amazing group of serious amateur astronomers to use professional facilities to confirm their planetary nebula discoveries: https://www.startnext.com/astro-joint-venture
We can now share an update resulting from that fundraising campaign: a newly discovered planetary nebula – https://www.astrobin.com/ngbh9q

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

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

Food for Thought

This month's thought-provoking statement is:

Hydrogen-poor white dwarfs are more massive – what are the implications?

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)

What am I thinking?

Marcelo M. Miller Bertolami

Instituto de Astrofísica

La Plata, Argentina

Do Planetary Nebulæ care about Planets?

Although I have been modeling central stars of planetary nebulæ (CSPNe) since my early Ph.D. days, in the last 5 years I have had the opportunity to come into closer contact with the PNe community. As someone who spent about a decade modeling CSPNe as single stars I was somewhat shocked to learn that a vast majority of the community thinks that binarity is a key ingredient in the formation *and* shaping of most (or even all) PNe – Moe & De Marco 2006, ApJ; Jones & Boffin 2017, Nature Astronomy; Boffin & Jones 2019, The Importance of Binaries in the Formation and Evolution of Planetary Nebulæ). While I see the reasons to claim the latter, I fail to grasp completely the former. To me formation and shaping of PNe are two different issues.

We know, from systems such as Henize 2-428 (Santander-García 2015, Nature), that post-common envelope evolution leads to the formation of a PNe. Also, it is true that the binary fraction in low-mass stars (F-type and cooler, $M_{\rm ZAMS} < 1.7\ {\rm M}_\odot$) is close to 50%, and it is even larger in intermediate-mass stars. But many of those systems will be too far away for binary interaction to play a significant role, with most solar-like stars located at 45 au while a significant fraction of intermediate-mass stars might be located as far as 350 au (Duchêne & Kraus 2013, ARA&A). Consequently, a large number of low- and intermediate-mass stars are either single or live in systems which are wide enough so that their components will not interact during their whole life, evolving mostly as single stars – with the possible exception of some interaction through winds. Under these circumstances I wonder how essential binary evolution can be for the formation of PNe, even if it proves to be key for the shaping of some of them.

More troubling to me is the fact that our current understanding of single stars suggests that they should form PNe. Although there are still uncertainties, AGB winds are relatively well understood (Höfner & Olofsson 2018, A&ARv), and it is now even possible to model them both for C-rich (Mattsson, Wahlin & Höfner 2010, A&A) and O-rich stars (Bladh et al. 2019, A&A). As a consequence, we are now quite certain that most AGB stars lose mass at very high rates at the end of their lives, and thanks to hydrodynamical models of PNe (Perinotto et al. 2004, A&A; Schönberner & Steffen 2019, A&A) we know that after leaving the AGB this material should be observed as a PN. Moreover, since the computation of single stellar evolution tracks with an updated treatment of convective boundary mixing and opacities by Kitsikis (2008, Ph.D. thesis, Ludwig-Maximilians-Universität München; for details see Weiß & Ferguson 2009, A&A), it is clear that moderately low mass stars, with initial masses slightly above the solar mass, should evolve fast enough through the post-AGB phase to form PNe. If PNe are not formed by single stars (or stars in non-interacting binary systems), then our current understanding of low- and intermediate-mass stars evolution and winds has to be wrong. Quite on the contrary, in the recent catalog of CSPNe compiled by Weidman et al. (2020, arXiv:2005.10368) $\sim 50\%$ (88 out of 175 objects) of the sample have values of all three surface parameters ($\log L_\star$, $\log T_{\rm eff}$ and $\log g$, and consequenly also masses) consistent with the predictions from single stellar evolution models. Moreover, ages derived from single stellar evolution models for $\sim 40\%$ (67 out of 175 objects) are also consistent with the expected lifetimes of PNe. This does not imply that these objects are indeed single stars. But I think that the fact that single stellar evolution models are able to describe the main properties of a significant fraction of CSPNe should not be overlooked.

In light of the previous theoretical and observational arguments it seems to me that binarity might not be key for the formation of PNe, regardless of whether it plays a key role in the shaping of PNe. But even regarding the shaping of PNe, I think that there are alternatives which have not been studied thoroughly enough.

The number of detected binaries in PNe surveys is still relatively low ($\sim 20\%$) even after many years of active searches for binaries (De Marco 2009, PASP; Jones 2018, arXiv:1806.08244). Also, the dearth of binaries in proto-planetary nebulæ is staggering (Hrivnak et al. 2017, IAUS 323). So why is it that binarity is so appealing? As far as I understand one of the key reasons is the overwhelming majority of aspherical PNe (Jones 2018, arXiv:1806.08244; Boffin & Jones 2019, The Importance of Binaries in the Formation and Evolution of Planetary Nebulæ), and in particular the large number of axisymmetric ones which point to the existence of some source of angular momentum. But given the relative dearth of detected stellar companions one might wonder whether this is the only possibility. Moreover, we now know that many low-mass stars harbor planetary systems with one or more giant planets.

Although this is admittedly not a new idea (Soker 1996, ApJL; Soker 1996 ApJ), I have been thinking lately that not enough attention has been paid to the impact of planets in the formation and shaping of PNe. While the mass stored by planets is a negligible part of the system, a completely different situation happens with angular momentum. As an example, in our solar system planets harbor only 0.13% of the Solar System mass, while harboring almost all its angular momentum. The amount of angular momentum stored in Jupiter's orbit alone is already about 2 orders of magnitude higher than that stored in the Sun (Armitage 2010, Astrophysics of Planet Formation). Envelopes of evolved AGB stars are very expanded and their gravitational bound to the rest of the star is feeble. It seems to me that the ejection and shaping of these loosely bound envelopes due to the tidal interaction and subsequent engulfment of a giant planet like Jupiter should still not be discarded. In fact, Sabach & Soker (2018, MNRAS) played with the idea but claimed that mass-loss rates have to be much lower than expected from our current understanding for this scenario to be viable. But, how certain are we that planets cannot shape PNe under normal mass-loss rates? And even if giant planets are not responsible for the formation of PNe, how certain are we that, given their large orbital angular momentum, current planetary companions are not relevant for the shaping of axysimmetric PNe?

