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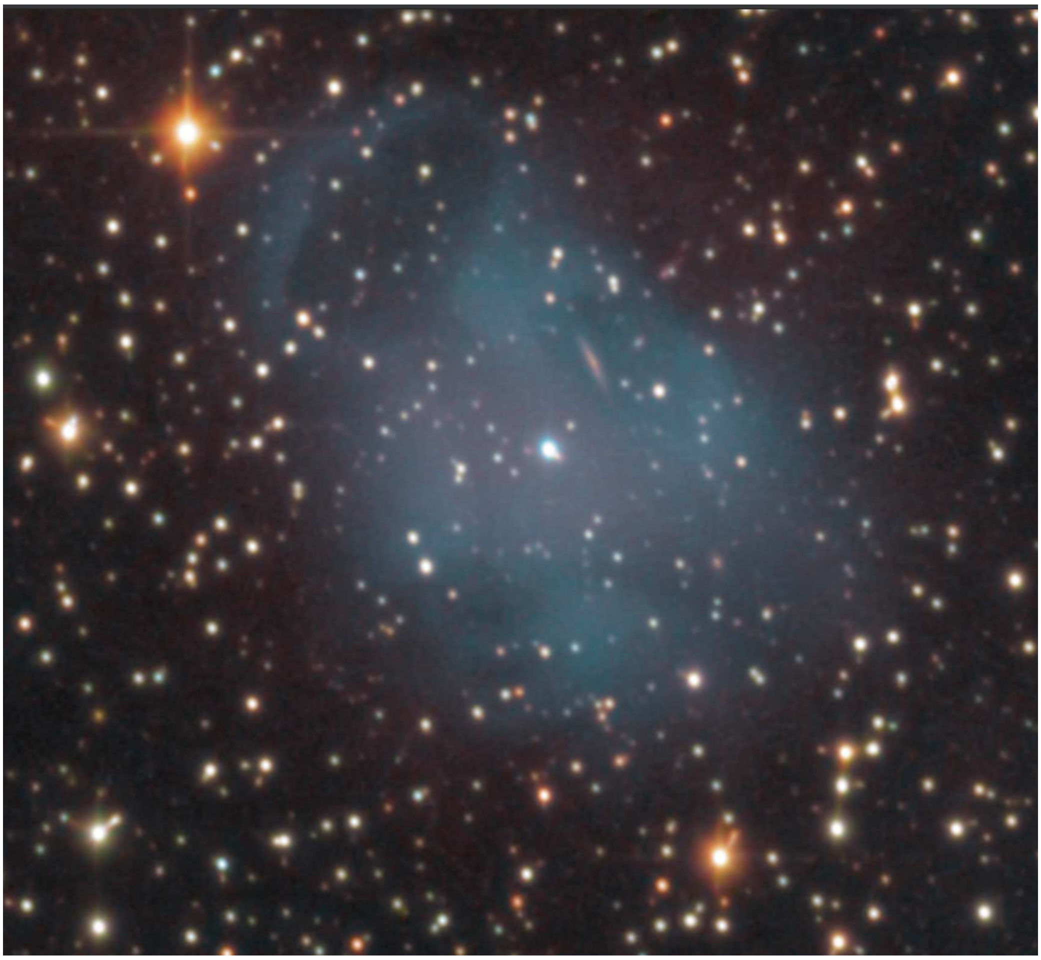

Figure 1: Planetary nebula DS 1, observed by Steve Crouch in Australia and suggested by Sakib Rasool. For more details see http://members.pcug.org.au/∼stevec/DS1_STXL6303_RC14.htm.

Editorial

Dear Colleagues,

Happy 2020! It is a pleasure to present you the 270^{th} issue of the AGB Newsletter, the first of a new decade full of promises and surprises.

Congratulations to Dr. Tiina Liimets on her successful Ph.D. thesis defense! We wish her all the best in her career.

For those of you not yet in the possession of a Philosopher's Degree, there are two opportunities in Leuven (Belgium) to apply for.

Leuven also plays host to IAU Symposium 366 on the outflows from evolved stars, which no doubt interests many of you. Likewise, many of you may be interested in the planetary nebulæ conference to be held in beautiful Krakow (Poland).

Please turn this page, to find the third opinion piece, this time brought to you by the brilliant JJ Eldridge. It follows the Food for Thought in the previous edition and inspired this month's Food for Thought – we've queried this issue a number of times but it is clear no-one has the answers yet. Comments, as always, are welcome and can be sent to the usual address astro.agbnews@keele.ac.uk.

The next issue is planned to be distributed around the 1^{st} of February.

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

Food for Thought

This month's thought-provoking statement is:

What fraction of stars will never become an AGB star or red supergiant because of binary interaction?

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?

JJ Eldridge

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What are some of the things that binaries do?

Over the last decade, in collaboration with Assoc. Prof. Elizabeth Stanway (University of Warwick, UK), we have been trying to create a binary population and spectral synthesis code that is built around detailed stellar models (see bpass.auckland.ac.nz for details). The aim is to make predictions covering all possible aspects of the stellar population. So far weve achieved a lot (e.g., Eldridge et al. 2017). Although initially we concentrated on massive stars as they are mostly simpler. Over the last few years weve begun to look at lower mass stars, including AGB stars.

While the models weve employed in our current models account for AGB stars in a simple way (Stanway & Eldridge 2018) there is so much we havent included. The good news is that even our simple prescription, along with the many other additions has vastly improved how well we can reproduce old stellar populations that contain these stars. But we know we still must do better.

However, were left with the question how should we improve how we include AGB stars?. This can be broken down into two parts, first is: how do binaries affect AGB evolution? and second is: what do we want to be able to predict about AGB stars?.

