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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

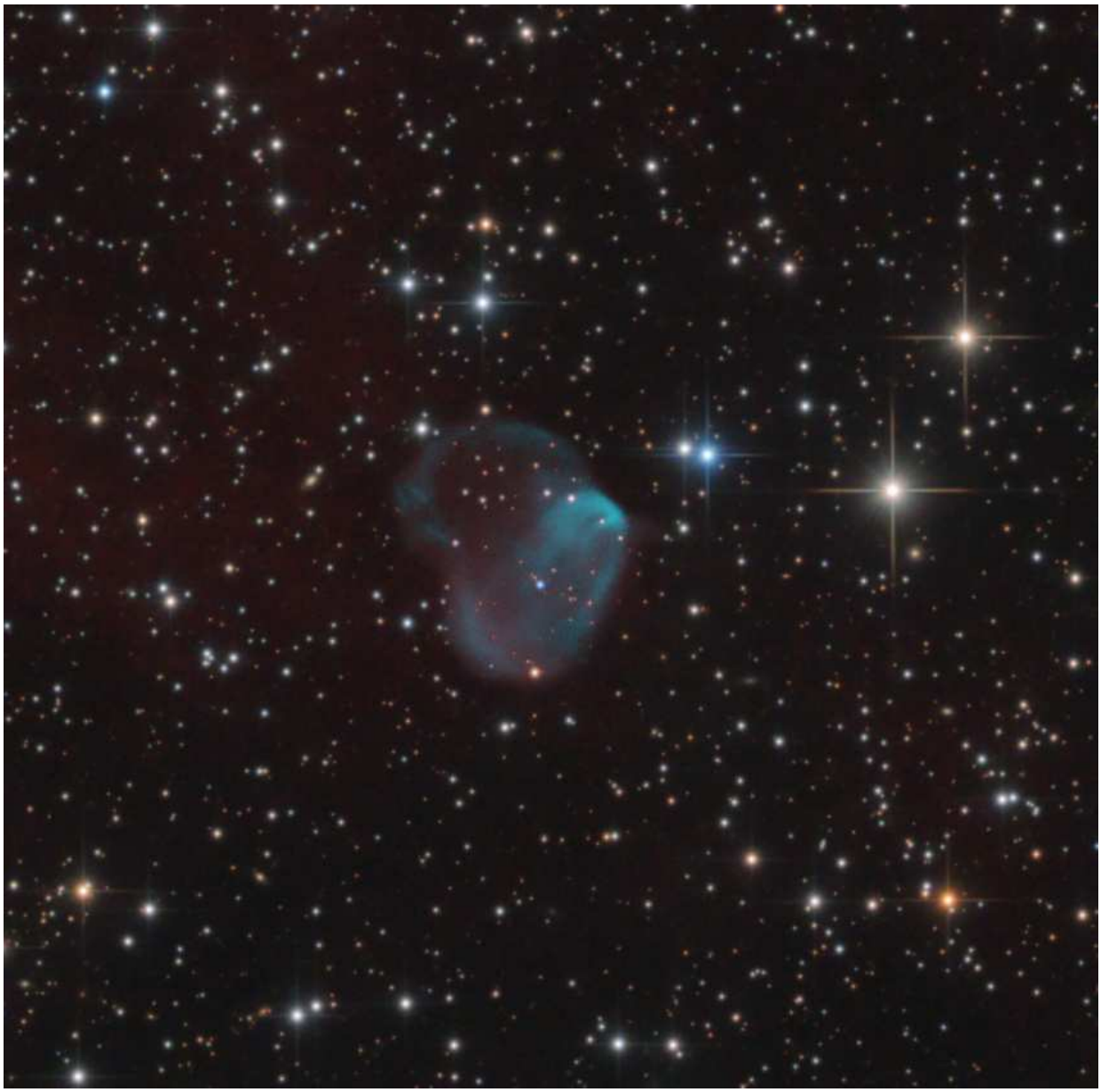

Figure 1: Patchick 5 – one of hundreds of planetary nebulæ discovered by amateurs, this one by Dana Patchick. This image is courtesy of Bernhard Hubl. For more details see http://www.astrophoton.com/PN_Patchick5.htm.

Editorial

Dear Colleagues,

It is a pleasure to present you the 252$^{\rm nd}$ issue of the AGB Newsletter.

Congratulations to Javier Alonso-Santiago with his philosopher's degree!

Consider attending the workshop on the OST, possibly our next big toy for infrared astronomy.