In view of all these thoughts, I think that more attention should be devoted to the importance of planets in the shaping (and may be even in the formation) of planetary nebulæ. Could it be that (at least some of) Herschel's "planetary nebulæ" are indeed related to planets?

The closest extremely low-mass white dwarf to the Sun

Adela Kawka[1], *Jeffrey D. Simpson*[2], *Stephane Vennes*[3], *Michael S. Bessell*[4], *Gary S. Da Costa*[4], *Anna F. Marino*[5,6] *and Simon J. Murphy*[7]

[1]International Centre for Radio Astronomy Research – Curtin University, G.P.O. Box U1987, Perth, WA 6845, Australia
[2]School of Physics, UNSW Sydney, Sydney NSW 2052, Australia
[3]Mathematical Sciences Institute, The Australian National University, Canberra, ACT 0200, Australia
[4]Research School of Astronomy & Astrophysics, The Australian National University, Canberra, ACT 2611, Australia
[5]Dipartmento di Fisica e Astronomica Galileo Galilei, Università di Padova, Vicolo dell'Osservatorio 3, Padova I-35122, Italy
[6]Centro di Ateneo di Studi e Attivita Spaziali "Giuseppe Colombo" – CISAS, Via Venezia 15, Padova IT-35131, Italy
[7]School of Science, The University of New South Wales, Canberra, Canberra, ACT 2600, Australia

We present the orbit and properties of 2MASS J050051.85−093054.9, establishing it as the closest ($d \approx 71$ pc) extremely low mass white dwarf to the Sun. We find that this star is hydrogen-rich with $T_{\rm eff} \approx 10\,500$ K, $\log g \approx 5.9$, and, following evolutionary models, has a mass of ≈ 0.17 $M_\odot$. Independent analysis of radial velocity and TESS photometric time series reveals an orbital period of ≈ 9.5 h. Its high velocity amplitude ($K \approx 144$ km s^{-1}) produces a measurable Doppler beaming effect in the TESS light curve with an amplitude of 1 mmag. The unseen companion is most likely a faint white dwarf. 2MASS J050051.85−093054.9 belongs to a class of post-common envelope systems that will most likely merge through unstable mass transfer and in specific circumstances lead to Type Ia supernova explosions.

Accepted for publication in MNRAS Letters
Available from https://arxiv.org/abs/2004.07556

Common envelope evolution on the asymptotic giant branch: unbinding within a decade?

Luke Chamandy[1], *Eric G. Blackman*[1], *Adam Frank*[1], *Jonathan Carroll-Nellenback*[1] *and Yisheng Tu*[1]

[1]University of Rochester, USA

Common envelope (CE) evolution is a critical but still poorly understood progenitor phase of many high-energy astrophysical phenomena. Although 3D global hydrodynamic CE simulations have become more common in recent years, those involving an asymptotic giant branch (AGB) primary are scarce, due to the high computational cost from the larger dynamical range compared to red giant branch (RGB) primaries. But CE evolution with AGB progenitors is desirable to simulate because such events are the likely progenitors of most bi-polar planetary nebulæ (PNe), and prominent observational testing grounds for CE physics. Here we present a high resolution global simulation of CE evolution involving an AGB primary and 1 $M_\odot$ secondary, evolved for 20 orbital revolutions. During the last 16 of these orbits, the envelope unbinds at an almost constant rate of about 0.1–0.2 $M_\odot$ yr^{-1}. If this rate were maintained, the envelope would be unbound in less than 10 yr. The dominant source of this unbinding is consistent with inspiral; we assess the influence of the ambient medium to be subdominant. We compare this run with a previous run that used an RGB phase primary evolved from the same 2 $M_\odot$ main sequence star to assess the influence of the evolutionary state of the primary. When scaled appropriately, the two runs are quite similar, but with some important differences.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2004.06829

Chemical modelling of dust–gas chemistry within AGB outflows – II. Effect of the dust-grain size distribution

M. Van de Sande[1], *C. Walsh*[2] *and T. Danilovich*[1]

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

[2]School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT, UK

AGB stars are, together with supernovæ, the main contributors of stellar dust to the interstellar medium (ISM). Dust grains formed by AGB stars are thought to be large. However, as dust nucleation and growth within their outflows are still not understood, the dust-grain size distribution (GSD) is unknown. This is an important uncertainty regarding our knowledge of the chemical and physical history of interstellar dust, as AGB dust forms $\sim 70\%$ of the starting point of its evolution. We expand on our chemical kinetics model, which uniquely includes a comprehensive dust-gas chemistry. The GSD is now allowed to deviate from the commonly assumed canonical Mathis et al. (1977) distribution. We find that the specific GSD can significantly influence the dust–gas chemistry within the outflow. Our results show that the level of depletion of gas-phase species depends on the average grain surface area of the GSD. Gas-phase abundance profiles and their possible depletions can be retrieved from observations of molecular emission lines when using a range of transitions. Due to degeneracies within the prescription of GSD, specific parameters cannot be retrieved, only (a lower limit to) the average grain surface area. Nonetheless, this can discriminate between dust composed of predominantly large or small grains. We show that when combined with other observables such as the spectral energy distribution and polarised light, depletion levels from molecular gas-phase abundance profiles can constrain the elusive GSD of the dust delivered to the ISM by AGB outflows.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2005.01553

On aging star clusters using red supergiants independent of the fraction of interacting binary stars

J.J. Eldridge[1], *Emma R. Beasor*[2,3] *and N. Britavskiy*[4,5]

[1]Department of Physics, University of Auckland, Private Bag 92019, Auckland, New Zealand

[2]NSF National Optical–Infrared Astronomy Research Laboratory, 950 N. Cherry Ave., Tucson, AZ 85719, USA

[3]Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool L3 5RF, UK

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

[5]Universidad de La Laguna, Dpto. Astrofísica, E-38206 La Laguna, Tenerife, Spain

We use the Binary Population and Spectral Synthesis (BPASS) models to test the recent suggestion that red supergiants can provide an accurate age estimate of a co-eval stellar population that is unaffected by interacting binary stars. Ages are estimated by using both the minimum luminosity red supergiant and the mean luminosity of red supergiants in a cluster. We test these methods on a number of observed star clusters and find our results in agreement with previous estimates. Importantly we find the difference between the ages derived from stellar population models with and without a realistic population of interacting binary stars is only a few 100,000 years at most. We find that the mean luminosity of red supergiants in a cluster is the best method to determine the age of a cluster because it is based o the entire red supergiant population rather than using only the least luminous red supergiant.