I think binaries' greatest effect on AGB stars is preventing their formation. In many systems a binary interaction will remove the hydrogen envelope and send the star down the white dwarf cooling track before second dredge-up and thermal pulses can occur. Even with weak mass-loss from an interaction, with only some envelope removed, the AGB lifetime of a star will be decreased.

The situation becomes more complex if we also consider stars that merge, or companions that accrete material from a companion star that become single after a primary star supernova. In both cases the star may end up with a unique interior composition and structure profile. Its unlikely but this may have an impact on the later evolution of thermal pulses of the star. At the very least it will change the number of AGB stars wed expect with different initial masses away from that assumed from simply applying the initial mass function.

To answer these questions means that within BPASS we should include AGB stars as detailed models as far as we can. However, since we need to calculate 10 000s of detailed AGB models and it is still at times a numerical challenge to follow thermal pulses, we will need to draw the line at thermal pulses and approximate them or even ignore them, in the next step.

But having a better idea of how binaries affect the lead up to thermals pulses will allow us to understand where we can best expect the numerical effort in future when we finally do add that level of detail.

And why do I want to think about AGB stars and binaries? I really guess its just to find out what were not seeing or mistaken about just because we havent understood exactly what binaries do to stellar populations.

Hubble Space Telescope observations of Mira variables in Type Ia supernova host NGC 1559: an alternative candle to measure the Hubble constant

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We present year-long, near-infrared *Hubble* Space Telescope WFC3 observations used to search for Mira variables in NGC 1559, the host galaxy of the Type Ia supernova (SN Ia) 2005df. This is the first dedicated search for Miras, highly-evolved low-mass stars, in a SN Ia host and subsequently the first calibration of the SN Ia luminosity using Miras in a role historically played by Cepheids. We identify a sample of 115 O-rich Miras with $P < 400$ days based on their light curve properties. We find that the scatter in the Mira Period–Luminosity Relation (PLR) is comparable to Cepheid PLRs seen in SN Ia supernova host galaxies. Using a sample of O-rich Miras discovered in NGC 4258 with HST F160W and its maser distance, we measure a distance modulus for NGC 1559 of $\mu_{1559} = 31.41 \pm 0.050$ (statistical) ± 0.060 (systematic) mag. Based on the light curve of the normal, well-observed, low-reddening SN 2005df, we obtain a measurement of the fiducial SN Ia absolute magnitude of $M_B^0 = -19.27 \pm 0.13$ mag. With the Hubble diagram of SNe Ia we find $H_0 = 72.7 \pm 4.6$ km s^{-1} Mpc^{-1}. Combining the calibration from the NGC 4258 megamaser and the Large Magellanic Cloud detached eclipsing binaries gives a best value of $H_0 = 73.3 \pm 4.0$ km s^{-1} Mpc^{-1}. This result is within 1-σ of the Hubble constant derived using Cepheids and multiple calibrating SNe Ia. This is the first of four expected calibrations of the SN Ia luminosity from Miras which should reduce the error in H_0 via Miras to $\sim 3\%$. In light of the present Hubble tension and JWST, Miras have utility in the extragalactic distance scale to check Cepheid distances or calibrate nearby SNe in early-type host galaxies that would be unlikely targets for Cepheid searches.

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Low-degree mixed modes in red giant stars with moderate core magnetic fields

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Observations of pressure–gravity mixed modes, combined with a theoretical framework for understanding mode formation, can yield a wealth of information about deep stellar interiors. In this paper, we seek to develop a formalism for treating the effects of deeply buried core magnetic fields on mixed modes in evolved stars, where the fields are moderate, i.e. not strong enough to disrupt wave propagation, but where they may be too strong for non-degenerate first-order perturbation theory to be applied. The magnetic field is incorporated in a way that avoids having to use this. Inclusion of the Lorentz force term is shown to yield a system of differential equations that allows for the magnetically-affected eigenfunctions to be computed from scratch, rather than following the approach of first-order perturbation theory. For sufficiently weak fields, coupling between different spherical harmonics can be neglected, allowing for reduction to a second-order system of ordinary differential equations akin to the usual oscillation equations that can be solved analogously. We derive expressions for (i) the mixed-mode quantization condition in the presence of a field and (ii) the frequency shift associated with the magnetic field. In addition, for modes of low degree we uncover an extra offset term in the quantization condition that is sensitive to properties of the evanescent zone. These expressions may be inverted to extract information about the stellar structure and magnetic field from observational data.

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Analysis of first overtone bands of isotopologues of CO and SiO in stellar spectra

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The first overtone ($\Delta v = 2$) bands of the mono-substituted isotopologues of CO at 2.3 μm in the spectrum of Arcturus (K2 III), and of the mono-substituted isotopologues of SiO at 4 μm in the spectrum of the red giant HD 196610 (M6 III) are modelled. To investigate problems involving the computation of the first overtone bands of isotopologues of CO and SiO in spectra of late-type stars and to determine isotopic abundances. We use fits of theoretical synthetic spectra to the observed stellar molecular bands of CO and SiO to determine abundances of isotopes of C, O and Si. Fits of synthetic spectra of the CO first overtone bands at 2.3 μm computed with three available line lists (Goorvitch, HITEMP2010 and Li et al.) to the observed spectrum of Arcturus provide the same carbon abundance [C] = -0.6 and isotopic ratio of carbon $^{12}C/^{13}C = 10 \pm 2$. However, the quality of fits to the observed spectrum differ for three line lists used. Furthermore, the derived oxygen isotopic ratio $^{16}O/^{18}O = 2000 \pm 500$ is larger than that known in the solar system where $^{16}O/^{18}O = 500$. The silicon isotopic ratio in the atmosphere of the red giant HD 196610 is revised. Using the ExoMol SiO line list with appropriate statistical weights for the SiO isotopologues the 'non-solar' ratio ^{28}Si:^{29}Si:$^{30}Si = 0.86 \pm 0.03 : 0.12 \pm 0.02 : 0.02 \pm 0.01$ is obtained. We found that a) the computed isotopic carbon and silicon ratios determined by the fits to the observed spectrum depend on the adopted abundance of C and Si, respectively; b) Correct treatment of the nuclear spin degeneracies parameter is of crucial importance for the use of nowadays HITRAN/ExoMol line lists in the astrophysical computations.