The *Food for Thought* "Observations need models just as much as models need observations" has provoked some interesting reactions. Pierre Darriulat pointed out that in French this is called "La Palissade" in reference to Jacques de La Palisse, a marshall under François Ier, who died in 1525 in Pavia fighting the Italians. A popular French song includes the verse "S'il n'etait pas mort / Il serait encore en vie" ("If he weren't dead / He would still be alive"). Another colleague wrote: "Observations are objective; models are subjective. Objective things stand alone; they are the rocks, unalterable, and the bases for the construction or creation of things subjective. Subjective things need observations to hang on, without doubt, but the observations are hard facts and do not need models. However, *humans* need models in order to interpret the observations, but that is not the same thing as observations needing models".

The next issue is planned to be distributed around the 6$^{\rm th}$ of August.

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

Food for Thought

This month's thought-provoking statement is:

What will the merger (itself, not the product) look like, of two ordinary white dwarfs (sum $< 1.4\ M_\odot$*)?*

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

Stellar models with calibrated convection and temperature stratification from 3D hydrodynamics simulations

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Stellar evolution codes play a major role in present-day astrophysics, yet they share common simplifications related to the outer layers of stars. We seek to improve on this by the use of results from realistic and highly detailed 3D hydrodynamics simulations of stellar convection. We implement a temperature stratification extracted directly from the 3D simulations into two stellar evolution codes to replace the simplified atmosphere normally used. Our implementation also contains a non-constant mixing-length parameter, which varies as a function of the stellar surface gravity and temperature – also derived from the 3D simulations. We give a detailed account of our fully consistent implementation and compare to earlier works, and also provide a freely available MESA-module. The evolution of low-mass stars with different masses is investigated, and we present for the first time an asteroseismic analysis of a standard solar model utilising calibrated convection and temperature stratification from 3D simulations. We show that the inclusion of 3D results have an almost insignificant impact on the evolution and structure of stellar models – the largest effect are changes in effective temperature of order 30 K seen in the pre-main sequence and in the red-giant branch. However, this work provides the first step for producing self-consistent evolutionary calculations using fully incorporated 3D atmospheres from on-the-fly interpolation in grids of simulations.

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Available from https://arxiv.org/abs/1806.00020

86 GHz SiO maser survey of late-type stars in the Inner Galaxy. IV. SiO emission and infrared data for sources in the Scutum and Sagittarius–Carina arms, $20^\circ < l < 50^\circ$.

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We present an 86 GHz SiO ($v = 1$, $J = 2 \rightarrow 1$) maser search toward late-type stars located within $|b| < 0.^\circ5$ and $20^\circ < l < 50^\circ$. This search is an extension at longer longitudes of a previously published work. We selected 135 stars from the MSX catalog using color and flux criteria and detected 92 (86 new detections). The detection rate is 68%, the same as in our previous study. The last few decades have seen the publication of several catalogs of point sources detected in infrared surveys (MSX, 2MASS, DENIS, ISOGAL, WISE, GLIMPSE, AKARI, and MIPSGAL). We searched each catalog for data on the 444 targets of our earlier survey and for the 135 in the survey reported here. We confirm that, as anticipated, most of our targets have colors typical of oxygen-rich asymptotic giant branch (AGB) stars. Only one target star may have already left the AGB. Ten stars have colors typical of carbon-rich stars, meaning a contamination of our sample with carbon stars $\lesssim$1.7%.

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CO envelope of the symbiotic star R Aqr seen by ALMA

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The symbiotic star R Aqr is part of a small sample of binary AGB stars observed with the Atacama Large Millimeter/submillimeter Array (ALMA). The sample stars are: R Aqr, Mira, W Aql, and π^1 Gru. The sample covers a range in binary separation and wind properties, where R Aqr is the source with the smallest separation. The R Aqr binary pair consists of an M-type AGB star and a white dwarf at a separation of 45 mas, equivalent to about 10 au at 218 pc. The aim of the ALMA study is to investigate the dependence of the wind shaping on the binary separation and to provide constraints for hydrodynamical binary interaction models. R Aqr is particularly interesting as the source with the smallest separation and a complex circumstellar environment that is strongly affected by the interaction between the two stars and by the high-energy radiation resulting from this interaction and from the hot white dwarf companion. The CO($J = 3 \rightarrow 2$) line emission has been observed with ALMA at $\sim 0\farcs5$ spatial resolution. The CO envelope around the binary pair is marginally resolved, showing what appears to be a rather complex distribution. The outer radius of the CO emitting region is estimated from the data and found to be about a factor of 10 larger than previously thought. This implies an average mass-loss rate during the past ~ 100 yr of $\dot{M} \approx 2 \times 10^{-7}$ $M_\odot$ yr^{-1} , a factor of 45 less than previous estimates. The channel maps are presented and the molecular gas distribution is discussed and set into the context of what was previously known about the system from multi-wavelength observations. Additional molecular line emission detected within the bandwidth covered by the ALMA observations is also presented. Because of the limited extent of the emission, firm conclusions about the dynamical evolution of the system will have to wait for higher spatial resolution observations. However, the data presented here support the assumption that the mass-loss rate from the Mira star strongly varies and is focused on the orbital plane.