Published in MNRAS, 495, L102 (2020)
Available from https://arxiv.org/abs/2004.08502

On the role of reduced wind mass-loss rate in enabling exoplanets to shape planetary nebulæ

Ahlam Hegazi[1], *Ealeal Bear*[1] *and Noam Soker*[1]

[1]Technion, Israel

We use the stellar evolution code MESA-binary and follow the evolution of six exoplanets to determine their potential role in the future evolution of their parent star on the red giant branch (RGB) and on the asymptotic giant branch (AGB). We limit this study to planets with orbits that have semi-major axis of 1 au $< a <$ 20 au, a high eccentricity, $e > 0.25$, and having a parent star of mass $M > 1$ $M_\odot$. We find that the star HIP 75458 will engulf its planet HIP 75458 b during its RGB phase. The planet will remove the envelope and terminate the RGB evolution, leaving a bare helium core of mass 0.4 $M_\odot$ that will evolve to form a helium white dwarf. Only in one system out of six, the planet β Pic c will enter the envelope of its parent star during the AGB phase. For that to occur, we have to reduce the wind mass-loss rate by a factor of about four from its commonly used value. This strengthens an early conclusion, which was based on exoplanets with circular orbits, that states that to have a non-negligible fraction of AGB stars that engulf planets we should consider lower wind mass-loss rates of isolated AGB stars (before they are spun-up by a companion). Such an engulfed planet might lead to the shaping of the AGB mass-loss geometry to form an elliptical planetary nebula.

Submitted to a journal
Available from https://arxiv.org/abs/2004.09077

The Carnegie Supernova Project II. Observations of the intermediate luminosity red transient SNhunt120

M. Stritzinger[1], *F. Taddia*[1], *M. Fraser*[2], *T. Tauris*[1], *N. Suntzeff*[3] *et al.*

[1]Århus, Denmark
[2]Dublin, Ireland
[3]Texas A&M, USA

We present multi-wavelength observations of two gap transients followed by the Carnegie Supernova Project-II and supplemented with data obtained by a number of different programs. Here in the first of two papers, we focus on the intermediate luminosity red transient (ILRT) designated SNhunt120, while in a companion paper we examine the luminous red nova AT 2014ej. Our data set for SNhunt120 consists of an early optical discovery, estimated to be within 3 days after outburst, the subsequent optical and near-infrared broadband followup extending over a ~ 2 month period, two visual- and two near-infrared wavelength spectra, and *Spitzer* Space Telescope observations extending from early (+28 d) to late (+1155 d) phases. SNhunt120 resembles other ILRTs such as NGC 300-2008-OT and SN 2008S, and like these other ILRTs, SNhunt120 exhibits prevalent mid-infrared emission at both early and late phases. From the comparison of SNhunt120 and other ILRTs to electron-capture supernova simulations, we find that the current models underestimate the explosion kinetic energy and thereby produce synthetic light curves that over-estimate the luminosity. Finally, examination of pre-outburst *Hubble* Space Telescope images yields no progenitor detection.

Submitted to A&A
Available from https://arxiv.org/abs/2005.00319

Active red giants: close binaries versus single rapid rotators

Patrick Gaulme[1,2], *Jason Jackiewicz*[2], *Federico Spada*[1], *Drew Chojnowski*[2], *Benoît Mosser*[3], *Jean McKeever*[4], *Anne Hedlund*[2], *Mathieu Vrard*[5,6], *Mansour Benbakoura*[7,8] *and Cilia Damiani*[1]

[1]Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077, Göttingen, Germany
[2]Department of Astronomy, New Mexico State University, P.O. Box 30001, MSC 4500, Las Cruces, NM 88003-8001, USA
[3]LESIA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université de Paris, 92195 Meudon, France
[4]Department of Astronomy, Yale University, P.O. Box 208101, New Haven, CT 06520-8101, USA
[5]Department of Astronomy, The Ohio State University, 140 West 18th Avenue, Columbus OH 43210, USA
[6]Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Rua das Estrelas, 4150-762, Porto, Portugal
[7]IRFU, CEA, Université Paris–Saclay, F-91191 Gif-sur-Yvette Cedex, France
[8]Université Paris Diderot, AIM, Sorbonne Paris Cité, CEA, CNRS, F-91191 Gif-sur-Yvette Cedex, France

Oscillating red-giant stars have provided a wealth of asteroseismic information regarding their interiors and evolutionary states, which enables detailed studies of the Milky Way. The objective of this work is to determine what fraction of red-giant stars shows photometric rotational modulation, and understand its origin. One of the underlying questions is the role of close binarity in this population, standing upon the fact that red giants in short-period binary systems (less than 150 days or so) have been observed to display strong rotational modulation. We selected a sample of about 4500 relatively bright red giants observed by *Kepler*, and show that about 370 of them ($\sim 8\%$) display rotational modulation. Almost all have oscillation amplitudes below the median of the sample, while 30 of them are not oscillating at all. Of the 85 of these red giants with rotational modulation chosen for follow-up radial-velocity observation and analysis, 34 show clear evidence of spectroscopic binarity. Surprisingly, 26 of the 30 nonoscillators are in this group of binaries. To the contrary, about 85% of the active red giants with detectable oscillations are not part of close binaries. With the help of the stellar masses and evolutionary states computed from the oscillation properties, we shed light on the origin of their activity. It appears that low-mass red-giant branch stars tend to be magnetically inactive, while intermediate-mass ones tend to be highly active. The opposite trends are true for helium-core burning (red clump) stars, whereby the lower-mass clump stars are comparatively more active and the higher-mass ones less active. In other words, we find that low-mass red-giant branch stars gain angular momentum as they evolve to clump stars, while higher-mass ones lose angular momentum. The trend observed with low-mass stars leads to possible scenarios of planet engulfment or other merging events during the shell-burning phase. Regarding intermediate-mass stars, the rotation periods that we measure are long with respect to theoretical expectations reported in the literature, which reinforces the existence of an unidentified sink of angular momentum after the main sequence. This article establishes strong links between rotational modulation, tidal interactions, (surface) magnetic fields, and oscillation suppression. There is a wealth of physics to be studied in these targets that is not available in the Sun.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2004.13792

