Figure 1: R Aquarii is a symbiotic system; the picture shows an incredibly detailed image of the interacting couple obtained with ESO-VLT’s SPHERE instrument. For more details see https://www.eso.org/public/images/eso1840a.
Dear Colleagues,

Happy New Year! It is a pleasure to present you the 258th issue of the AGB Newsletter.

Last month’s Food for Thought resulted in two reactions regarding the topic of the next IAU symposium related to our field. Elizabeth Griffin suggested "Cool giants and supergiants: unique contributors to (or unique challenges for) the Time Domain". She added: "Much has already been tackled in the time domain from the aspect of early-type stars. Cool giants and supergiants offer a different set of challenges, from macroturbulence, unstable and non-uniform chromospheres (driven by much longer activity cycles), mass loss in bunches and streams, radial pulsations... all of which give rise to short-term, medium-term or long-term changes."

Bruce Balick suggested "Close AGB Binaries and the Formation of Planetary Nebulae, and added an elaborate justification: "There is a rapidly converging consensus that mass exchange processes among close binary stars containing an AGB star is the initial step in imprinting the structures of PNe. The white paper ‘Evolved Stars’ in ‘Science with a Next-Generation Very Large Array ASP Conference Series, Monograph 7’(draft edition, ed. E.J. Murphy, 2018 Astronomical Society of the Pacific, p127) makes the case very succinctly:

Binary companions are thought to play a significant role in the late evolutionary stages of Sun-like stars. For example, binary interactions are widely believed to underlie the formation of most PNe and may hold the key to the resolution of a long-standing puzzle, namely that although PNe evolve from AGB stars, whose CSEs typically appear spherical with relatively, slow, isotropic expansion ($v_{\text{exp}} \sim 5–15 \text{ km s}^{-1}$), the vast majority of PNe and pPNe exhibit axisymmetric structures, with a variety of elliptical, bipolar, and multipolar morphologies, as well as fast, collimated outflows ($v_{\text{exp}} \gtrsim 50–100 \text{ km s}^{-1}$).

In the past few years theoretical progress in understanding how rePNe are formed and launched has been exceptionally rapid. To quote Akashi & Soker (2018, MNRAS, 481, 2754):

Binary systems shape most, and probably all, PNe (e.g., Akras et al. 2016; Ali et al. 2016; Bond et al. 2016; Chen et al. 2016; Chotellis et al. 2016; García-Rojas et al. 2016; Hillwig et al. 2016; Jones et al. 2016; Madappatt et al. 2016; Chen et al. 2017; De Marco & Izzard 2017; Hillwig et al. 2017; Jones & Boffin 2017; Souicka et al. 2017; Aller et al. 2018; Barker et al. 2018; Bujarrabal et al. 2018; Ilkiwicz et al. 2018; Jones 2018; Miszalski et al. 2018b, for a sample of papers from the last 3 years; for a different model see García-Segura et al. 2005). In some cases there is a direct link between the presence of a binary central star and the presence of jets (e.g., Boffin et al. 2012; Miszalski et al. 2013, 2018a), and binary AGB systems and the presence of jets launched by the companion to the AGB star (e.g., Thomas et al. 2013; Gorlova et al. 2015; Bollen et al. 2017; Van Winckel 2017).

The next IAU symposium meeting can be the concert hall of an exciting overture for an upcoming decade of very exciting new theoretical models and high-resolution imaging observations of PNe as an array of new optical, IR, and radio tools reach full operation. To quote Eric Lagadec (2018, Galaxies, 6, 99),

Thanks to news(sic) instruments on the most advanced telescopes (e.g., the VLTI, SPHERE/VLT and ALMA), high angular resolution observations are revolutionising our view of the ejection of gas and dust during the AGB and post-AGB phases… We can now probe regions between 1 and 20 milliarcsec in size from the optical to the submillimetre domain. For a star at 100 parsec, this means we can map material as close 0.1 AU of the central star, i.e., that we can map the surfaces of nearby giant stars.

The next IAU meeting is a propitious opportunity to inform and engage the larger PN community is a discussion of one of the most important and elusive questions, ‘Why do PNe have their characteristic shapes?’ just as some fundamental and exciting answers begin to emerge. This question has been asked about planetary nebulae since the discovery the Dumbbell Nebula, M 27, by Charles Messier in 1764. The topic has not been the theme of any IAU Meetings on PNe for many years. The time is right.”

2
Figure 2: New high-resolution astronomical imaging instruments anticipated over the next decade (courtesy Eric Lagadec, used by permission).