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Available from https://arxiv.org/abs/1806.04979

The evolutionary nature of RV Tauri stars in the SMC and LMC

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Based on their stellar parameters and the presence of a mid-IR excess due to circumstellar dust, RV Tauri stars have been classified as post-AGB stars. Our recent studies, however, reveal diverse SEDs among RV Tauri stars, suggesting they may occupy other evolutionary channels as well. The aim of this paper is to present the diverse SED characteristics of RV Tauri stars and investigate their evolutionary nature as a function of their SEDs. We carried out a systematic study of RV Tauri stars in the SMC and LMC because of their known distances and hence luminosities. Their SEDs were classified in three groups: dusty (disc-type), non-dusty (non-IR) and uncertain. A period–luminosity–colour (PLC) relation was calibrated. The luminosities from the PLC were complemented with the ones found using their SEDs and the stars were placed on the HR-diagram. The I-band time series were used to search for period changes via $(O-C)$ analyses in order to identify period changes. The four main results from this study are: 1) RV Tauri stars with a clear IR-excess have disc-type SEDs, which indicates that the dust is trapped in a stable disc. Given the strong link between disc-type SEDs and binarity in the Galaxy, we postulate that these are binaries as well. These cover a range of luminosites and we argue that the more luminous ones are post-AGB stars while the lower luminosity ones are likely post-Red Giant Branch (post-RGB) stars. 2) Two of these objects have variable mean brightness with periods

of 916 and 850 days, respectively, caused by variable extinction during orbital motion. 3) The non-dusty RV Tauri stars and the objects with an uncertain SED evolve such that the circumstellar dust has dispersed. If they are single stars, they are post-AGB objects of low initial mass (< 1.25 $M_\odot$), while if they are binaries, the low-luminosity part of the sample are likely post-RGB stars. 4) We find that RV Tauri stars with dust are on average more luminous than the rest of the sample.

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The mysterious cut-off of the Planetary Nebula Luminosity Function

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Planetary Nebulæ (PN) emit enormous amount of energy in several emission lines. Measuring the line-flux for PNe in a given stellar population, the Planetary Nebula Luminosity Function (PNLF) can be compiled. Surveys of PNe revealed that the faint-end of the PNLF can be approximated by a simple exponential dependency expected for an expanding spherical shell. However at the bright-end there exists a steep cut-off which was unexpected and remains unexplained. Interestingly, the cut-off value appears to be nearly the same for different stellar populations as young spiral galaxies and old elliptical galaxies and, despite the lack of understanding, became an extragalactic distance estimator. Here we show that the recently computed post-AGB evolutionary tracks are capable to explain the decades old mystery. All new models with ages between 1 and 7 Gyr (progenitor masses between 2.0 and 1.1 $M_\odot$) evolve fast enough to ionize the PN, and at similar post-AGB luminosity which allows the [O III] 500.7-nm line to reach nearly the same magnitude. The new models predict that the Sun at the end of its life will form a rather faint PN.

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and from https://www.nature.com/articles/s41550-018-0453-9

Calibrating long period variables as standard candles with machine learning

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Variable stars with well-calibrated period-luminosity relationships provide accurate distance measurements to nearby galaxies and are therefore a vital tool for cosmology and astrophysics. While these measurements typically rely on samples of Cepheid and RR Lyræ stars, abundant populations of luminous variable stars with longer periods of 10–1000 d remain largely unused. We apply machine learning to derive a mapping between light-curve features of these variable stars and their magnitude to extend the traditional period–luminosity (PL) relation commonly used for Cepheid samples. Using photometric data for long period variable stars in the Large Magellanic cloud (LMC), we demonstrate that our predictions produce residual errors comparable to those obtained on the corresponding Cepheid population. We show that our model generalizes well to other samples by performing a blind test on photometric data from the Small Magellanic Cloud (SMC). Our predictions on the SMC again show small residual errors and biases, comparable to results that employ PL relations fitted on Cepheid samples. The residual biases are complementary between the long period variable and Cepheid fits, which provides exciting prospects to better control sources of systematic error in cosmological distance measurements. We finally show that the proposed methodology can be used

to optimize samples of variable stars as standard candles independent of any prior variable star classification.