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Circumstellar CO $J = 3 \rightarrow 2$ detected around the evolving metal-poor ([Fe/H] ≈ -1.15 dex) AGB star RU Vulpeculæ

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We report the first detection of CO $J = 3 \rightarrow 2$ around a truly metal-poor evolved star. RU Vulpeculæ is modelled to have $T_{\rm eff} \approx 3620$ K, $L \approx 3128 \pm 516$ L$_\odot$, $\log g = 0.0 \pm 0.2$ dex and [Fe/H] = -1.3 to -1.0 dex, and is modelled to have recently undergone a thermal pulse. Its infrared flux has approximately doubled over 35 years. ALMA observations show the $3 \rightarrow 2$ line is narrow (half-width $\sim$ 1.8–3.5 km s^{-1}). The $2 \rightarrow 1$ line is much weaker: it is not confidently

detected. Spectral-energy-distribution fitting indicates very little circumstellar absorption, despite its substantial mid-infrared emission. A VISIR mid-infrared spectrum shows features typical of previously observed metal-poor stars, dominated by a substantial infrared excess but with weak silicate and (possibly) Al_2O_3 emission. A lack of resolved emission, combined with weak $2 \rightarrow 1$ emission, indicates the dense circumstellar material is truncated at large radii. We suggest that rapid dust condensation is occurring, but with an aspherical geometry (e.g., a disc or clumps) that does not obscure the star. We compare with T UMi, a similar star which is currently losing its dust.

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Preliminary analysis of periodogram shapes and their classification

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A periodogram analysis of 47 stars noted in GCVS as RV-type stars was carried out. The research methods applied here to RV-type stars have previously been applied to long-period variables Mira-type stars and semi-regular variables. Periodograms are previously classified by their shape, or rather the presence or absence of certain structures: two peaks in a 2:1 ratio, the presence of satellites at these peaks indicating the result of beats. Table 1 shows the classification groups. Examples of periodograms of stars of all three groups are shown. The study identified stars that most likely do not belong to the RV Tauri type. The star SU Gem has been studied in detail, which shows rather the variability characteristic of the Mira-type or semi-regular. A summary of the results is given in table 2. The elements was calculated on databases AAVSO, AFOEV and ASAS. The period of 50 days specified in GCVS was not revealed according to our researches. According to the observations of different databases, the period of 684 days is specified in the range from 682 to 715 days.

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Matter mixing in aspherical core-collapse supernovæ: three-dimensional simulations with single star and binary merger progenitor models for SN 1987A

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We perform three-dimensional hydrodynamic simulations of aspherical core-collapse supernovæ focusing on the matter mixing in SN 1987A. The impacts of four progenitor (pre-supernova) models and parameterized aspherical explosions are investigated. The four pre-supernova models include a blue supergiant (BSG) model based on a slow merger scenario developed recently for the progenitor of SN 1987A (Urushibata et al. 2018). The others are a BSG model based on a single star evolution and two red supergiant (RSG) models. Among the investigated explosion (simulation) models, a model with the binary merger progenitor model and with an asymmetric bipolar-like explosion, which invokes a jetlike explosion, best reproduces constraints on the mass of high velocity ^{56}Ni, as inferred from the observed [Fe II] line profiles. The advantage of the binary merger progenitor model for the matter mixing is the flat and less extended

ρr^3 profile of the C+O core and the helium layer, which may be characterized by the small helium core mass. From the best explosion model, the direction of the bipolar explosion axis (the strongest explosion direction), the neutron star (NS) kick velocity, and its direction are predicted. Other related implications and future prospects are also given.

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Simulating dust grain–radiation coupling on a moving mesh

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We present a model for the interaction between dust and radiation fields in the radiation hydrodynamic code AREPO-RT, which solves the moment-based radiative transfer equations on an unstructured moving mesh. Dust is directly treated using live simulation particles, each of which represent a population of grains that are coupled to hydrodynamic motion through a drag force. We introduce methods to calculate radiation pressure on and photon absorption by dust grains. By including a direct treatment of dust, we are able to calculate dust opacities and update radiation fields self-consistently based on the local dust distribution. This hybrid scheme coupling dust particles to an unstructured mesh for radiation is validated using several test problems with known analytic solutions, including dust driven via spherically-symmetric flux from a constant luminosity source and photon absorption from radiation incident on a thin layer of dust. Our methods are compatible with the multifrequency scheme in AREPO-RT, which treats UV and optical photons as single-scattered and IR photons as multi-scattered. At IR wavelengths, we model heating of and thermal emission from dust. Dust and gas are not assumed to be in local thermodynamic equilibrium but transfer energy through collissional exchange. We estimate dust temperatures by balancing these dust-radiation and dust-gas energy exchange rates. This framework for coupling dust and radiation can be applied in future radiation hydrodynamic simulations of galaxy formation.

