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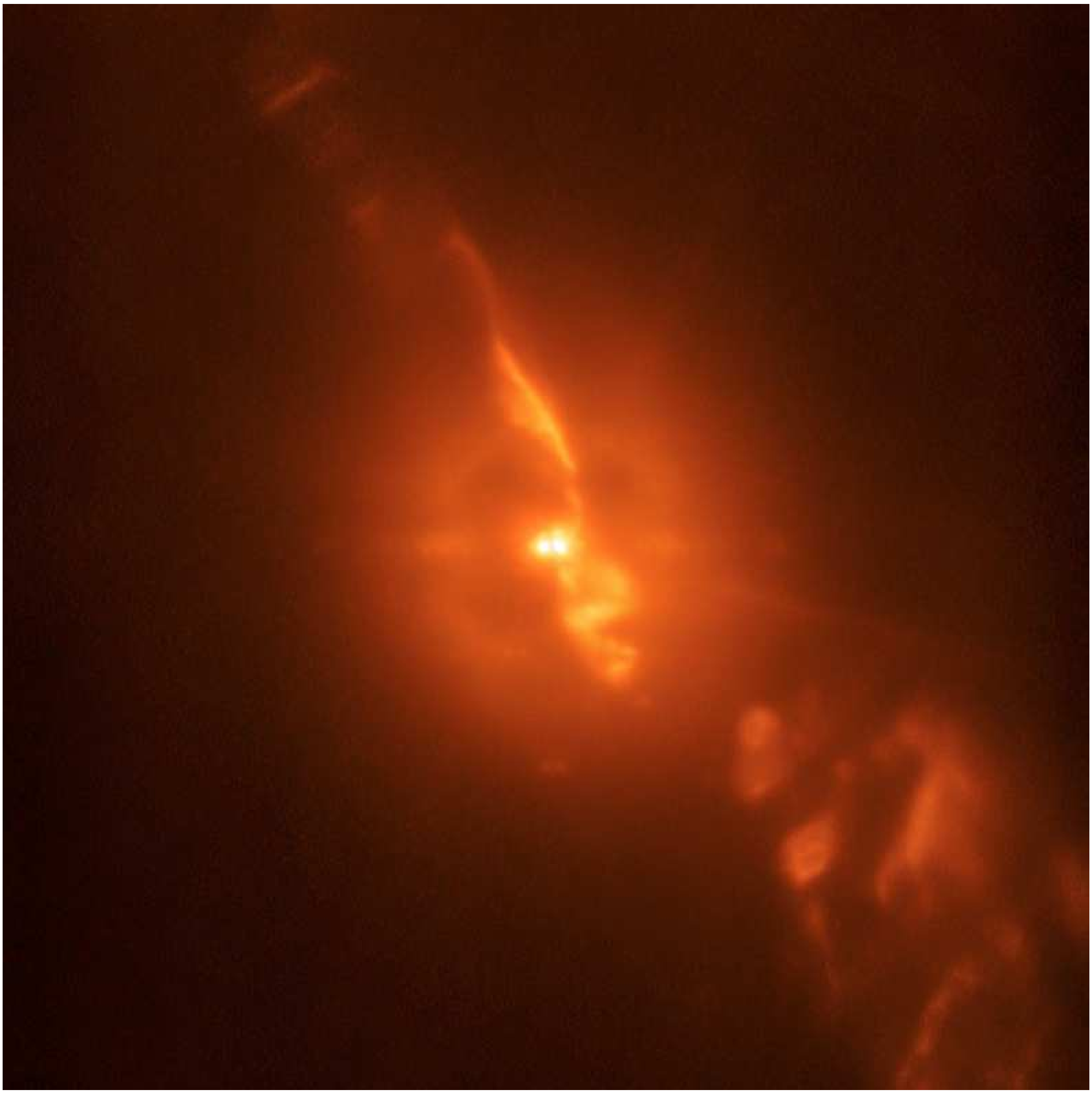

Figure 1: R Aquarii is a symbiotic system; the picture shows an incredibly detailed image of the interacting couple obtained with ESO-VLT's SPHERE instrument. For more details see https://www.eso.org/public/images/eso1840a.

Editorial

Dear Colleagues,

Happy New Year! It is a pleasure to present you the 258$^{\rm th}$ 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 Nebulæ, 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 ($v_{\rm exp} \sim 5$–15 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 ($v_{\rm exp} \gtrsim 50$–100 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; Chiotellis 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; Sowicka et al. 2017; Aller et al. 2018; Barker et al. 2018; Bujarrabal et al. 2018; Iłkiewicz 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 thepresence 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 nebulæ 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."