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The nature of the Stingray Nebula from radio observations

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We have analysed the full suite of Australia Telescope Compact Array data for the Stingray planetary nebula. Data were taken in the 4- to 23-GHz range of radio frequencies between 1991 and 2016. The radio flux density of the nebula generally declined during that period, but between 2013 and 2016 it shows signs of halting that decline. We produced the first spatially resolved radio images of the Stingray nebula from data taken in 2005. A ring structure, which appears to be associated with the ring seen in HST images, was visible. In addition, we found a narrow extension to the radio emission towards the eastern and western edges of the nebula. We derived the emission measure of the nebula – this decreased between 1992 and 2011, suggesting that the nebula is undergoing recombination. The radio spectral index is broadly consistent with a free–free emission mechanism, however a single data point hints that a steeper spectral index has possibly emerged since 2013, which could indicate the presence of synchrotron emission. If a non-thermal component component has emerged, such as one associated with a region that is launching a jet or outflow, we predict that it would intensify in the years to come.

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Dissecting the X-ray emission in the young planetary nebula NGC 7027

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We present analysis of a second observation of the young planetary nebula (PN) NGC 7027 by the *Chandra* X-ray Observatory. This latest 59.2 ks exposure with ACIS-S was acquired approximately 14 years after the initial 18.2 ks ACIS-S observation, and the improved photon statistics allow us to perform a detailed spatial and spectral analysis of the X-ray emission. Comparison with multi-wavelength imaging of NGC 7027 reveals a strong anti-correlation between extinction across the nebula and the soft band X-ray emission. Dissecting the X-ray emission into low- and high-extinction regions results in more robust characterization of the plasma spectral properties. We determine that the X-ray emitting plasma has a temperature of ~ 3.6 MK, is deficient in Fe, and has an X-ray luminosity of $L_{\rm X} \sim 7 \times 10^{31}$ erg s^{-1}, all of which are generally consistent with the plasma properties found in PN hot bubbles. We find no evidence of evolution in the X-ray surface brightness over the 14 year baseline between *Chandra* observations. Our analysis underscores the importance of accounting for nebular absorption of the X-ray emission in accurately determining plasma properties for hot bubbles within PNe.

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Do close-in giant planets orbiting evolved stars prefer eccentric orbits?

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The NASA *Kepler* and K2 missions have recently revealed a population of transiting giant planets orbiting moderately evolved, low-luminosity red giant branch stars. Here, we present radial velocity (RV) measurements of three of these systems, revealing significantly non-zero orbital eccentricities in each case. Comparing these systems with the known planet population suggests that close-in giant planets around evolved stars tend to have more eccentric orbits than those around main sequence stars. We interpret this as tentative evidence that the orbits of these planets pass through a transient, moderately eccentric phase where they shrink faster than they circularize due to tides raised on evolved host stars. Additional RV measurements of currently known systems, along with new systems discovered by the recently launched NASA Transiting Exoplanet Survey Satellite (TESS) mission, may constrain the timescale and mass dependence of this process.

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δ Mus revisited: rectifying a 82-yr old mistake

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The red giant δ Muscæ is known since 1919 to be a spectroscopic binary, and the first and only orbit was determined in 1936, claiming the period to be 847 days. This was discrepant with the *Hipparcos* determined astrometric orbit. Using the latest data available for this object – leading to a 100 yr time-span – we show here that the correct period is 423 d, and are able for the first time to combine the spectroscopic orbit with the *Hipparcos* orbit. Using all the available information, we find that the ~ 1.2 $M_\odot$ red giant must have a ~ 0.3–0.4 $M_\odot$ M dwarf companion, and that the system will soon evolve towards a He WD binary system. Given its relatively short period, δ Muscæ may be an ideal benchmark for testing astrometric orbits obtained by Gaia for very bright stars.

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On the detection of CO and mass loss of Bulge OH/IR stars

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We report on the successful search for CO (2–1) and (3–2) emission associated with OH/IR stars in the Galactic Bulge.