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Evolution from spherical AGB wind to multipolar outflow in pre-planetary nebula IRAS 17150−3224

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We have mapped the pre-planetary nebula IRAS 17150−3224 in 350 GHz continuum and CO $J = 3$–2 line at an angular resolution of about $0.''09$ using the Atacama Large Millimeter/submillimeter Array. A continuum source is detected at the center of the nebula, elongated along the equatorial plane, likely tracing a dusty torus around the central source. Continuum emission is also detected on both sides of the central continuum source in the equatorial plane, probably resulting from interactions of collimated fast winds with envelope material in the equator. CO emission is detected along the optical lobe. Although the optical lobe appears as bipolar, CO map shows that it is actually a quadrupolar outflow consisting of two overlapping bipolar outflows. Two additional younger bipolar outflows are also detected in CO, one at lower latitude and the other along the equatorial plane. In the CO position–velocity maps, blueshifted absorption stripes are detected in the outflow emissions, due to absorption by a series of shells produced by a series of asymptotic giant branch (AGB) wind ejections. By modeling the morphology and kinematics of the AGB wind and

outflows, we find that the AGB wind could end about 1300 yr ago, the quadrupolar outflow was ejected about 350 yr ago, and the two additional bipolar outflows were ejected about 280 and 200 ago, respectively. The outflows could be produced either by bullets coming from an explosion, or by a precessing collimated fast wind with a time-dependent ejection velocity.

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J-PLUS: Tools to identify compact planetary nebulæ in the Javalambre and southern photometric local universe surveys

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From the approximately 3,500 planetary nebulæ (PNe) discovered in our Galaxy, only 14 are known to be members of the Galactic halo. Nevertheless, a systematic search for halo PNe has never been performed. In this study, we present new photometric diagnostic tools to identify compact PNe in the Galactic halo by making use of the novel 12-filter system projects, J-PLUS (Javalambre Photometric Local Universe Survey) and S-PLUS (Southern-Photometric Local Universe Survey). We reconstructed the IPHAS (Isaac Newton Telescope (INT) Photometric Hα Survey of the Northern Galactic Plane) diagnostic diagram and propose four new ones using i) the J-PLUS and S-PLUS synthetic photometry for a grid of photo-ionisation models of halo PNe, ii) several observed halo PNe, as well as iii) a number of other emission-line objects that resemble PNe. All colour–colour diagnostic diagrams are validated using two known halo PNe observed by J-PLUS during the scientific verification phase and the first data release (DR1) of S-PLUS and the DR1 of J-PLUS. By applying our criteria to the DR1s ($\sim 1,190$ deg^2), we identified one PN candidate. However, optical follow-up spectroscopy proved it to be an H II region belonging to the UGC 5272 galaxy. Here, we also discuss the PN and two H II galaxies recovered by these selection criteria. Finally, the cross-matching with the most updated PNe catalogue (HASH) helped us to highlight the potential of these surveys, since we recover all the known PNe in the observed area. The tools here proposed to identify PNe and separate them from their emission-line contaminants proved to be very efficient thanks to the combination of many colours, even when applied – like in the present work – to an automatic photometric search that is limited to compact PNe.

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A companion star launching jets in the wind acceleration zone of a giant star

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By conducting three-dimensional (3D) hydrodynamical simulations we find that jets that a main sequence companion launches as it orbits inside the wind acceleration zone of an asymptotic giant branch (AGB) star can efficiently remove mass from that zone. We assume that during the intensive wind phase a large fraction of the gas in the acceleration zone does not reach the escape velocity. Therefore, in the numerical simulations we blow the wind with a velocity just below the escape velocity. We assume that a main sequence companion accretes mass from the slow wind via an accretion disk, and launches two opposite jets perpendicular to the equatorial plane. This novel flow interaction shows that by launching jets a companion outside a giant star, but close enough to be in the acceleration zone of a

slow intensive wind, can enhance the mass loss rate from the giant by ejecting some gas that would otherwise fall back onto the giant star. The jets are bent inside the wind acceleration zone and eject mass in a belt on the two sides of the equatorial plane. The jet–wind interaction contains instabilities that mix shocked jets' gas with the wind, leading to energy transfer from the jets to the wind. As well, our new simulations add to the rich variety of jet-induced outflow morphologies from evolved stars.

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MAVKA: program of statistically optimal determination of phenomenological parameters of extrema. Parabolic spline algorithm and analysis of variability of the semi-regular star Z UMa

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Advanced MAVKA software for the approximation of extrema observations is used to analyze the variability of the brightness of pulsating and eclipsing stars, but may be useful in analyzing signals of any nature. A new algorithm using a parabolic (quadratic) spline is proposed. In contrast to the traditional definition of a spline as a piecewise-defined function at fixed intervals, a spline is proposed to be divided into three intervals, but the positions of the boundaries between the intervals are additional parameters. The spline defect is 1, that is, the function and its first derivative are continuous and the second derivative can be discontinuous at the boundaries. Such a function is an enhancement of the "asymptotic parabola" (Marsakova & Andronov 1996). The dependence of the fixed signal approximation accuracy on the location of the boundaries of the interval is considered. The parameter accuracy estimates using the least squares method and bootstrap are compared. The variability of the semi-regular pulsating star Z UMa is analyzed. The presence of multi-component variability of an object, including, four periodic oscillations and significant variability of the amplitudes and phases of individual oscillations is shown.