We encourage you all to get organised and make these meetings happen! The Working Group on Red Giants and Supergiants (within the IAU Commission on Stellar Evolution), and the AGB Newsletter, remain at your service.

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

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

Food for Thought

This month’s thought-provoking statement is:

What fraction of stars evolve as single stars all the way to the PN phase?

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)
A runaway giant in the Galactic halo

Philip Massey1, Stephen E. Levine1, Kathryn F. Neugent1,2, Emily Levesque2, Nidia Morrell3 and Brian Skiff1

1Lowell Observatory, USA
2Dept. of Astronomy, University of Washington, USA
3Las Campanas Observatory, Chile

New evidence provided by the Gaia satellite places the location of the runaway star J01020100−7122208 in the halo of the Milky Way (MW) rather than in the Small Magellanic Cloud (SMC) as previously thought. We conduct a reanalysis of the star’s physical and kinematic properties, which indicates that the star may be an even more extraordinary find than previously reported. The star is a 180 Myr old 3–4 M☉ G5–8 bright giant, with an effective temperature of 4800 ± 100 K, a metallicity of Fe/H = −0.5, and a luminosity of log L/L☉ = 2.70 ± 0.20. A comparison with evolutionary tracks identifies the star as being in a giant or early asymptotic giant branch stage. The proper motion, combined with the previously known radial velocity, yields a total Galactocentric space velocity of 296 km s⁻¹. The star is currently located 6.4 kpc below the plane of the MW, but our analysis of its orbit shows it passed through the disk sin25 Myr ago. The star’s metallicity and age argue against it being native to the halo, and we suggest that the star was likely ejected from the disk. We discuss several ejection mechanisms, and conclude that the most likely scenario is ejection by the MW’s central black hole based upon our analysis of the star’s orbit. The identification of the large radial velocity of J01020100−7122208 came about as a happenstance of it being seen in projection with the SMC, and we suggest that many similar objects may be revealed in Gaia data.

Published in Astronomical Journal
Available from https://arxiv.org/abs/1810.04083

Unravelling the baffling mystery of the ultrahot wind phenomenon in white dwarfs

Nicole Reindl1, M. Bainbridge1, N. Przybilla2, S. Geier3, M. Prvák4, J. Krtička4, R. H. Østensen5, J. Telting6 and K. Werner7

1University of Leicester, UK
2Universität Innsbruck, Austria
3University of Potsdam, Germany
4Masaryk University, Poland
5Missouri State University, USA
6Nordic Optical Telescope, Spain
7Eberhard Karls University Tübingen, Germany

The presence of ultra-high excitation (UHE) absorption lines (e.g., O viii) in the optical spectra of several of the hottest white dwarfs poses a decades-long mystery and is something that has never been observed in any other astrophysical object. The occurrence of such features requires a dense environment with temperatures near 10⁶ K, by far exceeding the stellar effective temperature. Here we report the discovery of a new hot wind white dwarf, GALEX J014636.8+323615. Astonishingly, we found for the first time rapid changes of the equivalent widths of the UHE features, which are correlated to the rotational period of the star (P = 0.242035 d). We explain this with the presence of a wind-fed circumstellar magnetosphere in which magnetically confined wind shocks heat up the material to the high temperatures required for the creation of the UHE lines. The photometric and spectroscopic variability of GALEX J014636.8+323615 can then be understood as consequence of the obliquity of the magnetic axis with respect to the rotation axis of the white dwarf. This is the first time a wind-fed circumstellar magnetosphere around an apparently isolated white dwarf has been discovered and finally offers a plausible explanation of the ultra hot wind
Thermal emission in the South–West clump of VY CMa

Michael S. Gordon, Terry J. Jones, Roberta M. Humphreys, Steve Ertel, Philip M. Hinz and William F. Hoffmann

1Minnesota Institute for Astrophysics, USA
2SOFIA Science Center, USA
3Steward Observatory, USA

We present high spatial resolution LBTI/NOMIC 9–12 µm images of VY CMa and its massive outflow feature, the South–West (SW) Clump. Combined with high-resolution imaging from HST (0.4–1 µm) and LBT/LMIRCam (1–5 µm), we isolate the spectral energy distribution (SED) of the clump from the star itself. Using radiative-transfer code DUSTY, we model both the scattered light from VY CMa and the thermal emission from the dust in the clump to estimate the optical depth, mass, and temperature of the SW Clump. The SW Clump is optically thick at 8.9 µm with a brightness temperature of ∼200 K. With a dust chemistry of equal parts silicates and metallic iron, as well as assumptions on grain size distribution, we estimate a dust mass of 5.4 × 10^{-5} M⊙. For a gas-to-dust ratio of 100, this implies a total mass of 5.4 × 10^{-3} M⊙. Compared to the typical mass-loss rate of VY CMa, the SW Clump represents an extreme, localized mass-loss event from \sim 300 years ago.