We observed a sample of eight extremely red AGB stars with the APEX telescope and detected seven. The sources were selected at sufficient high galactic latitude to avoid interference by interstellar CO, which hampered previous studies of inner galaxy stars. To study the nature of our sample and the mass loss we constructed the SEDs from photometric data and *Spitzer* IRS spectroscopy. In a first step we apply radiative transfer modelling to fit the SEDs and obtain luminosities and dust mass loss rates (MLR). Through dynamical modelling we then retrieve the total MLR and the gas-to-dust ratios. We derived variability periods of our stars. The luminosities range between ≈ 4000 and 5500 $L_\odot$ and periods are below 700 days. The total MLR ranges between 10^{-5} and 10^{-4} $M_\odot$ yr^{-1}. Comparison with evolutionary models shows that the progenitor mass is approximately 1.5 Msun, similar to the Bulge Miras and are of intermediate age (3 Gyr). The gas-to-dust ratios are between 100 and 400 and are similar to what is found for OH/IR stars in the Galactic Disk. One star, IRAS 17347−2319, has a very short period of approximately 300 days which may be decreasing further. It may belong to a class of Mira variables with a sudden change in period as observed in some Galactic objects. It would be the first example of an OH/IR star in this class and deserves further follow-up observations.

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Extended dust emission from nearby evolved stars

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We present *James Clerk Maxwell* Telescope Sub-millimetre Common-User Bolometer Array 2 (SCUBA-2) 450 and 850 μm observations of 14 asymptotic giant branch stars (9 O-rich, 4 C-rich, and 1 S-type) and one red supergiant in the solar neighbourhood. We combine these observations with *Herschel*/PACS observations at 70 and 160 μm and obtain azimuthally averaged surface-brightness profiles and their point spread function-subtracted residuals. The extent of the SCUBA-2 850-μm emission ranges from 0.01 to 0.16 pc with an average of ~ 40 per cent of the total flux being emitted from the extended component. By fitting a modified blackbody to the four-point spectral energy distribution at each point along the residual profile we derive the temperature (T), spectral index of dust emissivity (β), and dust column density (Σ) as a function of radius. For all the sources, the density profile deviates significantly from what is expected for a constant mass-loss rate, showing that all the sources have undergone variations in mass loss during this evolutionary phase. In combination with results from CO line emission, we determined the dust-to-gas mass ratio for all the sources in our sample. We find that, when sources are grouped according to their chemistry, the resulting average dust-to-gas ratios are consistent with the respective canonical values. However, we see a range of values with significant scatter which indicate the importance of including spatial information when deriving these numbers.

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Evolved stars in the Local Group galaxies – II. AGB, RSG stars and dust production in IC 10

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We study the evolved stellar population of the Local Group galaxy IC 10, with the aim of characterizing the individual sources observed and to derive global information on the galaxy, primarily the star formation history and the dust production rate. To this aim, we use evolutionary sequences of low- and intermediate-mass stars, evolved through the asymptotic giant branch phase, with the inclusion of the description of dust formation. We also use models of higher mass stars. The evolved stellar population is dominated by carbon stars, that account for 40% of the sources brighter than the tip of the red giant branch. Most of these stars descend from $\sim$ 1.1–1.3 $M_\odot$ progenitors, formed during the major epoch of star formation, which occurred $\sim$ 2.5 Gyr ago. The presence of a significant number of bright stars indicates that IC 10 has been site of significant star formation in recent epochs and currently hosts a group of massive stars in the core helium-burning phase. Dust production in this galaxy is largely dominated by carbon stars; the overall dust production rate estimated is 7×10^{-6} $M_\odot$ yr^{-1}.

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The Gaia–ESO Survey: the origin and evolution of *s*-process elements

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Several works have found an increase of the abundances of the *s*-process neutron-capture elements in the youngest Galactic stellar populations. These trends provide important constraints on stellar and Galactic evolution and they need to be confirmed with large and statistically significant samples of stars spanning wide age and distance intervals. We aim to trace the abundance patterns and the time evolution of five *s*-process elements – two belonging to the first peak, Y and Zr, and three belonging to the second peak, Ba, La, and Ce – using the Gaia–ESO idr5 results for open clusters and disc stars. From the UVES spectra of cluster member stars, we determined the average composition of clusters with ages $>$ 0.1 Gyr. We derived statistical ages and distances of field stars, and we separated them into thin and thick disc populations. We studied the time- evolution and dependence on metallicity of abundance ratios using open clusters and field stars whose parameters and abundances were derived in a homogeneous way. Using our large and homogeneous sample of open clusters, thin and thick disc stars, spanning an age range larger than 10 Gyr, we confirm an increase towards young ages of *s*-process abundances in the solar neighbourhood. These trends are well defined for open clusters and stars located nearby the solar position and they may be explained by a late enrichment due to significant contribution to the production of these elements from long-living low-mass stars. At the same time, we find a strong dependence of the *s*-process abundance ratios on the Galactocentric distance and on the metallicity of the clusters and field stars. Our results, derived from the largest and most homogeneous sample of *s*-process abundances in the literature, confirm the growth with decreasing stellar ages of the *s*-process abundances in both field and open cluster stars. At the same time, taking advantage of the abundances of open clusters located in a wide Galactocentric range, these results offer a new perspective on the dependence of the *s*-process evolution on the metallicity and star formation history, pointing to different behaviours at various Galactocentric distances.