The validity of the Schönberg–Chandrasekhar limit in describing stellar evolution

Janusz Ziółkowski[1] *and Andrzej Zdziarski*[1]

[1]N. Copernicus Astronomical Center, Poland

We discuss the Schönberg–Chandrasekhar limit in the light of the modern theory of stellar evolution. We find it remains a valid concept with the numerical value of the limiting fractional mass of the He core lying in a relatively narrow range of 0.09–0.11 for stars in the mass range of 1.4–7 $M_{\odot}$. Crossing this limit is associated with some restructuring of the star, which manifests itself by a characteristic kink (first a decrease then an increase) in the evolution of the radius vs. time. This also coincides with the moment the star moves from the subgiant branch to the red giant branch. The crossing is associated with some acceleration of the rate of the growth of the stellar radius and luminosity, but this acceleration is not substantial and the evolution does not change qualitatively. Therefore, the Schönberg–Chandrasekhar limit, while remaining a valid concept, is not a particularly useful tool in constraining the evolutionary status of a specific object.

Submitted to MNRAS
Available from https://arxiv.org/abs/2005.01361

Rotationally driven ultraviolet emission of red giant stars

Don M. Dixon[1,2], *Jamie Tayar*[3] *and Keivan G. Stassun*[1,2]

[1]Vanderbilt University, USA
[2]Fisk University, USA
[3]University of Hawai'i, USA

Main sequence stars exhibit a clear rotation–activity relationship, in which rapidly rotating stars drive strong chromospheric/coronal ultraviolet and X-ray emission. While the vast majority of red giant stars are inactive, a few percent exhibit strong ultraviolet emission. Here we use a sample of 133 red giant stars observed by SDSS APOGEE and GALEX to demonstrate an empirical relationship between NUV excess and rotational velocity ($v \sin i$). Beyond this simple relationship, we find that NUV excess also correlates with rotation period and with Rossby number in a manner that shares broadly similar trends to those found in M dwarfs, including activity saturation among rapid rotators. Our data also suggest that the most extremely rapidly rotating giants may exhibit so-called "super-saturation", which could be caused by centrifugal stripping of these stars rotating at a high fraction of breakup speed. As an example application of our empirical rotation–activity relation, we demonstrate that the NUV emission observed from a recently reported system comprising a red giant with a black hole companion is fully consistent with arising from the rapidly rotating red giant in that system. Most fundamentally, our findings suggest a common origin of chromospheric activity in rotation and convection for cool stars from main sequence to red giant stages of evolution.

Accepted for publication in The Astronomical Journal
Available from https://arxiv.org/abs/2005.00577

Statistical relations between stellar spectral and luminosity classes and stellar effective temperature and surface gravity

Oleg Malkov[1,2], *Dana Kovaleva*[2], *Sergey Sichevsky*[2] *and Gang Zhao*[1]

[1]Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[2]Institute of Astronomy, Russian Academy of Sciences, 48 Pyatnitskaya St., Moscow 119017, Russia

We have determined new statistical relations to estimate the fundamental atmospheric parameters of effective temperature and surface gravity, using MK spectral classification, and vice versa. The relations were constructed based on the published calibration tables (for main sequence stars) and observational data from stellar spectral atlases (for giants and supergiants). These new relations were applied to field giants with known atmospheric parameters, and the results of the comparison of our estimations with available spectral classification had been quite satisfactory.

Accepted for publication in Research in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2004.07627

Gaia DR2 colour–temperature relations based on infrared flux method results

A. Mucciarelli[1,2] *and M. Bellazzini*[2]

[1]Dipartimento di Fisica & Astronomia, Università di Bologna, Italy
[2]INAF–Osservatorio di Astrofisica e Scienza dello Spazio di Bologna, taly

The ESA/Gaia mission is providing accurate and precise all-sky photometry. We combined effective temperatures derived, for a sample of dwarf and giant stars, by González Hernández & Bonifacio (2009) using the Infrared Flux Method, with the photometry available from the second release of the ESA/Gaia mission. We provide colour–temperature relations for the broad-band colours (BP–RP), (BP–G), (G–RP), (G–K), (BP–K), (RP–K). These relations allow the exploitation of the all-sky Gaia DR2 photometry to obtain precise effective temperatures.

Published in RNAAS
Available from https://arxiv.org/abs/2004.06140

Carbon stars as standard candles – I. The luminosity function of carbon stars in the Magellanic Clouds

Paul Ripoche[1,2], Jeremy Heyl[1], Javiera Parada[1] and Harvey Richer[1]

[1]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z1, Canada
[2]École normale supérieure Paris–Saclay, 94235 Cachan Cedex, France

Our goal in this paper is to derive a carbon-star luminosity function that will eventually be used to determine distances to galaxies at 50–60 Mpc and hence yield a value of the Hubble Constant. Cool N-type carbon stars exhibit redder near-infrared colours than oxygen-rich stars. Using 2MASS near-infrared photometry and Gaia Data Release 2, we identify carbon stars in the Magellanic Clouds (MC) and the Milky Way (MW). Carbon stars in the MC appear as a distinct horizontal feature in the near-infrared ($(J - K_s)_0$, M_J) colour–magnitude diagram. We build a colour selection ($1.4 < (J - K_s)_0 < 2$ mag) and derive the luminosity function of the colour-selected carbon stars. We find the median absolute magnitude and the dispersion, in the J band, for the Large Magellanic Cloud and the Small Magellanic Cloud to be, respectively, ($\bar{M}_J = -6.284 \pm 0.004$ mag, $\sigma = 0.352 \pm 0.005$ mag) and ($\bar{M}_J = -6.160 \pm 0.015$ mag, $\sigma = 0.365 \pm 0.014$ mag). The difference between the MCs may be explained by the lower metallicity of the Small Magellanic Cloud, but in any case it provides limits on the type of galaxy whose distance can be determined with this technique. To account for metallicity effects, we developed a composite magnitude, named C, for which the error-weighted mean C magnitude of the MC are equal. Thanks to the next generation of telescopes (JWST, ELT, TMT), carbon stars could be detected in MC-type galaxies at distances out to 50–60 Mpc. The final goal is to eventually try and improve the measurement of the Hubble constant while exploring the current tensions related to its value.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2005.05539