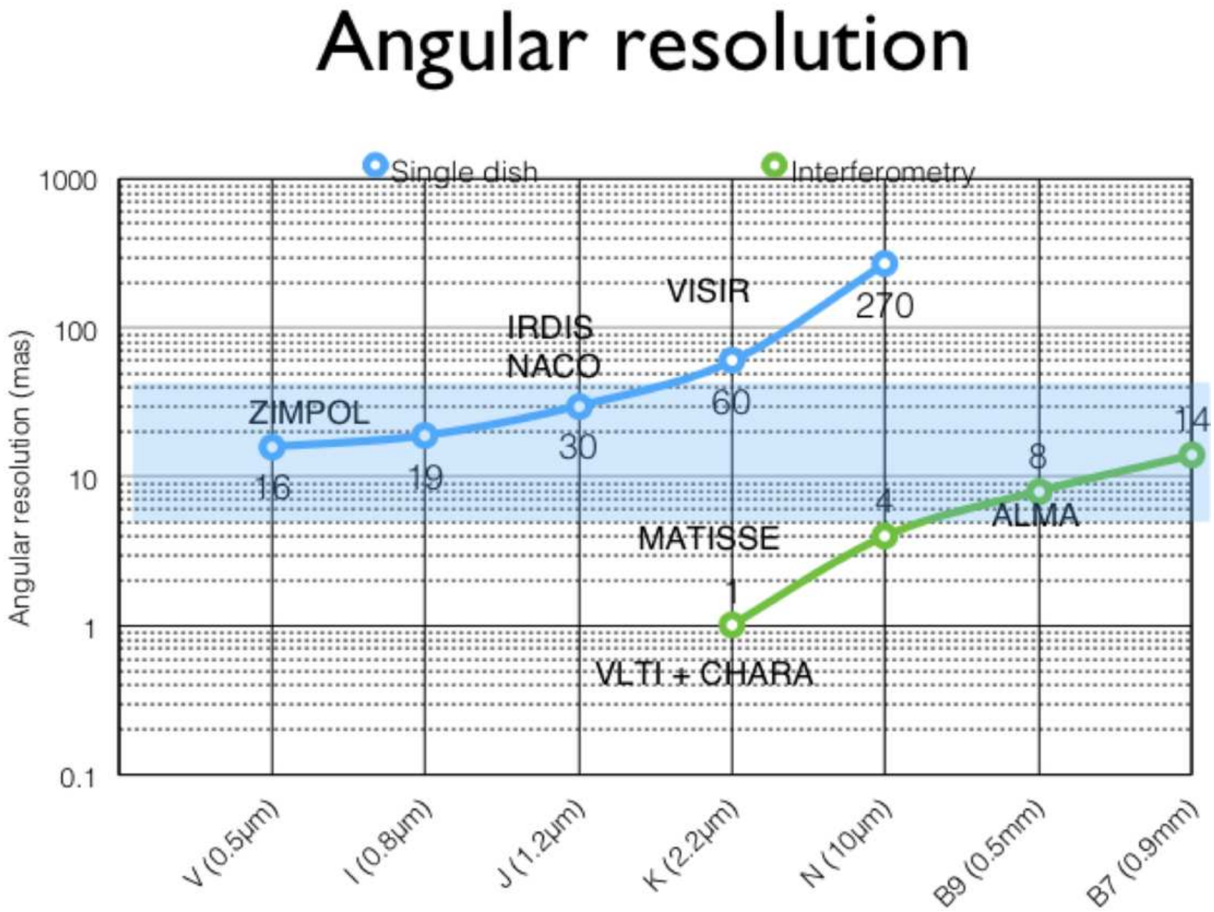

Figure 2: New high-resolution astronomical imaging instruments anticipated over the next decade (courtesy Eric Lagadec, used by permission).

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)

Refereed Journal Papers

A runaway giant in the Galactic halo

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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 $M_\odot$ G5–8 bright giant, with an effective temperature of 4800 ± 100 K, a metallicity of $\mathrm{Fe/H} = -0.5$, and a luminosity of $\log L/L_\odot = 2.70 \pm 0.20$. 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 *sim*25 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

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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 10^6 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

phenomenon.

Published in MNRAS Letters
Available from https://arxiv.org/abs/1811.02922
and from https://academic.oup.com/mnrasl/article/482/1/L93/5146410

Thermal emission in the South–West clump of VY CMa

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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} $M_\odot$. For a gas-to-dust ratio of 100, this implies a total mass of 5.4×10^{-3} $M_\odot$. Compared to the typical mass-loss rate of VY CMa, the SW Clump represents an extreme, localized mass-loss event from $\lesssim 300$ years ago.

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

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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.

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Available from https://arxiv.org/abs/1807.01304

Ultraviolet and optical spectroscopy of AGB stars showing UV excess

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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 Fe I and Fe II 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 Mg II λ2800 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 Mg II λ2800 in o 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 Fe II emission lines near this same phase and, like the Mg II 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.

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proEQUIB: IDL library for plasma diagnostics and abundance analysis

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The emission lines emitted from gaseous nebulæ 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 nebulæ observed using integral field spectroscopy.

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and from https://doi.org/10.21105/joss.00899

A comparison of stellar and gas-phase chemical abundances in dusty early-type galaxies

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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 Spectographs (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 supernovæ progenitors do not significantly affect the line ratios.

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

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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.