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Planetary Nebulæ in the UWISH2 survey

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Near-infrared imaging in the 1–0 S(1) emission line of molecular hydrogen is able to detect planetary nebulæ (PNe) that are hidden from optical emission line surveys. We present images of 307 objects from the UWISH2 survey of the northern Galactic Plane, and with the aid of mid-infrared colour diagnostics draw up a list of 291 PN candidates. The majority, 183, are new detections and 85 per cent of these are not present in Hα surveys of the region. We find that more than half (54 per cent) of objects have a bipolar morphology and that some objects previously considered as elliptical or point-source in Hα imaging, appear bipolar in UWISH2 images. By considering a small subset of objects for which physical radii are available from the Hα surface brightness-radius relation, we find evidence that the H_2 surface brightness remains roughly constant over a factor 20 range of radii from 0.03 to 0.6 pc, encompassing most of the visible lifetime of a PN. This leads to the Hα surface brightness becoming comparable to that of H_2 at large radius (> 0.5 pc). By combining the number of UWISH2 PNe without Hα detection with an estimate of the PN detection efficiency in H_2 emission, we estimate that PN numbers from Hα surveys may underestimate the true PN number by a factor between 1.5 and 2.5 within the UWISH2 survey area.

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The Owl and other strigiform nebulæ: multipolar cavities within a filled shell

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We present the results of long-slit échelle spectroscopy and deep narrow-band imaging of the Owl Nebula (NGC 3587), obtained at the Observatorio Astronómico Nacional, San Pedro Mártir. These data allow us to construct an iso-velocity data cube and develop a 3-D morpho-kinematic model. We find that, instead of the previously assumed bipolar dumbbell shape, the inner cavity consists of multi-polar fingers within an overall tripolar structure. We identify three additional planetary nebulæ that show very similar morphologies and kinematics to the Owl, and propose that these constitute a new class of strigiform (owl-like) nebulæ. Common characteristics of the strigiform nebulæ include a double-shell (thin outside thick) structure, low-luminosity and high-gravity central stars, the absence of a present-day stellar wind, and asymmetric inner cavities, visible in both optical and mid-infrared emission lines, that show no evidence for surrounding bright rims. The origin of the cavities is unclear, but they may constitute relics of an earlier stage of evolution when the stellar wind was active.

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The role of dredge-up in double white dwarf mergers

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We present the results of an investigation of the dredge-up and mixing during the merger of two white dwarfs with different chemical compositions by conducting hydrodynamic simulations of binary mergers for three representative mass ratios. In all the simulations, the total mass of the two white dwarfs is $\lesssim$1.0 $M_\odot$. Mergers involving a CO and a He white dwarf have been suggested as a possible formation channel for R Coronæ Borealis type stars, and we are interested in testing if such mergers lead to conditions and outcomes in agreement with observations. Even if the conditions during the merger and subsequent nucleosynthesis favor the production of ^{18}O, the merger must avoid dredging up large amounts of ^{16}O, or else it will be difficult to produce sufficient ^{18}O to explain the oxygen ratio observed to be of order unity. We performed a total of 9 simulations using two different grid-based hydrodynamics codes using fixed and adaptive meshes, and one smooth particle hydrodynamics (SPH) code. We find that in most of the simulations, $> 10^{-2}$ $M_\odot$ of ^{16}O is indeed dredged up during the merger. However, in SPH simulations where the accretor is a hybrid He/CO white dwarf with a ~ 0.1 $M_\odot$ layer of helium on top, we find that no ^{16}O is being dredged up, while in the $q = 0.8$ simulation $< 10^{-4}$ $M_\odot$ of ^{16}O has been brought up, making a WD binary consisting of a hybrid CO/He WD and a companion He WD an excellent candidate for the progenitor of RCB stars.