ω Centauri: weak MgH band in red giants directly traces the helium content

Arumalla B.S. Reddy[1]

[1]Indian Institute of Astrophysics, II Block, Koramangala, Bangalore 560034, India

High spectral resolution and high signal-to-noise ratio optical spectra of red giants in the globular cluster ω Centauri are analysed for stellar parameters and chemical abundances of 15 elements including helium by either line equivalent widths or synthetic spectrum analyses. The simultaneous abundance analysis of MgH and Mg lines adopting theoretical photospheres and a combination of He/Hα ratios proved to be the only powerful probe to evaluate helium abundances of red giants cooler than 4400 K, wherein otherwise helium line transitions (He I 10830 and 5876 Å) present for a direct spectral line analysis. The impact of helium-enhanced model photospheres on the resulting abundance ratios is smaller than 0.15 dex, in agreement with past studies. The first indirect spectroscopic helium abundances measured in this paper for the most metal-rich cluster members reveal the discovery of seven He-enhanced giants ($\Delta Y = +0.15 \pm 0.04$), the largest such sample found spectroscopically to date. The average metallicity of -0.79 ± 0.06 dex and abundances for O, Na, Al, Si, Ca, Ti, Ni, Ba, and La are consistent with values found for the red giant branch (RGB-a) and subgiant branch (SGB-a) populations of ω Centauri, suggesting an evolutionary connection among samples. The He-enhancement in giants is associated with larger s-process elemental abundances, which correlate with Al and anticorrelate with O. These results support the formation of He-enhanced, metal-rich population of ω Centauri out of the interstellar medium enriched with the ejecta of fast rotating massive stars, binaries exploding as supernovæ and asymptotic giant branch (AGB) stars.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2004.09415

Detection of CH^+, CH and H_2 molecules in the young planetary nebula IC 4997

N. Kameswara Rao[1,2], *David L. Lambert*[3], *Arumalla B.S. Reddy*[1], *D.A. García-Hernández*[4,5], *Arturo Manchado*[4,5,6] *and J.J. Díaz-Luis*[7]

[1]Indian Institute of Astrophysics, Bangalore 560034, Karnataka, India

[2]W.J. McDonald Observatory, Department of Astronomy, University of Texas at Austin, TX 78712, USA

[3]W.J. McDonald Observatory and Department of Astronomy, The University of Texas at Austin, Austin, TX 78712-1205, USA

[4]Instituto de Astrofísica de Canarias (IAC), E-38205 La Laguna, Tenerife, Spain

[5]Departamento de Astrofísica, Universidad de La Laguna (ULL), E-38206 La Laguna, Tenerife, Spain

[6]Consejo Superior de Investigaciones Científicas, Madrid, Spain

[7]Observatorio Astronomico Nacional (OAN–IGN), Alfonso XII, 3 y 5, 28014 Madrid, Spain

We have detected CH^+ and CH molecular absorption lines from the young compact planetary nebula IC 4997 from high resolution optical spectra. A high-resolution infra-red (H and K bands) spectrum provides detection of H_2 emission lines amongst many other lines. The H_2 lines provide an excitation temperature of 2100 K which may result from UV fluorescence in the envelope or from shocks formed at the interface between an expanding outflow of ionized gas and the neutral envelope ejected when the star was on the AGB. It is suggested that the CH^+ may result from the endothermic reaction $C + H_2 \rightarrow CH^+ + H$. Intriguingly, CH^+ and also CH show a higher expansion velocity than H_2 emission suggesting they may be part of the post-shocked gas.

Accepted for publication in Publications of the Astronomical Society of the Pacific
Available from https://arxiv.org/abs/2005.00903

CO and HCN isotopologue ratios in the outflows of AGB stars

M. Saberi[1,2,3], *H. Olofsson*[1], *W.H.T. Vlemmings*[1], *E. De Beck*[1], *T. Khouri*[1] *and S. Ramstedt*[4]

[1]Department of Space, Earth and Environment, Chalmers University of Technology, Onsala Space Observatory, 439 92 Onsala, Sweden

[2]Rosseland Centre for Solar Physics, University of Oslo, P.O. Box 1029 Blindern, NO-0315 Oslo, Norway

[3]Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, NO-0315 Oslo, Norway

[4]Department of Physics and Astronomy, Division of Astronomy & Space Physics, Uppsala University, POBox 516, 751 20 Uppsala, Sweden

Context: Isotopologue line intensity ratios of circumstellar molecules have been widely used to trace the photospheric elemental isotopic ratios of evolved stars. However, depending on the molecular species and the physical conditions of the environment, the isotopologue ratio in the circumstellar envelope (CSE) may deviate considerably from the stellar atmospheric value.
Aims: In this paper, we aim to examine how the $^{12}CO/^{13}CO$ and $H^{12}CN/H^{13}CN$ abundance ratios vary radially due to chemical reactions in the outflows of asymptotic giant branch (AGB) stars and the effect of excitation and optical depth on the resulting line intensity ratios. We study both carbon-rich (C-type) and oxygen-rich (O-type) CSEs.
Methods: We performed chemical modeling to derive radial abundance distributions of our selected species in the CSEs over a wide range of mass-loss rates ($10^{-8} < \dot{M} < 10^{-4}$ $M_\odot$ yr^{-1}). We used these as input in a non-local thermodynamic equilibrium (non-LTE) radiative transfer code to derive the line intensities of several ground-state rotational transitions. We also test the influence of stellar parameters, physical conditions in the outflows, the intensity of the interstellar radiation field, and the importance of considering the chemical networks in our model results.
Results: We quantified deviations from the atmospheric value for typical outflows. We find that the circumstellar value of $^{12}CO/^{13}CO$ can deviate from its atmospheric value by up to 25–94% and 6–60% for C- and O-type CSEs, respectively, in radial ranges that depend on the mass-loss rate. We show that variations of the intensity of the interstellar radiation field and the gas kinetic temperature can significantly influence the CO isotopologue abundance ratio in the outer CSEs of both C-type and O-type. On the contrary, the $H^{12}CN/H^{13}CN$ abundance ratio is stable throughout the CSEs for all tested mass-loss rates. The radiative transfer modeling shows that the integrated line intensity ratio $I(^{12}CO)/I(^{13}CO)$ of different rotational transitions varies significantly for stars with mass-loss rates in the range from 10^{-7} to 10^{-6} $M_\odot$ yr^{-1} due to combined chemical and excitation effects. In contrast, the excitation