Accepted for publication in The Astronomical Journal
Available from https://arxiv.org/abs/1811.05998

Dramatic change in the boundary layer in the symbiotic recurrent nova T Coronae Borealis


1CONICET–Universidad de Buenos Aires, Instituto de Astronomía y Física del Espacio, (IAFE), Av. Inte. Güiraldes 2620, C1428ZAA, Buenos Aires, Argentina
2Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina
3Universidad Nacional Arturo Jauretche, Av. Calchaquí 6200, F. Varela, Buenos Aires, Argentina
4CRESST and X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
5Department of Physics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA
6Columbia Astrophysics Lab 550 W120th St., 1027 Pupin Hall, MC 5247 Columbia University, New York, New York 10027, USA
7Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, PA 15260, USA
8University College London, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, RH5 6NT, UK
9INAF – Istituto di Astrofisica Spaziale e Fisica Cosmica, Via U. La Malfa 153, I-90146 Palermo, Italy
10Departamento de Física y Astronomía, Universidad de La Serena, Av. Cisternas 1200, La Serena, Chile
11Instituto de Ciencias Astronómicas, de la Tierra y del Espacio (ICATE–CONICET), Av. España Sur 1512, J5402DSP, San Juan, Argentina

A sudden increase in the rate at which material reaches the most internal part of an accretion disk, i.e. the boundary layer, can change its structure dramatically. We have witnessed such change for the first time in the symbiotic recurrent nova T CrB. Our analysis of XMM–Newton, Swift Burst Alert Telescope (BAT) / X-Ray Telescope (XRT) / UltraViolet Optical Telescope (UVOT) and American Association of Variable Stars Observers (AAVSO) V- and
B-band data indicates that during an optical brightening event that started in early 2014 ($\Delta V \approx 1.5$ mag): (i) the hard X-ray emission as seen with BAT almost vanished; (ii) the XRT X-ray flux decreased significantly while the optical flux remained high; (iii) the UV flux increased by at least a factor of 40 over the quiescent value; and (iv) the X-ray spectrum became much softer and a bright, new, blackbody-like component appeared. We suggest that the optical brightening event, which could be a similar event to that observed about 8 years before the most recent thermonuclear outburst in 1946, is due to a disk instability.

Published in Astronomy & Astrophysics, 619, 61 (2018)

**Ultraviolet and optical spectroscopy of AGB stars showing UV excess**

*Roberto Ortiz¹, Martín A. Guerrero² and Roberto D.D. Costa¹*

¹Universidade de São Paulo (USP), Brazil
²Instituto de Astrofísica de Andalucía (IAA/CSIC), Spain

We have examined UV and optical $UB$ spectra of 20 UV-emitting AGB stars of various variability classes to study the intensity of the continuum and emission lines as a function of stellar visual magnitude to shed light on the origin of their UV emission. A significant fraction (60%) of these stars show Fe¹ and Fe¹¹ emission lines and $\sim 1/4$ show Balmer lines in emission. The emission in the GALEX [FUV] and [NUV] bands is dominated by continuum emission, with a limited ($\leq 36\%$) contribution from emission lines. The UV spectra of sources with multiple GALEX or IUE observations reveal short-term (of a few days or less) variability, which does not follow the pulsation cycle. The intensity of the Mg¹¹ $\lambda 2800$ doublet, a classical diagnostic of chromospheric activity, is anti-correlated with the spectral slope in the near-UV that could be partially attributed to temperature variations in a stellar chromosphere. We observed that the intensity of Mg¹¹ $\lambda 2800$ in $\alpha$ Cet has a sharp maximum at the phase $\phi \simeq 0.35$ after the light curve maximum. Other LPV stars (T Cet and R Com) show strong UV Fe¹¹ emission lines near this same phase and, like the Mg¹¹ doublet, their excitation can be driven by pulsation. Our results suggest that far-UV emission from AGB stars might be external (hot companion, accretion disk), but contemporary photometric and spectral UV observations covering the whole pulsation period are required to ascertain its true origin.