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MUSE crowded field 3D spectroscopy in NGC 300 I. First results from central fields

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Aims: As a new approach to the study of resolved stellar populations in nearby galaxies, our goal is to demonstrate with a pilot study in NGC 300 that integral field spectroscopy with high spatial resolution and excellent seeing conditions reaches an unprecedented depth in severely crowded fields.
Methods: Observations by MUSE with seven pointings in NGC 300 have resulted in data cubes that are analyzed in four ways: (1) Point spread function-fitting 3D spectroscopy with PampelMUSE, as already successfully pioneered in globular clusters, yields deblended spectra of individually distinguishable stars, thus providing a complete inventory of blue and red supergiants, and asymptotic giant branch (AGB) stars of type M and C. The technique is also applicable to emission line point sources and provides samples of planetary nebulæ (PNe) that are complete down to $m_{5007} = 28$ mag. (2) Pseudo-monochromatic images, created at the wavelengths of the most important emission lines and corrected for continuum light with the P3D visualization tool, provide maps of H II regions, supernova remnants (SNR), and the diffuse interstellar medium (ISM) at a high level of sensitivity, where also faint point sources stand out and allow

for the discovery of PNe, Wolf–Rayet (WR) stars, etc. (3) The use of the P3D line-fitting tool yields emission line fluxes, surface brightness, and kinematic information for gaseous objects, corrected for absorption line profiles of the underlying stellar population in the case of Hα. (4) Visual inspection of the data cubes by browsing through the row-stacked spectra image in P3D is demonstrated to be efficient for data mining and the discovery of background galaxies and unusual objects.
Results: We present a catalog of luminous stars, rare stars such as WR, and other emission line stars, carbon stars, symbiotic star candidates, PNe, H II regions, SNR, giant shells, peculiar diffuse and filamentary emission line objects, and background galaxies, along with their spectra.
Conclusions: The technique of crowded-field 3D spectroscopy, using the PampelMUSE code, is capable of deblending individual bright stars, the unresolved background of faint stars, gaseous nebulæ, and the diffuse component of the ISM, resulting in unprecedented legacy value for observations of nearby galaxies with MUSE.

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Thesis

Clusters with K supergiants

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The initial mass with which a star is born is the fundamental parameter that will determine the evolution and properties of the star. According to their mass, stars follow two different evolutionary branches: either the red giant or the red supergiant phase (RSG). In the first case, the red giant evolves into an AGB star and ends its life expelling its outer layers in the form of a planetary nebula, leaving as a remnant a white dwarf. In the second, the RSG suffers a core collapse which releases a large amount of energy, exploding as a supernova (SN). In this occasion, the residual object is a very compact (a neutron star or a black hole). The boundary between both scenarios would be approximately around 8–9 $M_\odot$, depending on models.

In recent years, several programmes for the search of SNe progenitors have been carried out. Their results are questioning the classical paradigm which explains the origin of these objects. The minimum mass to produce a SN explosion might be up to two solar masses below the limit traditionally accepted: stars of only 6–7 $M_\odot$ could become a SN in low-metallicity environments and binary systems.

The main goal of this thesis is to provide for the first time a series of observational evidences that may serve to constrain theoretical models. To do this, we have studied a sample of evolved stars contained in young clusters, ideal laboratories to study the stellar evolution of their members. We performed a literature search for young open clusters with ages between 30–100 Ma, which cover the mass transition for a SN explosion (6–9 $M_\odot$) according to recent works. We found that clusters in this age range have on average only two red (super)giants. Nevertheless, for our sample we selected the clusters statistically more significant, those containing at least five evolved stars, namely: NGC 2345, NGC 3105, NGC 6067, NGC 6649, NGC 6664 and Trumpler 35. In total, they host half a hundred of (super)giants, most of them red although we also found some blue and yellow ones.

On the one hand, we carried out a study of every cluster in a consistent way by combining photometry (our own or archival) and low- or moderate-resolution spectroscopy. In this manner, besides the characterisation of the cluster itself, we obtain the age and mass of its evolved stars. Most of these stars have spectral types K, hence the name of the thesis. On the other hand, from high-resolution spectroscopy ($R = 48\,000$) we characterised these stars by calculating both their atmospheric stellar parameters and chemical abundances for some elements (Li, O, Na, Mg, Si, Ca, Ti, Ni, Rb, Y and Ba). The instrument used was FEROS, which is mounted on the 2.2-m telescope at the La Silla Observatory (Chile).

In this thesis we performed the most complete study to date of the clusters contained in our sample. For the first time, a detailed spectroscopic analysis was carried out on stars of NGC 3105, NGC 6649, NGC 6664 and Trumpler 35. For the other two clusters, NGC 2345 and NGC 6067, the number of objects studied here is higher than that reported in the only paper previously published in each case. In this age range, our sample represents half the clusters observed spectroscopically and 87% of evolved stars analysed.

For these clusters, using as a proxy the iron abundance, we obtained metallicities compatible with the Galactic gradient derived from Cepheids, although our values are systematically somewhat lower. Chemical abundances are also compatible with the Galactic trend observed in the thin disc as well as the theoretical scenario which describes the chemical evolution of the Milky Way. Particularly noteworthy is the over-abundance of [Ba/Fe] found in our sample, which supports the enhanced *s*-process suggested to explain the enrichment of Ba in young open clusters.