conditions for the HCN isotopologues are the same for both isotopologues.
Conclusions: We demonstrate the importance of using the isotopologue abundance profiles from detailed chemical models as inputs to radiative transfer models in the interpretation of isotopologue observations. Previous studies of circumstellar CO isotopologue ratios are based on multi-transition data for individual sources and it is difficult to estimate the errors in the reported values due to assumptions that are not entirely correct according to this study. If anything, previous studies may have overestimated the circumstellar $^{12}CO/^{13}CO$ abundance ratio. The use of the HCN molecule as a tracer of C isotope ratios is affected by fewer complicating problems, but we note that the corrections for high optical depths are very large in the case of high-mass-loss-rate C-type CSEs; and in O-type CSEs the $H^{13}CN$ lines may be too weak to detect.

Accepted for publication in Astronomy & Astrophysics
Available from https://arxiv.org/abs/2005.06063

Flickering of the jet-ejecting symbiotic star MWC 560

R.K. Zamanov[1], S. Boeva[1], K.A. Stoyanov[1], G. Latev[1], B. Spassov [1], A. Kurtenkov[1] and G. Nikolov[1]

[1]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, Tsarigradsko Shose 72, BG-1784 Sofia, Bulgaria

We analyzed the optical photometric data of short-term variability (flickering) of the accreting white dwarf in the jet-ejecting symbiotic star MWC 560. The observations were obtained on 17 nights during the period November 2011 to October 2019. The color–magnitude diagram shows that the hot component of the system becomes redder as it gets brighter. For the flickering source, we find that it has color $0.14 < B - V < 0.40$ mag, temperature in the range $6300 < T_{\rm fl} < 11,000$ K, and radius $1.2 < R_{\rm fl} < 18$ $R_\odot$. We find a strong correlation (correlation coefficient 0.76, significance < 0.001) between B band magnitude and the average radius of the flickering source – as the brightness of the system increases, the size of the flickering source also increases. The estimated temperature is similar to that of the bright spot of cataclysmic variables. In 2019, the flickering was missing, and the B–V color of the hot component became bluer.
(acknowledgement: project KP-6-H28/2, Bulgarian National Science Fund)

Published in Astron. Nachr. 1-11 (2020)
Available from https://arxiv.org/abs/2004.00511
and from https://onlinelibrary.wiley.com/doi/abs/10.1002/asna.202013730

Evolved massive stars at low metallicity II. Red supergiant stars in the Small Magellanic Cloud

Ming Yang[1], Alceste Z. Bonanos[1], Bi-Wei Jiang[2], Jian Gao[2], Panagiotis Gavras[3], Grigoris Maravelias[1], Shu Wang[4], Xiao-Dian Chen[4], Frank Tramper[1], Yi Ren[2], Zoi T. Spetsieri[1] and Meng-Yao Xue[5]

[1]IAASARS, National Observatory of Athens, Vas. Pavlou and I. Metaxa, Penteli 15236, Greece

[2]Department of Astronomy, Beijing Normal University, Beijing 100875, People's Republic of China

[3]Rhea Group for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain

[4]CAS Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Datun Road 20A, Beijing 100101, People's Republic of China

[5]International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia

We present the most comprehensive red supergiant (RSG) sample for the Small Magellanic Cloud (SMC) up to now, including 1,239 RSG candidates. The initial sample is derived based on a source catalog for the SMC with conservative ranking. Additional spectroscopic RSGs are retrieved from the literature, as well as RSG candidates selected based on the inspection of Gaia and 2MASS color–magnitude diagrams (CMDs). We estimate that there are in total $\sim 1,800$ or more RSGs in the SMC. We purify the sample by studying the infrared CMDs and the variability of the objects, though there is still an ambiguity between asymptotic giant branch stars (AGBs) and RSGs at the red end of our sample. One heavily obscured target is identified based on multiple NIR and MIR CMDs. The investigation of color-color diagrams (CCDs) shows that, there are much less RSGs candidates ($\sim 4\%$) showing PAH emission features compared to the Milky Way and LMC ($\sim 15\%$). The MIR variability of RSG sample increases with luminosity. We separate the RSG sample into two subsamples ("risky" and "safe") and identify one M5e AGB star in the "risky" subsample, based on simultaneous inspection of variabilities, luminosities and colors. The degeneracy of mass-loss rate (MLR), variability and luminosity of RSG sample is discussed, indicating that most of the targets with large variability are also the bright ones with large MLR. Some targets show excessive dust emission, which may be related to previous episodic mass loss events. We also roughly estimate the total gas and dust budget produced by entire RSG population as $\sim 1.9^{+2.4}_{-1.1} \times 10^{-6}$ $M_\odot$ yr^{-1} in the most conservative case, according to the derived MLR from IRAC1–IRAC4 color. Based on the MIST models, we derive a linear relation between $T_{\rm eff}$ and observed $J - K_{\rm s}$ color with reddening correction for the RSG sample. By using a constant bolometric correction and this relation, the Geneva evolutionary model is compared with our RSG sample, showing a good agreement and a lower initial mass limit of ~ 7 $M_\odot$ for the RSG population. Finally, we compare the RSG sample in the SMC and the LMC. Despite the incompleteness of LMC sample in the faint end, the result indicates that the LMC sample always shows redder color (except for the IRAC1–IRAC2 and WISE1–WISE2 colors due to CO absorption) and larger variability than the SMC sample, which is likely due to a positive relation between MLR/variability and the metallicity.