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Confirming the presence of second population stars and the iron discrepancy along the AGB of the globular cluster NGC 6752

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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 [Fe I/H] and [Fe II/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 ~ 100 K. We found that even if the photometric temperatures alleviate the iron discrepancy with respect to the spectroscopic ones, a systematic difference between [Fe I/H] and [Fe II/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.

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A new outburst of the yellow hypergiant star ρ Cas

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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 ρ 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 ρ Cas which occurred in 2013, accompanied by a temperature decrease of ~ 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 ρ 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 [Ca II] lines. We conclude that the occasionally detected emission in the spectra of ρ 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.

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The variable carbon star CGCS 6107

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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 ~ 500 days. An appreciable color variation was observed, the star being bluer when brighter. Hα emission was present around maxima. The spectrum is that of an N-type giant veiled by a variable dusty envelope.

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Available from http://ibvs.konkoly.hu/pub/ibvs/6201/6254.pdf

From evolved stars to the evolution of IC 1613

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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 ~ 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 9×10^7 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 ~ 18 Gyr in a closed-box model, but is likely to cease much earlier than that unless gas can be accreted from outside.

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

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Context: We follow up on a previous finding that AGB Mira variables containing the third dredge-up indicator

technetium (Tc) in their atmosphere form a different sequence of K–[22] colour as a function of pulsation period than Miras without Tc. A near-to-mid-infrared colour such as K–[22] is a good probe for the *dust* mass-loss rate of the stars. Contrary to what might be expected, Tc-poor Miras show *redder* K–[22] colours (i.e. higher dust mass-loss rates) than Tc-rich Miras at a given period.
Aims: Here, the previous sample is extended and the analysis is expanded towards other colours and dust spectra. The most important aim is to investigate if the same two sequences can be revealed in the *gas* mass-loss rate.
Methods: We analyse new optical spectra and expand the sample by including more stars from the literature. Near- and mid-IR photometry and ISO dust spectra of our stars are investigated where available. Literature data of gas mass-loss rates of Miras and semi-regular variables are collected and analysed.
Results: Our results show that Tc-poor Miras are redder than Tc-rich Miras in a broad range of the mid-IR, suggesting that the previous finding based on the K–[22] colour is not due to a specific dust feature in the 22-μm band. We establish a linear relation between K–[22] and the gas mass-loss rate. We also find that the 13-μm feature disappears above $K-[22] \simeq 2.17$ mag, corresponding to $\dot{M}_{\rm g} \sim 2.6 \times 10^{-7}$ M$_\odot$ yr^{-1}. Similar sequences of Tc-poor and Tc-rich Miras in the gas mass-loss rate vs. period diagram are however not found, most probably owing to limitations in the available data.
Conclusions: Different hypotheses to explain the observation of two sequences in the P vs. K–[22] diagram are discussed and tested, but so far none of them convincingly explains the observations. Nevertheless, we might have found an hitherto unknown, but potentially important process influencing mass loss on the TP-AGB.

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Warm CO in evolved stars from the THROES catalogue. II. *Herschel*/PACS spectroscopy of C-rich envelopes

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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 ($T_{\rm rot}$) and masses ($M_{\rm H_2}$) 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 $T_{\rm rot}$ and $M_{\rm H_2}$.
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 $M_{\rm H_2} \sim 10^{-2}$–10^{-5} M$_\odot$, anti-correlated with temperature. For some strong CO emitters we infer a double temperature (warm $T_{\rm rot} \sim 400$ K and hot $T_{\rm rot} \sim 820$ K) component. From the analysis of IRC +10°216, we corroborate that the effect of line variability is perceptible on the $T_{\rm rot}$ of the hot component only, and certainly insignificant on $M_{\rm H_2}$ 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.

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An adaptive optics survey of stellar variability at the Galactic center

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We present a ≈ 11.5 year adaptive optics (AO) study of stellar variability and search for eclipsing binaries in the central ~ 0.4 pc ($\sim 10''$) of the Milky Way nuclear star cluster. We measure the photometry of 563 stars using the Keck II NIRC2 imager (K$'$ and, $\lambda_0 = 2.124$ μm). We achieve a photometric uncertainty floor of $\Delta m_{K'} \sim 0.03$ ($\approx 3\%$), comparable to the highest precision achieved in other AO studies. Approximately half of our sample ($50 \pm 2\%$) shows variability. $52\pm5\%$ of known early-type young stars and $43\pm4\%$ 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 $2.4 \pm 1.7\%$. We find no evidence of an eclipsing binary among the young S-stars nor among the young stellar disk members. 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.

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

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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 5×10^{-6} $M_\odot$ yr^{-1}, and W Hya 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 W Hya, 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 W Hya 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: $C^{34}S$, ^{29}SiS, ^{30}SiS, $Si^{33}S$, $Si^{34}S$, $^{29}Si^{34}S$, and $^{30}Si^{34}S$. Overall the isotopic ratios we derive for IK Tau suggest a lower metallicity than solar.

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Review Paper

AGB population as probes of galaxy structure and evolution

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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.

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