Finally, we have covered a range of masses between 5.5–9.5 $M_{\odot}$. We have not found any significant trend in the chemical composition from red luminous giants to supergiants. We have not spotted any super-AGB star either. From an observational point of view, the transition of the spectral types observed in our sample, from medium- or late-K II/Ib to early-M Ib, might be related to the AGB/RSG mass boundary at solar metallicity.

Thesis directed by Ignacio Negueruela and Amparo Marco. Defence date: 26-01-2018
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Announcement

From first stars to life: science with the OST

4–7 September 2018
Oxford, UK

We would like to have additional contributed talks from the stellar community. Please come and share your views on the future of evolved stars in the far-infrared.

The Origins Space Telescope (OST) is one of the four NASA 2020 Decadal survey missions currently under study. OST will carry a suite of instruments covering the 6 to 600 μm and with its cooled telescope (down to 4K) will deliver superb imaging and spectroscopic capabilities including far infrared polarimetry. Details on the instruments and their capabilities are available at https://asd.gsfc.nasa.gov/firs/flyer/ and http://origins.ipac.caltech.edu/page/simulation-tools. The focus of the workshop is to bring together European scientists interested in the OST to discuss potential science projects.

OST Science: The infrared is the key wavelength regime for understanding the formation and early evolution of galaxies, stars and planetary systems. These wavelengths probe the obscured Universe from Cosmic Dawn to protoplanetary disks tracing both the dust and the dominant atomic, ionic and molecular cooling lines. When studied together dust continuum and lines allow us to trace the chemical enrichment of the gas in the Universe and the physical processes which determine the evolution from the primordial gas to habitable exoplanets. In particular, the infrared is host to a series of molecular bio-markers that can be used to characterize the atmospheres of exoplanets. Only in the IR can we follow the water trail in the Universe, from distant galaxies down to the solar system.

Previous space IR missions such as ISO, *Spitzer*, *Herschel* and *Planck* demonstrated the importance of the IR regime in understanding the interplay between stars and the interstellar medium in our Galaxy and in external galaxies near and far. This complex interplay between poorly understood baryonic processes sets the life cycle of star formation and stellar death and, ultimately, the growth and evolution of galaxies and supermassive black holes. The IR allows us to probe dust-obscured galaxies at the peak of their star formation as well as supermassive black holes during their most intense growth spurts thereby unveiling the formative processes behind these enigmatic objects and their possible co-evolution.

All of the above processes are thought to have evolved rapidly during the rise of metals in the first stars and galaxies during the Cosmic Dawn when the first black holes also formed, before reaching a quasi-steady state as the cosmos matured. At every step along the way, however, there are significant gaps in our understanding the role the baryonic cycle and astrochemistry play in the inner workings of galaxies as well as the late stages of planetary formation. These gaps will not be filled in by the JWST nor ALMA but require a large aperture space-borne cooled telescope capable of achieving unprecedented IR sensitivities and high spatial resolution.

Building on the success of the previous far-IR missions and their importance for the European astronomical community, the goal of this Symposium is to bring together the community in order to home in on the most pressing questions a next-generation far-IR facility of this kind would be able to tackle. The Symposium will focus on the following themes:

- The rise of metals and dust
- Cosmic Dawn and the adolescent Universe
- The Starburst–AGN connection: finding the hidden supermassive black holes
- Stars and ISM: the baryonic cycle
- Astrochemistry
- The Solar System & protoplanetary disks
- Characterization of Exoplanets

Format: The workshop will consist of invited and contributed talks. We ask interested participants to consult the OST webpage and come prepared to discuss their science project. There will be a presentation of the US-led science themes and OST science instruments but the focus will be on community-proposed science projects. Posters are also welcome. The audience is limited to 100 people.

Location: The workshop will be held in the Physics Department at the University of Oxford, UK, during September 4–7, 2018. There will be a small registration fee ($\sim$ 90 GBP) to cover coffee breaks and lunches.

Organizers: D. Rigopoulou (Univ. of Oxford, co-Chair), S. Aalto (Chalmers Univ. Of Technology, co-Chair), A. Cooray (UC Irvine), E. De Beck (Chalmers Univ. of Technology), M. Gerin (Paris Observatory), M. Griffin (Univ. of Cardiff), F. Helmich (SRON), M. Meixner (Space Telescope Science Institute), M. Wiedner (Paris Observatory), P. Hartogh (Max-Planck for Solar System Research)

See also http://www.ost-meeting.com