Published in Monthly Notices of the Royal Astronomical Society
Available from [https://doi.org/10.1093/mnras/sty3076](https://doi.org/10.1093/mnras/sty3076)

**PROEQUIB: IDL library for plasma diagnostics and abundance analysis**

*Ashkbiz Danehkar¹,²*

¹Research Centre in Astronomy, Astrophysics and Astrophotonics, Macquarie University, Sydney, NSW 2109, Australia
²Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

The emission lines emitted from gaseous nebulae carry valuable information about the physical conditions and chemical abundances of ionized gases in these objects, as well as the interstellar extinction. "PROEQUIB" is a library containing several application programming interface (API) functions developed in the Interactive Data Language (IDL), which can be used for plasma diagnostics and abundance analysis of nebular spectra. This IDL library can also be used by the GNU Data Language (GDL), which is a free and open-source IDL compiler. This package includes several API functions to determine physical conditions and chemical abundances from collisionally excited lines (CEL) and recombination lines (RL), derive interstellar extinctions from Balmer lines, and deredden the observed fluxes. This IDL library heavily relies on the IDL Astronomy User’s library and the IDL "ATOMNeb" library. The API functions of this IDL library can easily be utilized for spatially-resolved studies of ionized gaseous nebulae observed using integral field spectroscopy.

Available from [https://arxiv.org/abs/1812.01605](https://arxiv.org/abs/1812.01605) and [https://doi.org/10.21105/joss.00899](https://doi.org/10.21105/joss.00899)
A comparison of stellar and gas-phase chemical abundances in dusty early-type galaxies

Emily Griffith\(^1\), Paul Martini\(^{1,2}\) and Charlie Conroy\(^3\)

\(^1\)Department of Astronomy, The Ohio State University, 140 West 18\(^{th}\) Avenue, Columbus, OH 43210, USA
\(^2\)Center for Cosmology and Astro-Particle Physics, The Ohio State University, 191 West Woodruff Avenue, Columbus OH, 43210, USA
\(^3\)Department of Astronomy, Harvard University, Cambridge, MA 02138, USA

While we observe a large amount of cold interstellar gas and dust in a subset of the early-type galaxy (ETG) population, the source of this material remains unclear. The two main, competing scenarios are external accretion of lower mass, gas-rich dwarfs and internal production from stellar mass loss and/or cooling from the hot interstellar medium (ISM). We test these hypotheses with measurements of the stellar and nebular metallicities of three ETGs (NGC 2768, NGC 3245, and NGC 4694) from new long-slit, high signal-to-noise ratio spectroscopy from the Multi-Object Double Spectrographs (MODs) on the Large Binocular Telescope (LBT). These ETGs have modest star formation rates and minimal evidence of nuclear activity. We model the stellar continuum to derive chemical abundances and measure gas-phase abundances with standard nebular diagnostics. We find that the stellar and gas-phase abundances are very similar, which supports internal production and is very inconsistent with the accretion of smaller, lower metallicity dwarfs. All three of these galaxies are also consistent with an extrapolation of the mass–metallicity relation to higher mass galaxies with lower specific star formation rates. The emission line flux ratios along the long-slit, as well as global line ratios clearly indicate that photo-ionization dominates and ionization by alternate sources including AGN activity, shocks, cosmic rays, dissipative magneto-hydrodynamic waves, and single degenerate Type Ia supernovae progenitors do not significantly affect the line ratios.

Accepted for publication in MNRAS

Onset of non-linear internal gravity waves in intermediate-mass stars

R.P. Ratnasingam\(^1\), P.V.F. Edelmann\(^1\) and T.M. Rogers\(^{1,2}\)

\(^1\)School of Mathematics, Statistics and Physics, Newcastle University, Newcastle upon Tyne, NE1 7RU, UK
\(^2\)Planetary Science Institute, Tucson, AZ 85721, USA

Internal gravity waves (IGW) propagate in the radiation zones of all stars. During propagation, their amplitudes are affected by two main features: radiative diffusion and density stratification. We have studied the implications of these two features on waves travelling within the radiative zones of non-rotating stars with stellar parameters obtained from the one-dimensional stellar evolution code, MESA. As a simple measure of induced wave dynamics, we define a criterion to see if waves can become non-linear and if so, under what conditions. This was done to understand the role IGW may play in angular momentum transport and mixing within stellar interiors. We find that the IGW generation spectrum, convective velocities, and the strength of density stratification all play major roles in whether waves become non-linear. With increasing stellar mass, there is an increasing trend in non-linear wave energies. The trends with different metallicities and ages depend on the generation spectrum.