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The MUSE view of the planetary nebula NGC 3132

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Aims: 2D spectroscopic data for the whole extent of the NGC 3132 planetary nebula have been obtained. We deliver a reduced datacube and high-quality maps on a spaxel-by-spaxel basis for the many emission lines falling within the MUSE spectral coverage over a range in surface brightness > 1000. Physical diagnostics derived from the emission line images, opening up a variety of scientific applications, are discussed.
Methods: Data were obtained during MUSE commissioning on the ESO Very Large Telescope and reduced with the standard ESO pipeline. Emission lines were fitted by Gaussian profiles. The dust extinction, electron densities and temperatures of the ionised gas and abundances were determined using PYTHON and PYNEB routines.
Results: The delivered datacube has a spatial size of $\sim 63''$–$123''$, corresponding to $\sim$ 0.26–0.51 pc^2 for the adopted distance, and a contiguous wavelength coverage of 4750–9300 Å at a spectral sampling of 1.25 Å pix^{-1}. The nebula

presents a complex reddening structure with high values ($c(\mathrm{H}\beta) \sim 0.4$) at the rim. Density maps are compatible with an inner high-ionisation plasma at moderate high density (~ 1000 cm^{-3}) while the low-ionisation plasma presents a structure in density peaking at the rim with values ~ 700 cm^{-3}. Median T_e using different diagnostics decreases according to the sequence [N II],[S II] $\rightarrow$ [S III] $\rightarrow$ [O I] $\rightarrow$ He I $\rightarrow$ Paschen Jump. Likewise the range of temperatures covered by recombination lines is much larger than those obtained from collisionally excited lines (CELs), with large spatial variations within the nebula. If these differences were due to the existence of high density clumps, as previously suggested, these spatial variations suggest changes in the properties and/or distribution of the clumps within the nebula. We determined a median helium abundance He/H = 0.124, with slightly higher values at the rim and outer shell. The range of measured ionic abundances for light elements are compatible with literature values. Our kinematic analysis nicely illustrates the power of 2D kinematic information in many emission lines to shed light on the intrinsic structure of the nebula. Specifically, our derived velocity maps support a geometry for the nebula similar to the diabolo-like model proposed by Monteiro et al. (2000), but oriented with its major axis roughly at P.A. $\sim -22°$. We identified two low-surface brightness arc-like structures towards the northern and southern tips of the nebula, with high extinction, high helium abundance, and strong low-ionisation emission lines. They are spatially coincident with some extended low-surface brightness mid-IR emission. The characteristics of the features are compatible with being the consequence of precessing jets caused by the binary star system. A simple 1D CLOUDY model is able to reproduce the strong lines in the integrated spectrum of the whole nebula with an accuracy of $\sim 15\%$.
Conclusions: Together with the work on NGC 7009 presented by Walsh et al. (2018), the present study illustrates the enormous potential of wide field integral field spectrographs for the study of Galactic PNe.

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Multi-algorithm analysis of the semi-regular variable DY Per, the prototype of the class of cool R CrB variables

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Multiple algorithms of time series analysis are briefly reviewed and partially illustrated by application to the visual observations of the semi-regular variable DY Per from the AFOEV database. These algorithms were implemented in the software MCV (Andronov & Baklanov 2004), MAVKA (Andrych & Andronov 2019; Andrych et al. 2019). Contrary to the methods of physical modeling, which need to use too many parameters, many of which may not be determined from pure photometry (like temperature/spectral class, radial velocities, mass ratio), phenomenological algorithms use smaller number of parameters. Beyond the classical algebraic polynomials, in the software MAVKA are implemented other algorithms, totally 21 approximations from 11 classes. Photometric observations of DY Per from the AFOEV international database were analyzed. The photometric period has switched from $P = 851.1$ d(4.1) to $P = 780.5$ d(2.7) after JD 2454187(9) d. A parameter of sinusoidality is introduced, which is equal to the ratio of effective semi-amplitudes of the signal determined from a sine fit and the running parabola scalegram.

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and from http://www.astronomianova.org/publikacje.php

MAGRITTE, a modern software library for 3D radiative transfer: I. Non-LTE atomic and molecular line modelling

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Radiative transfer is a key component in almost all astrophysical and cosmological simulations. We present MAGRITTE: a modern open-source software library for 3D radiative transfer. It uses a deterministic ray-tracer and formal solver, i.e. it computes the radiation field by tracing rays through the model and solving the radiative transfer equation in its second-order form along a fixed set of rays originating from each point. MAGRITTE can handle structured and unstructured input meshes, as well as smoothed-particle hydrodynamics (SPH) particle data. In this first paper, we describe the numerical implementation, semi-analytic tests and cross-code benchmarks for the non-LTE line radiative transfer module of MAGRITTE. This module uses the radiative transfer solver to self-consistently determine the populations of the quantised energy levels of atoms and molecules using an accelerated Λ iteration (ALI) scheme. We compare MAGRITTE with the established radiative transfer solvers RATRAN (1D) and LIME (3D) on the van Zadelhoff benchmark and present a first application to a simple Keplerian disc model. Comparing with LIME, we conclude that MAGRITTE produces more accurate and more precise results, especially at high optical depth, and that it is faster.

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Long secondary periods in luminous red giant variables

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The origin of long secondary periods (LSPs) in red giant variables is unknown. We investigate whether stellar pulsations in red giants can explain the properties of the LSP variability. $VIJHK_s$ light curves obtained by OGLE and the IRSF/SIRIUS survey in the Small Magellanic Cloud are examined. The sample of oxygen-rich LSP stars show evidence of a phase lag between the light curves of optical and near- IR band. The change in radius contributes the bolometric change roughly half as much as the change in temperature, implying that the change in effective temperature plays an important role in the luminosity change associated with the LSPs. We have created numerical models based on the spherical harmonics to calculate the light amplitudes of dipole mode variability and have found that the models can roughly reproduce the amplitude–amplitude relations (e.g., $(\Delta I,\, \Delta H)$). The LSP variability can be reproduced by the dipole mode oscillations with temperature amplitude of $\lesssim$100 K and $\lesssim$150 K for oxygen-rich stars and most carbon stars, respectively. Radial pulsation models are also examined and can reproduce the observed colour change of the LSPs. However, there is still an inconsistency in length between the LSP and periods of radial fundamental mode. On the other hand, theoretical PL relations of the dipole mode corresponding to so-called oscillatory convective mode were roughly consistent with observation. Hence our result suggests that the observations can be consistent with stellar pulsations corresponding to oscillatory convective modes.