Accepted for publication in A&A
Available from https://arxiv.org/abs/2005.10108

Optical spectroscopy and X-ray observations of the D-type symbiotic star EF Aql

K.A. Stoyanov[1], K. Iłkiewicz[2], G.J.M. Luna[3,4,5], J. Mikołajewska[2], K. Mukai[6,7], J. Martí[8], G. Latev[1], S. Boeva[1] and R.K. Zamanov[1]

[1]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, Tsarigradsko Shose 72, BG-1784 Sofia, Bulgaria
[2]Nicolaus Copernicus Astronomical Centre, Polish Academy of Sciences, Bartycka 18, P-00716 Warsaw, Poland
[3]CONICET–Universidad de Buenos Aires, Instituto de Astronomía y Física del Espacio (IAFE), Av. Inte. Güiraldes 2620,C1428ZAA, Buenos Aires, Argentina
[4]Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina
[5]Universidad Nacional de Hurlingham, Av. Gdor. Vergara 2222, Villa Tesei, Buenos Aires, Argentina
[6]CRESST and X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[7]Department of Physics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA
[8]Departamento de Física (EPSJ), Universidad de Jaén, Campus Las Lagunillas, A3-420, 23071, Jaén, Spain

We performed high-resolution optical spectroscopy and X-ray observations of the recently identified Mira-type symbiotic star EF Aql. Based on high-resolution optical spectroscopy obtained with SALT, we determine the temperature ($\sim 55\,000$ K) and the luminosity (~ 5.3 $L_\odot$) of the hot component in the system. The heliocentric radial velocities of the emission lines in the spectra reveal possible stratification of the chemical elements. We also estimate the mass-loss rate of the Mira donor star. Our Swift observation did not detect EF Aql in X-rays. The upper limit of the X-ray observations is 10^{-12} erg cm^{-2} s^{-1}, which means that EF Aql is consistent with the faintest X-ray systems detected so far. Otherwise we detected it with the UVOT instrument with an average UVM2 magnitude of 14.05. During the exposure, EF Aql became approximately 0.2 UVM2 magnitudes fainter. The periodogram analysis of the V-band data reveals an improved period of 320.4 ± 0.3 d caused by the pulsations of the Mira-type donor star. The spectra are available upon request from the authors.
(Acknowledgements: K-06-H28/2 08.12.2018, Bulgarian National Science Fund)

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2005.03379

ALMA reveals the coherence of the magnetic field geometry in OH 231.8+4.2

L. Sabin[1], *R. Sahai*[2], *W.H.T. Vlemmings*[3], *Q. Zhang*[4], *A.A. Zijlstra*[5], *T. Gledhill*[6], *M. Huarte-Espinosa*[7], *A.F. Pérez Sánchez*[8,9], *E. Lagadec*[10] *and S.G. Navarro*[11]

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 877, C.P. 22860, Ensenada, B.C., México
[2]Jet Propulsion Laboratory, MS 183-900, California Institute of Technology, Pasadena, CA 91109, USA
[3]Department of Space, Earth and Environment, Chalmers University of Technology, SE-43992 Onsala, Sweden
[4]Center for Astrophysics – Harvard & Smithsonian, 60 Garden Street, Cambridge, MA 02138, USA
[5]Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Oxford Road, Manchester M13 9PL, UK
[6]School of Physics, Astronomy & Mathematics, University of Hertfordshire, College Lane, Hatfield, Hertfordshire AL10 9AB, UK
[7]Hewlett Packard Enterprise Data Science Institute, University of Houston, 4718 Calhoun Rd. Houston, TX, 77204, USA
[8]European Southern Observatory, Alonso de Córdova 3107, Vitacura, Casilla 19001, Santiago de Chile, Chile
[9]Leiden Observatory, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands
[10]Université Côte d'Azur, OCA, CNRS, Lagrange, France
[11]Instituto de Astronomía y Meteorología, Universidad de Guadalajara, 44130 Guadalajara, Jalisco, México

In a continuing effort to investigate the role of magnetic fields in evolved low and intermediate mass stars (principally regarding the shaping of their envelopes), we present new ALMA high resolution polarization data obtained for the nebula OH 231.8+4.2. We found that the polarized emission likely arises from aligned grains in the presence of magnetic fields rather than radiative alignment and self scattering. The ALMA data show well organized electric field orientations in most of the nebula and the inferred magnetic field vectors (rotated by 90 degrees) trace an hourglass morphology centred on the central system of the nebula. One region in the southern part of OH 231.8+4.2 shows a less organized distribution probably due to the shocked environment. These findings, in conjunction with earlier investigations (maser studies and dust emission analysis at other scales and wavelengths) suggest an overall magnetic hourglass located inside a toroidal field. We propose the idea that the magnetic field structure is closely related to the architecture of a magnetic tower and that the outflows were therefore magnetically launched. While the current dynamical effect of the fields might be weak in the equatorial plane principally due to the evolution of the envelope, it would still be affecting the outflows. In that regard, the measurement of the magnetic field at the stellar surface, which is still missing, combined with a full MHD treatment are required to better understand and constrain the events occurring in OH 231.8+4.2.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from https://arxiv.org/abs/2005.10398

The near-infrared polarization of pre-planetary nebula Frosty Leo

E.O. Serrano-Bernal[1], *L. Sabin*[2], *A. Luna*[1], *R. Devaraj*[3], *Y.D. Mayya*[1] *and L. Carrasco*[1]

[1]Instituto Nacional de Astrofísica, Óptica y Electrónica, México
[2]Instituto de Astronomía, Universidad Nacional Autónoma de México, México
[3]Dublin Institute for Advanced Studies, Astronomy and Astrophysics Section, Ireland

We present a near-infrared imaging polarimetric study of the pre-planetary nebula: Frosty Leo. The observations were carried out in J, H and K′ bands using the new polarimeter POLICAN mounted on the 2.1m telescope of the *Guillermo Haro* Astrophysical Observatory, Sonora, México. The most prominent result observed in the polarization maps is a large and well defined dusty envelope (35″ diameter in H-band). The polarization position angles in the envelope are particularly well ordered and nearly parallel to the equator of the nebula (seen in J and H bands). The nebula presents a known bipolar outflow and the envelope completely wraps around it. Within the bipolar lobes, we find high polarization levels ranging from 60% (J band) to 90% (K′ band) and the polarization angles trace a centrosymmetric pattern. We found the remnants of superwind shells at the edges of the bipolar lobes and the duration of this phase is around 600 yrs. The origin of polarization features in the nebula is most likely due to a combination of single and multiple scattering. Our results clearly demonstrate new structures that provide new hints on the evolution of

Frosty Leo from its previous asymptotic giant branch phase.