Published in Monthly Notices of the Royal Astronomical Society
Confirming the presence of second population stars and the iron discrepancy along the AGB of the globular cluster NGC 6752

A. Mucciarelli\textsuperscript{1,2}, E. Lapenna\textsuperscript{1,2}, C. Lardo\textsuperscript{3}, P. Bonifacio\textsuperscript{4}, F.R. Ferraro\textsuperscript{1,2} and B. Lanzoni\textsuperscript{1,2}

\textsuperscript{1}DIFA – University of Bologna, Italy
\textsuperscript{2}INAF – OAS, Bologna, Italy
\textsuperscript{3}EPFL, Switzerland
\textsuperscript{4}GEPI – Paris, France

Asymptotic giant branch (AGB) stars in the globular cluster NGC 6752 have been found to exhibit some chemical peculiarities with respect to the red giant branch (RGB) stars. A discrepancy between $[\text{Fe}^\text{I}/\text{H}]$ and $[\text{Fe}^\text{II}/\text{H}]$ (not observed in RGB stars) has been detected adopting spectroscopic temperatures. Moreover, a possible lack of second-population stars along the AGB was claimed. The use of photometric temperatures based on $(V–K)$ colors was proposed to erase this iron discrepancy. Also, ad hoc scenarios have been proposed to explain the absence of second-population AGB stars.

Here we analyzed a sample of 19 AGB and 14 RGB stars of NGC 6752 observed with the spectrographs UVES. The two temperature scales agree very well for the RGB stars while for the AGB stars there is a systematic offset of $\sim 100$ K. We found that even if the photometric temperatures alleviate the iron discrepancy with respect to the spectroscopic ones, a systematic difference between $[\text{Fe}^\text{I}/\text{H}]$ and $[\text{Fe}^\text{II}/\text{H}]$ is still found among the AGB stars. An unexpected result is that the photometric temperatures do not satisfy the excitation equilibrium in the AGB stars. This suggests that standard 1D-LTE model atmospheres are unable to properly describe the thermal structure of AGB stars, at variance with the RGB stars.

The use of photometric temperatures confirms the previous detection of second-population AGB stars in this cluster, with the presence of clear correlations/anti-correlations among the light element abundances. This firmly demonstrates that both first and second-population stars evolve along the AGB of NGC 6752.

Accepted for publication in ApJ
Available from \url{https://arxiv.org/abs/1811.10626}

A new outburst of the yellow hypergiant star $\rho$ Cas

Michaela Kraus\textsuperscript{1}, Indrek Kolka\textsuperscript{2}, Anna Aret\textsuperscript{1,2}, Dieter H. Nickeler\textsuperscript{1}, Grigoris Maravelias\textsuperscript{3,4}, Tõnis Eenmäe\textsuperscript{2}, Alex Lobel\textsuperscript{5} and Valentina G. Klochkova\textsuperscript{6}

\textsuperscript{1}Astronomický ústav, Akademie věd České republiky, Fricova 298, 251 65 Ondřejov, Czech Republic
\textsuperscript{2}Tartu Observatory, University of Tartu, 61602 Tõravere, Tartumaa, Estonia
\textsuperscript{3}IESL, Foundation for Research and Technology–Hellas, 100 Nikolaou Plastira Street, 71110 Heraklion, Crete, Greece
\textsuperscript{4}Physics Department, University of Crete, P.O. Box 2208, 71003 Heraklion, Crete, Greece
\textsuperscript{5}Royal Observatory of Belgium, Ringlaan 3, 1180, Brussels, Belgium
\textsuperscript{6}Special Astrophysical Observatory of the Russian Academy of Sciences, Nizhnii Arkhyz 369167, Russia

Yellow hypergiants are evolved massive stars that were suggested to be in post-red supergiant stage. Post-red supergiants that evolve back to the blue, hot side of the Hertzsprung–Russell diagram can intersect a temperature domain in which their atmospheres become unstable against pulsations (the Yellow Void or Yellow Wall), and the stars can experience outbursts with short, but violent mass eruptions. The yellow hypergiant $\rho$ Cas is famous for its historical and recent outbursts, during which the star develops a cool, optically thick wind with a very brief but high mass-loss rate, causing a sudden drop in the light curve. Here we report on a new outburst of $\rho$ Cas which occurred in 2013, accompanied by a temperature decrease of $\sim 3000$ K and a brightness drop of 0.6 mag. During the outburst TiO bands appear, together with many low excitation metallic atmospheric lines characteristic for a later spectral type. With this new outburst, it appears that the time interval between individual events decreases, which might indicate that $\rho$ Cas is preparing for a major eruption that could help the star to pass through the Yellow Void. We also analysed the emission features that appear during phases of maximum brightness and find that they vary synchronous with the emission in the prominent $[\text{Ca}^\text{II}]$ lines. We conclude that the occasionally detected emission in the spectra of $\rho$ Cas, as well as certain asymmetries seen in the absorption lines of low to medium-excitation potential, are circumstellar in nature, and we discuss the possible origin of this material.