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Lithium-rich giants in LAMOST survey. I. The catalog

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Standard stellar evolution model predicts a severe depletion of lithium (Li) abundance during the first dredge up process (FDU). Yet a small fraction of giant stars are still found to preserve a considerable amount of Li in their atmospheres after the FDU. Those giants are usually identified as Li-rich by a widely used criterion, $A(\mathrm{Li}) > 1.5$ dex. A large number of works dedicated to searching for and investigating this minority of the giant family, and the amount of Li-rich giants, has been largely expanded on, especially in the era of big data. In this paper, we present a catalog of Li-rich giants found from the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) survey with Li abundances derived from a template-matching method developed for LAMOST low- resolution spectra. The catalog contains 10,535 Li-rich giants with Li abundances from ~ 1.5 to ~ 4.9 dex. We also confirm that the ratio of Li-rich phenomenon among giant stars is about 1% – or more specifically, 1.29% – from our statistically important sample. This is the largest Li-rich giant sample ever reported to date, which significantly exceeds amount of all reported Li-rich giants combined. The catalog will help the community to better understand the Li-rich phenomenon in giant stars.

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Carbon and oxygen isotopic ratios. II. Semiregular variable M giants

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Carbon and oxygen isotopic ratios are reported for a sample of 51 SRb- and Lb-type variable asymptotic giant branch stars. Vibration-rotation first- and second-overtone CO lines in 1.5–2.5 μm spectra were measured to derive isotopic ratios for $^{12}C/^{13}C$, $^{16}O/^{17}O$, and $^{16}O/^{18}O$. Comparisons with previous measurements for individual stars and with various samples of evolved stars, as available in the extant literature, are discussed. Using the oxygen isotopic ratios, the masses of the SRb stars can be derived. Combining the masses with Gaia luminosities, the SRb stars are shown to be antecedents of the Mira variables. The limiting parameters where plane-parallel, hydrostatic equilibrium model atmospheres can be used for abundance analysis of M giants are explored.

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Infrared properties of asymptotic giant branch stars in our Galaxy and the Magellanic Clouds

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We investigate infrared properties of asymptotic giant branch (AGB) stars in our Galaxy and the Magellanic Clouds using various infrared observational data and theoretical models. We use catalogs for the sample of 4996 AGB stars

in our Galaxy and about 39,000 AGB stars in the Magellanic Clouds from the available literature. For each object in the sample, we cross-identify the 2MASS, WISE, and *Spitzer* counterparts. To compare the physical properties of O-rich and C-rich AGB stars in our Galaxy and the Magellanic Clouds, we present IR two-color diagrams (2CDs) using various photometric data. We perform radiative transfer model calculations for AGB stars using various possible parameters of central stars and dust shells. Using dust opacity functions of amorphous silicate and amorphous carbon, the theoretical dust shell models can roughly reproduce the observations of AGB stars on various IR 2CDs. Compared with our Galaxy, we find that the Magellanic Clouds are deficient in AGB stars with thick dust shells. Compared with the Large Magellanic Cloud (LMC), the Small Magellanic Cloud (SMC) is more deficient in AGB stars with thick dust shells. This could be because the Magellanic Clouds are more metal poor than our Galaxy and the LMC is more metal rich than the SMC. We also present IR properties of known pulsating variable. Investigating the magnitude distributions at MIR bands for AGB stars in the Magellanic Clouds, we find that the SMC is more deficient in the bright AGB stars at MIR bands compared with the LMC.

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Computer modeling of irregularly spaced signals. Statistical properties of the wavelet approximation using a compact weight function

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The algorithm of modified wavelet analysis is discussed. It is based on the weighted least squares approximation. Contrary to the Gaussian as a weight function, we propose to use a compact weight function. The accuracy estimates using the statistically correct expressions for the least squares approximations with an additional weight function are compared with that obtained using the bootstrap method.

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Available from https://arxiv.org/abs/1912.13096

Magnetic activity and evolution of the four Hyades K giants

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We determine the exact physical parameters of the four Hyades cluster K giants, using their parallaxes and atmospheric modeling of our red-channel TIGRE high-resolution spectra. Performing a comparison with well-tested evolutionary tracks, we derive exact masses and evolutionary stages. At an age of 588 (±60) Myr and with a metallicity of $Z = 0.03$ (consistent with the spectroscopic abundances), we find HD 27371 and HD 28307, the two less bright K giants, at the onset of central helium-burning, entering their blue loops with a mass of 2.62 $M_{\odot}$, while the slightly brighter stars HD 28305 and HD 27697 are already exiting their blue loop. Their more advanced evolution suggests a higher mass of 2.75 $M_{\odot}$.
Notably, this pairing coincides with the different activity levels, which we find for these four stars from chromospheric activity monitoring with TIGRE and archival Mount Wilson data as well as from ROSAT coronal detections: The two less evolved K giants are the far more active pair, and we confidently confirm their rotation with periods of about 142 days. This work therefore provides some first, direct evidence of magnetic braking during the 130-Myr lasting phase of central helium-burning, similar to what has long been known to occur to cool main-sequence stars.