Accepted for publication in MNRAS
Available from https://arxiv.org/abs/2005.07348

Catalogue of central stars of planetary nebulæ: expanded edition

W.A. Weidmann[1,2], M.B. Mari[4], E.O. Schmidt[3], G. Gaspar[1,2], M.M. Miller Bertolami[5,6], A.G. Oio[3], L.A. Gutiérrez-Soto[4], M.G. Volpe[3], R. Gamen[5,6] and D. Mast[1,2]

[1]Observatorio Astronómico de Córdoba. Universidad Nacional de Córdoba. Laprida 854, Córdoba, Argentina
[2]Consejo de Investigaciones Científicas y Técnicas de la República Argentina, Argentina
[3]Instituto de Astronomía Teórica y Experimental. CONICET–UNC, Córdoba. Laprida 854, Córdoba, Argentina
[4]Observatório do Valongo, Universidade Federal do Rio de Janeiro, Ladeira Pedro Antonio 43, 20080-090 Rio de Janeiro, Brazil
[5]Instituto de Astrofísica de La Plata, CONICET–UNLP, BuenosAires, Argentina Paseo del Bosque s/n, FWA, B1900 La Plata,Buenos Aires, Argentina
[6]Facultad de Ciencias Astronómicas y Geofísicas, UNLP, Buenos Aires, Argentina Paseo del Bosque s/n, FWA, B1900 La Plata,Buenos Aires, Argentina

Planetary nebulæ represent a potential late stage of stellar evolution, however the central stars (CSPNe) are relatively faint and therefore pertinent information is merely available for $< 20\%$ of the Galactic sample. Consequently, the literature was surveyed to construct a new catalogue of 620 CSPNe featuring important spectral classifications and information. The catalogue supersedes the existing iteration by 25%, and includes physical parameters such as luminosity, surface gravity, temperature, magnitude estimates, and references for published spectra. The marked statistical improvement enabled the following pertinent conclusions to be determined: the H-rich/H-poor ratio is 2:1, there is a deficiency of CSPNe with types [WC 5–6], and nearly 80% of binary central stars belong to the H-rich group. The last finding suggests that evolutionary scenarios leading to the formation of binary central stars interfere with the conditions required for the formation of H-poor CSPN. Approximately 50% of the sample with derived values of $\log L$, $\log T_{\rm eff}$ and $\log g$ exhibit masses and ages consistent with single stellar evolutionary models. The implication is that single stars are indeed able to form planetary nebulæ. Moreover, it is shown that H-poor CSPNe are formed by higher mass progenitors. The catalogue is available through the Vizier database.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/2005.10368

Period analysis of All-Sky Automated Survey for Supernovæ (ASAS-SN) data on a sample of ”irregular” pulsating red giants

John R. Percy[1]

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

All-Sky Automated Survey for Supernovae (ASAS-SN) data and, for some stars, AAVSO visual and V data have been used to study the possible periodicity of 74 ”irregular” pulsating red giants (PRGs) in the AAVSO observing program. Results have been obtained and tabulated for 41 of them. For most of the tabulated stars, the new data provide more and/or better results than AAVSO data alone. All have small amplitudes. Several of the stars appear to have long secondary periods, as well as a pulsation period. A very few may be bimodal. Only about half of the periods that we derive are consistent with the periods in the VSX catalogue. We recommend that the AAVSO consider which of these small-amplitude ”irregular” stars should continue to be observed, and how.

Accepted for publication in JAAVSO 48 (2020)
Available from aavso.org/apps/jaavso/article/3575/

ASAS-SN observations of long secondary periods in pulsating red giants

John R. Percy[1] *and Anthony Mark Wallace*[1]

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

About a third of alll pulsating red giants (PRGs) have long secondary periods (LSPs), an order of magnitude longer than their pulsation periods (P). Although LSPs have been known for many decades, their nature and cause are uncertain. We have analyzed data on 45 PRGs, from the All-Sky Automated Survey for Supernovae (ASAS-SN) and combined the results with data from the literature to draw a few new conclusions about this phenomenon. LSPs have V amplitudes of up to 0.45 mag. The ratio LSP/P has a peak at 10 ± 1, and a broader distribution at 7 ± 1. There is no obvious correlation between LSP/P and LSP itself. Previous studies have suggested that the pulsation amplitude does not vary around the LSP cycle, but varies on longer time scales of 20–45 P. However, we also find smaller variations around the LSP cycle, which may be partly due to the effect of the LSP variations on the pulsation amplitude determination, but otherwise appear to be real and common.

Published in JAAVSO 48 (2020)
Available from aavso.org/apps/jaavso/article/3569/

A note on bimodal pulsating red giants

John R. Percy[1]

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

ASAS-SN data and the AAVSO time-series analysis package VSTAR have been used to determine the pulsation periods of a sample of 23 bimodal pulsating red giants. The results have been combined with results from the literature to determine period ratios and pulsation modes, and how these vary systematically with the observed pulsation period(s). The results are consistent with previous results, and with theoretical predictions: most longer-period bimodal stars pulsate in the fundamental mode (period P_0) and the first overtone mode (period P_1), with P_1/P_0 decreasing slightly with increasing P_0; most shorter-period bimodal stars pulsate in the first-overtone mode and the second-overtone mode (period P_2), with P_2/P_1 decreasing slightly with increasing P_1. Stars with period 100 to 200 days show a mixture of the two behaviors.

Published in JAAVSO 48 (2020)
Available from aavso.org/apps/jaavso/article/3522/