Accepted for publication in MNRAS
Available from \url{https://arxiv.org/abs/1812.03065}
The variable carbon star CGCS 6107

Roberto Nesci\textsuperscript{1}, Massimo Calabresi\textsuperscript{2}, Corinne Rossi\textsuperscript{3} and Paolo Ochner\textsuperscript{4}

\textsuperscript{1}INAF/IAPS–Roma, Italy
\textsuperscript{2}Frasso Sabino Observatory, MPC 157, Italy
\textsuperscript{3}INAF/OAR, Monteporzio, Italy
\textsuperscript{4}INAF/OAPD Asiago, and Università di Padova, Italy

The spectroscopic and photometric variability of CGCS 6107 has been studied with four telescopes from 2015 to 2018. The star varied between $R = 11.4$ and 14.2 mag with a time scale of $\sim 500$ days. An appreciable color variation was observed, the star being bluer when brighter. H$\alpha$ emission was present around maxima. The spectrum is that of an N-type giant veiled by a variable dusty envelope.

Published in Information Bulletin on Variable Stars, vol. 63, #6254 (2018)
Available from \url{http://ibvs.konkoly.hu/pub/ibvs/6201/6254.pdf}

From evolved stars to the evolution of IC 1613

Seyed Azim Hashemi\textsuperscript{1,2}, Atefeh Javadi\textsuperscript{2} and Jacco Th. van Loon\textsuperscript{3}

\textsuperscript{1}Sharif University of Technology, Iran
\textsuperscript{2}IPM, Iran
\textsuperscript{3}Keele University, UK

IC 1613 is a Local Group dwarf irregular galaxy at a distance of 750 kpc. In this work, we present an analysis of the star formation history (SFH) of a field of $\sim 200$ square arcmin in the central part of the galaxy. To this aim, we use a novel method based on the resolved population of more highly evolved stars. We identify 53 such stars, 8 of which are supergiants and the remainder are long period variables (LPV), large amplitude variables (LAV) or extreme Asymptotic Giant Branch (x-AGB) stars. Using stellar evolution models, we find the age and birth mass of these stars and thus reconstruct the SFH. The average rate of star formation during the last Gyr is $\sim 3 \times 10^{-4} \, M_\odot \, yr^{-1} \, kpc^{-2}$. The absence of a dominant epoch of star formation over the past 5 Gyr, suggests that IC 1613 has evolved in isolation for that long, spared harrassment by other Local Group galaxies (in particular M 31 and the Milky Way). We confirm the radial age gradient, with star formation currently concentrated in the central regions of IC 1613, and the failure of recent star formation to have created the main HI supershell. Based on the current rate of star formation at $(5.5 \pm 2) \times 10^{-3} \, M_\odot \, yr^{-1}$, the interstellar gas mass of the galaxy of $9 \times 10^7 \, M_\odot$, and the gas production rate from AGB stars at $\sim 6 \times 10^{-4} \, M_\odot \, yr^{-1}$, we conclude that the star formation activity of IC 1613 can continue for $\sim 18$ Gyr in a closed-box model, but is likely to cease much earlier than that unless gas can be accreted from outside.

Accepted for publication in MNRAS
Available from \url{https://arxiv.org/abs/1812.07230}

The interplay between pulsation, mass loss, and third dredge-up: More about Miras with and without technetium

Stefan Uttenthaler\textsuperscript{1}, Iain McDonald\textsuperscript{2}, Klaus Bernhard\textsuperscript{6,4}, Sergio Cristallo\textsuperscript{5,6} and David Gobrecht\textsuperscript{7}

\textsuperscript{1}Kuffner Observatory, Vienna, Austria
\textsuperscript{2}Jodrell Bank Centre for Astrophysics, Manchester, UK
\textsuperscript{3}BAV, Berlin, Germany
\textsuperscript{4}AAVSO, Cambridge, USA
\textsuperscript{5}INAF – Osservatorio Astronomico, Italy
\textsuperscript{6}INFN – Sezione di Perugia, Italy
\textsuperscript{7}Instituut voor Sterrenkunde, Leuven, Belgium

Context: We follow up on a previous finding that AGB Mira variables containing the third dredge-up indicator
Warm CO in evolved stars from the THROES catalogue. II. 
Herschel/PACS spectroscopy of C-rich envelopes

J.M. da Silva Santos1,2, J. Ramos-Medina1, C. Sánchez Contreras1 and P. García-Lario3

1Centro de Astrobiología (CSIC–INTA), ESAC, Camino Bajo del Castillo s/n, 28691 Villanueva de la Cañada, Madrid, Spain
2Institute for Solar Physics, Department of Astronomy, Stockholm University, AlbaNova University Centre, SE-106 91 Stockholm, Sweden
3European Space Astronomy Center, P.O. Box 78, 28691, Villanueva de la Cañada, Madrid, Spain

Context: This is the second paper of a series making use of Herschel/PACS spectroscopy of evolved stars in the THROES catalogue to study the inner warm regions of their circumstellar envelopes (CSEs).