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Conference Paper

Asteroseismic ages of red-giant stars from grid-based modelling: the impact of systematics in effective temperature or metallicity

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An increasingly popular method to determine stellar ages of red-giant stars for the purpose of Galactic archaeology is asteroseismic[1] grid-based modelling (GBM). In GBM, observed parameters are compared to those obtained from a grid of stellar evolution models to obtain stellar parameters such as mass, radius and age. In asteroseismic GBM of red-giant stars with solar-like oscillations the large frequency separation ($\Delta\nu$) and the frequency of maximum oscillation power ($\nu_{\rm max}$) are commonly used asteroseismic observables, in addition to the usual spectroscopic parameters effective temperature ($T_{\rm eff}$) and metallicity ([Fe/H]). Different types of observations are required to obtain the observed parameters: $\Delta\nu$ and $\nu_{\rm max}$ require timeseries data, while a single epoch observation is sufficient to determine $T_{\rm eff}$ and [Fe/H].

The precision with which $\Delta\nu$ and $\nu_{\rm max}$ can be determined largely depends on the length of the time-series data (assuming the stars are bright enough that the oscillations can be detected). An increase in the time-span of the data and hence, the precision of the asteroseismic parameters is often obtained at the cost of number of stars observed. Different space mission have made different choices. The *Kepler* mission provided the longest ($\sim$ 4 years long) time-series data of red giants with solar-like oscillations currently available. At the other extreme, the TESS mission is providing $\sim$ 27-day to about 1-year long time-series for tens of thousands of oscillating red giants. The question that we aim to answer here is: with what precision should [Fe/H] and $T_{\rm eff}$ be obtained to derive stellar ages of red-giant stars through asteroseismic GBM given the precision of $\Delta\nu$ and $\nu_{\rm max}$ that we can expect from the TESS data?

To answer this question, we investigate the impact of uncertainties and biases (i.e. systematic errors) in $T_{\rm eff}$ and [Fe/H] on the determined ages of red-giant stars using asteroseismic GBM, given the precisions to which $\Delta\nu$ and $\nu_{\rm max}$ can be obtained with time-series data of $\sim$ 50 and $\sim$ 400 day length.

Poster contribution, published in Research Note of the AAS

Available from https://arxiv.org/abs/1910.14108

and from https://ui.adsabs.harvard.edu/link_gateway/2019RNAAS...3..165H/doi:10.3847/2515-5172/ab528e

Review Papers

Variable stars: a net of complementary methods for time series analysis. Application to RY UMa

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The expert system for time series analysis of irregularly spaced signals is reviewed. It consists of a number of complementary algorithms and programs, which may be effective for different types of variability. Obviously, for a pure sine signal, all the methods should produce the same results. However, for irregularly spaced signals with a complicated structure, e.g., a sum of different components, different methods may produce significantly different

[1]Asteroseismology is the study of the internal structures of stars through their global oscillations.

results. The basic approach is based on classical method of the least squares (Andronov, 1994, OAP, 7, 49). However, contrary to common "step-by-step" methods of removal important components, e.g., mean, trend ("detrending"), sine wave ("prewhitening"), where covariations between different components are ignored, i.e. erroneously assumed to be zero, we use complete mathematical models. Some of the methods are illustrated on the observations of the semi-regular pulsating variable RY UMa. The star shows a drastic cyclic change of semi-amplitude of pulsations between 0.01 to 0.37 mag, which is interpreted as a bias between the waves with close periods and a beat period of 4000 d (11 yr). The dominating period has changed from 307.35(8) d before 1993 to 285.26(6) d after 1993. The initial epoch of the maximum brightness for the recent interval is 2 454 008.8(5). It is suggested that the apparent period switch is due to variability of amplitudes of these two waves and an occasional swap of the dominating wave.

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Available from https://arxiv.org/abs/1910.08799

Unity and diversity of yellow hypergiants family

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We summarize the results of long-term spectral monitoring of yellow hypergiants (YHGs) of northern hemisphere with a $R \geq 60\,000$ resolution. The spectra of these F–G stars of extremely high luminosity, compactly located at the top of the Hertzsprung–Russell diagram revealed a variety of spectral features: various types of Hα profile, the presence (or absence) of forbidden and permitted emissions, as well as circumstellar components. Variability of spectral details of various nature is studied. An IR oxygen triplet OI 7773Å with extreme equivalent width values served as a luminosity criterion: the considered YHGs have an average value of $\log L/\mathrm{L}_\odot = 5.43 \pm 0.14$. Circumstellar envelope expansion rate in the range of $11 \div 40$ km s^{-1} and amplitude of pulsations in a narrow range of values $\Delta V_r = 7 \div 11$ km s^{-1} are determined for four objects. The reliability of the YHG status for V1427 Aql is reliably confirmed; manifestations of a significant dynamic instability of the upper layers of the atmosphere of ρ Cas after the 2017 ejection and stratification of its gas envelope are registered; the lack of companion in the system of the V509 Cas hypergiant is proven; a conclusion is made that the V1302 Aql hypergiant is approaching to the low-temperature boundary of the Yellow Void.

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Available from https://arxiv.org/abs/1911.09387

Seismic probe of transport processes in red giants

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Seismic data obtained with the space photometric CoRoT and *Kepler* instruments have led to a unprecendently precise characterization – in terms of masses and ages – of a large sample of post main sequence stars (low mass subgiant and red giants). The high quality of the collected seismic data and the subsequent theoretical work for interpreting them brought up a series of issues which revealed that our knowledge of the internal properties of red giant stars remains quite limited. Two such important issues are discussed here, namely mixing beyond the convective core of helium burning red giant stars and evolution of internal angular momentum for post main sequence stars. This includes how they were diagnosed and what are the resulting improvements in our understanding regarding these issues (or rather how far we are from a proper understanding and realistic modelling of the structure and evolution of post main sequence stars).