Aims: We analyze the CO emission spectra, including a large number of high-J CO lines (from \(J = 14–13\) to \(J = 45–44, \nu = 0\), as a proxy for the warm molecular gas in the CSEs of a sample of bright carbon-rich stars spanning different evolutionary stages from the Asymptotic Giant Branch (AGB) to the young planetary nebula (PNe) phase.

Methods: We use the rotational diagram (RD) technique to derive rotational temperatures \(T_{\text{rot}}\) and masses \(M_{\text{H}_2}\) of the envelope layers where the CO transitions observed with PACS arise. Additionally, we obtain a first order estimate of the mass-loss rates and assess the impact of the opacity correction for a range of envelope characteristic radii. We use multi-epoch spectra for the well studied C-rich envelope IRC +10°216 to investigate the impact of CO flux variability on the values of \(T_{\text{rot}}\) and \(M_{\text{H}_2}\).

Results: PACS sensitivity allowed the study of higher rotational numbers than before indicating the presence of a significant amount of warmer gas (\(\sim 200–900\) K) not traceable with lower-J CO observations at sub-mm/mm wavelengths. The masses are in the range \(M_{\text{H}_2} \sim 10^{-2}–10^{-5} M_\odot\), anti-correlated with temperature. For some strong CO emitters we infer a double temperature (warm \(T_{\text{rot}} \sim 400\) K and hot \(T_{\text{rot}} \sim 820\) K) component. From the analysis of IRC +10°216, we corroborate that the effect of line variability is perceptible on the \(T_{\text{rot}}\) of the hot component only, and certainly insignificant on \(M_{\text{H}_2}\) and, hence, the mass-loss rate. The agreement between our mass-loss rates and the literature across the sample is good. Therefore, the parameters derived from the RD are robust even when strong line flux variability occurs, with the major source of uncertainty in the estimate of the mass-loss rate being the size of the CO-emitting volume.

Accepted for publication in Astronomy and Astrophysics
Available from https://arxiv.org/abs/1812.07815
An adaptive optics survey of stellar variability at the Galactic center

Abhimat K. Gautam\textsuperscript{1}, Tuan Do\textsuperscript{1}, Andrea M. Ghez\textsuperscript{2}, Mark R. Morris\textsuperscript{1}, Gregory D. Martinez\textsuperscript{1}, Matthew W. Hosek, Jr.\textsuperscript{1}, Jessica R. Lu\textsuperscript{2}, Shoko Sakai\textsuperscript{3}, Gunther Witzel\textsuperscript{1}, Siyao Jia\textsuperscript{2}, Eric E. Becklin\textsuperscript{1} and Keith Matthews\textsuperscript{3}

\textsuperscript{1}Department of Physics and Astronomy, University of California, Los Angeles, USA
\textsuperscript{2}Department of Astronomy, University of California, Berkeley, USA
\textsuperscript{3}Division of Physics, Mathematics, and Astronomy, California Institute of Technology, USA

We present a \( \approx 11.5 \) year adaptive optics (AO) study of stellar variability and search for eclipsing binaries in the central \( \sim 0.4 \) pc \( (\sim 10^6) \) of the Milky Way nuclear star cluster. We measure the photometry of 563 stars using the Keck II NIRC2 imager \( (K' \text{ and } \lambda_0 = 2.124 \mu m) \). We achieve a photometric uncertainty floor of \( \Delta m_K \approx 0.03 (\approx 3\%) \), comparable to the highest precision achieved in other AO studies. Approximately half of our sample \( (50 \pm 2\%) \) shows variability. 52\% of known early-type young stars and 43\% of known late-type giants are variable. These variability fractions are higher than those of other young, massive star populations or late-type giants in globular clusters, and can be largely explained by two factors. First, our experiment time baseline is sensitive to long-term intrinsic stellar variability. Second, the proper motion of stars behind spatial inhomogeneities in the foreground extinction screen can lead to variability. We recover the two known Galactic center eclipsing binary systems: IRS 16SW and S4-258 (E60). We constrain the Galactic center eclipsing binary fraction of known early-type stars to be at least 2\%. These results are consistent with the local OB eclipsing binary fraction. We identify a new periodic variable, S2-36, with a 39.43 day period. Further observations are necessary to determine the nature of this source.

Accepted for publication in The Astrophysical Journal

An ALMA view of CS and SiS around oxygen-rich AGB stars

T. Danilovich\textsuperscript{1}, A.M.S. Richards\textsuperscript{2}, A.I. Karakas\textsuperscript{3}, M. Van de Sande\textsuperscript{3}, L. Decin\textsuperscript{1} and F. De Ceuster\textsuperscript{1,4}

\textsuperscript{1}Department of Physics and Astronomy, Institute of Astronomy, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
\textsuperscript{2}JBCA, Department Physics and Astronomy, University of Manchester, Manchester M13 9PL, UK
\textsuperscript{3}Monash Centre for Astrophysics, School of Physics & Astronomy, Monash University, Victoria 3800, Australia
\textsuperscript{4}Department of Physics and Astronomy, University College London, Gower Place, London, WC1E 6BT, UK

We aim to determine the distributions of molecular SiS and CS in the circumstellar envelopes of oxygen-rich asymptotic giant branch stars and how these distributions differ between stars that lose mass at different rates. In this study we analyse ALMA observations of SiS and CS emission lines for three oxygen-rich galactic AGB stars: IK Tau, with a moderately high mass-loss rate of \( 5 \times 10^{-6} \, M_\odot \, yr^{-1} \), and WHya and R Dor with low mass-loss rates of \( \sim 1 \times 10^{-7} \, M_\odot \, yr^{-1} \). These molecules are usually more abundant in carbon stars but the high sensitivity of ALMA allows us to detect their faint emission in the low mass-loss rate AGB stars. The high spatial resolution of ALMA also allows us to precisely determine the spatial distribution of these molecules in the circumstellar envelopes. We run radiative transfer models to calculate the molecular abundances and abundance distributions for each star. We find a spread of peak SiS abundances with \( \sim 10^{-8} \) for R Dor, \( \sim 10^{-7} \) for WHya, and \( \sim 3 \times 10^{-6} \) for IK Tau relative to H\( _2 \). We find lower peak CS abundances of \( \sim 7 \times 10^{-9} \) for R Dor, \( \sim 7 \times 10^{-8} \) for WHya and \( \sim 4 \times 10^{-7} \) for IK Tau, with some stratifications in the abundance distributions. For IK Tau we also calculate abundances for the detected isotopologues: C\textsuperscript{34}S, C\textsuperscript{32}S, C\textsuperscript{30}S, C\textsuperscript{32}S, C\textsuperscript{34}S, C\textsuperscript{36}S, and C\textsuperscript{38}S. Overall the isotopic ratios we derive for IK Tau suggest a lower metallicity than solar.

Accepted for publication in MNRAS
AGB population as probes of galaxy structure and evolution

Atefeh Javadi\textsuperscript{1} and Jacco Th. van Loon\textsuperscript{2}

\textsuperscript{1}School of Astronomy, Institute for Research in Fundamental Sciences (IPM), Tehran, 19395-5531, Iran
\textsuperscript{2}Lennard-Jones Laboratories, Keele University, ST5 5BG, UK

The evolution of galaxies is driven by the birth and death of stars. AGB stars are at the end points of their evolution and therefore their luminosities directly reflect their birth mass; this enables us to reconstruct the star formation history. These cool stars also produce dust grains that play an important role in the temperature regulation of the interstellar medium (ISM), chemistry, and the formation of planets. These stars can be resolved in all of the nearby galaxies. Therefore, the Local Group of galaxies offers us a superb near-field cosmology site. Here we can reconstruct the formation histories, and probe the structure and dynamics, of spiral galaxies, of the many dwarf satellite galaxies surrounding the Milky Way and Andromeda, and of isolated dwarf galaxies. It also offers a variety of environments in which to study the detailed processes of galaxy evolution through studying the mass-loss mechanism and dust production by cool evolved stars. In this paper, I will first review our recent efforts to identify mass-losing Asymptotic Giant Branch (AGB) stars and red supergiants (RSGs) in Local Group galaxies and to correlate spatial distributions of the AGB stars of different mass with galactic structures. Then, I will outline our methodology to reconstruct the star formation histories using variable pulsating AGB stars and RSGs and present the results for rates of mass-loss and dust production by pulsating AGB stars and their analysis in terms of stellar evolution and galaxy evolution.

Published in IAU Symposium 343 "Why Galaxies Care About AGB Stars: Continuing Challenge through Cosmic Time", eds. Franz Kerschbaum, Martin Groenewegen and Hans Olofsson