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Available from https://arxiv.org/abs/1910.09361

Thesis

Nebulosities and jets from outbursting evolved stars

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In this Ph.D. Thesis we study the occurrence of powerful stellar outbursts in the late phases of evolution of stars like the Sun. This is one of the most controversial topics in the field, as the extraordinary variety of shapes revealed by observations are not expected to be the result of the evolution of stars that are basically spherical all over their lives. The stellar ejecta that we study occur and develop on time-scales of years, even months. This allows us to study their evolution in real-time. A very rare opportunity in Astrophysics! To this aim, we have gathered over the years a unique collection of multi epoch images, from which we produce "movies" that reveal the expansion of the nebulæ as projected in the plane of the sky. Images are complemented by spectra that measure the line-of-sight velocities, also required to build 3D models of the dynamical evolution of the outflows, a privileged information for theoretical modelling.

Defended 3$^{\text{rd}}$ of October 2019, University of Tartu, Estonia. Supervisors Dr. Romano L.M. Corradi (Instituto de Astrofísica de Canarias, GRANTECAN, Spain) and Dr. Indrek Kolka (Tartu Observatory, University of Tartu, Estonia). Opponent Dr. Eric Lagadec (Observatoire de la Côte d'Azur, Laboratoire Lagrange, Université Côte d'Azur, France)
Available from https://arxiv.org/abs/1910.04157
and from https://dspace.ut.ee/handle/10062/64848

Job Advert

2 Ph.D. positions in the field of evolved stars, entitled "ATOMIUM: ALMA Tracing the Origins of Molecules formIng dUst in oxygen-rich M-type stars"

The Institute of Astronomy, K.U. Leuven, currently has 2 open PhD positions in the field of evolved stars and ALMA observations.

The aim of the 2 open Ph.D. positions is to establish the dominant physical and chemical processes in the winds of oxygen-rich evolved stars over a range of stellar masses, pulsation behaviours, mass-loss rates, and evolutionary phases. One student will focus on the analysis of the lower-mass asymptotic giant branch (AGB) stars, the other one on the more massive red supergiant (RSG) stars. The students will work in parallel to unravel the phase transition from gas-phase to dust species, pinpoint the chemical pathways, map the morphological structure, and study the interplay between dynamical and chemical phenomena for both types of stars.

More information and application instructions can be found on
https://fys.kuleuven.be/ster/vacancies/vacancies#PhD_ATOMIUM

See also https://fys.kuleuven.be/ster/vacancies/vacancies#PhD_ATOMIUM

First Announcement: IAU Symposium 366: The Origin of Outflows in Evolved Stars 5–10 October 2020, Leuven, Belgium

The 366th International Astronomical Union (IAU) Symposium will be held in the historic city of Leuven, Belgium in October 2020.

Rationale:
A proper understanding of stellar evolution and of the chemical make-up of the building blocks in the Universe near and far cannot be achieved without a detailed understanding of the wind physics during the late stages of stellar evolution as a function of the cosmic environment and hence metallicity. The goal of this IAU Symposium 366 is to propel our understanding of stellar wind physics across stellar mass by bringing together the scientific communities which often focus on either the low-mass or the massive stars. This cross-disciplinary approach will fuel new scientific ideas and insights and will facilitate for new collaborations to grow across communities.

Dedicated training sessions will be devoted to the education of Ph.D.s and young postdocs, focussing on astrophysical methods and (inter)personal skills. In addition, with the aim to foster the link between science and the arts, we have foreseen funding for an artist and a writer in residence.

Key topics of the conference include

- Theory of stellar outflows: low mass & massive stars
- Observing stellar outflows: low mass & massive stars
- Numerical models for stellar outflows: low mass & massive stars
- Binarity
- Enrichment of the interstellar medium by stellar winds
- Astrochemistry
- Current and new observing facilities
- Hot topics
- Education & Outreach

Conference website:
More information on deadlines, travel, financial aid, and the scientific/social/educational programma will soon be available on the conference website (www.iaus366.be). For questions you can contact us at iausleuven@kuleuven.be.

Important dates:

- January 2020: registration opens
- 03/05/2020: deadline for abstract submission and grant applications
- 08/06/2020: announcement of selected grants
- 13/06/2020: announcement of selected oral and poster presentations
- 05/07/2020: deadline for early-bird registration

- 05/10/2020: start symposium

Invited speakers include, e.g., Rafaella Margutti, Stanley Owocki, Suzanne Höfner, Andrea Chiavassa, Mengfei Zhang, Margaret Meixner, Benjamin Davies, Hugues Sana, Alexander Stephan, Amit Kashi, Selma de Mink, Chiaki Kobayashi, Nathan Smith, Sung-Chul Yoon.

We hope to welcome you at the IAUS366,

Leen Decin and Clio Gielen (K.U. Leuven, Belgium), chairs of the SOC and LOC

See also www.iaus366.be

Planetary Nebula Symposium XI

Dear All

The Organising Committee of IAU Commission H3 are happy to announce the continuation of the long-running series of PN symposia. These meetings cover all aspects of PN research and related stellar evolutionary stages, and have been very important for the development of the field. Previous meetings were in 2016 (Beijing), 2011 (Tenerife), 2006 (Hawai'i), 2001 (Canberra), 1996 (Groningen), 1992 (Innsbruck), 1987 (Mexico City), 1982 (London), 1977 (Ithaca), and 1967 (Czechoslovakia).

The coming meeting is number XI in the series, and will be held in

Krakow, Poland

20–24 June, 2022

The SOC will be chaired by Ryszard Szczerba. We are very excited about this symposium and the location (the historic centre of Krakow is a UNESCO world heritage site, with very good flight connections). We can strongly recommend it to you!

We wish you a Stellar 2020!

Albert Zijlstra
IAU Commission H3 'Planetary Nebulæ'