THE AGB NEWSLETTER

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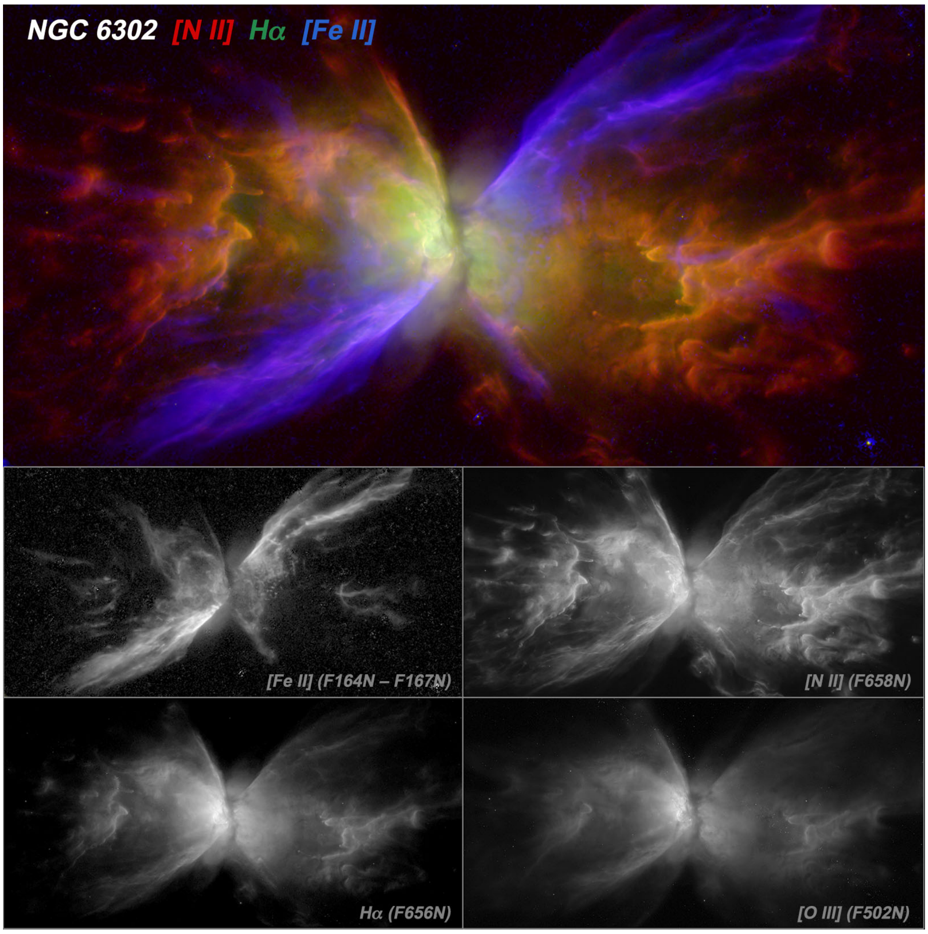

Figure 1: Multifilter images of the bipolar planetary nebula NGC 6302 obtained in HST program GO15953 (Joel Kastner et al.). The [Fe II]$\lambda 1.64\mu$m line (shown in blue in the color overlay) is a tracer of shocks with speeds > 100 km s^{-1} that is commonly found in the spectra of AGN, SNe, and Wolf–Rayet nebulæ but only rarely in PNe. The [Fe II] image indicates that unusually fast winds from the active stellar nucleus penetrate far into the nebula, possibly at various speeds, angles, and densities. A paper is in preparation.

Editorial

Dear Colleagues,

It is a pleasure to present you the 274^{th} issue of the AGB Newsletter. As COVID-19 continues to affect our lives it is becoming increasingly clear how it is affecting different people in different ways. Within Astronomy too, some will have increased private or public responsibilities or academic duties and others more free time for research. Some have the means to adapt, while others find it harder. It is important that we help eachother out, reach out to our students and do not take an unfair advantage. As a scientific community, too, we must emerge from this global challenge to our mindset in a positive way, more collaborative and less competitive.

In response to the restrictions on travel and congregation, the European Astronomical Society (following the example of the American Astronomical Society) have turned their annual meeting into an on-line one. See the advertisement at the end of the Newsletter and be quick to take part.

Two brilliant, motivated students could be starting their Ph.D. research with Susanne Höfner and Bernd Freytag in Uppsala – see the advertisement near the back.

Last month's Food for Thought provoked several responses:
"I think many things about the nature of science and research need to change in response to anthropogenic climate change, just like everything else in society. I think science culture has to change significantly – not because we're not doing enough, but because we *can* do more and should take the opportunity to lead the broader cultural changes by example. We were one of the early fields to speak out collectively on the issue, and it's a moral imperative that we lead by living and operating with climate change in mind.
Regarding meetings, I think we continue to have them because that's simply how things have always been done in living memory and it's just assumed that that's the best way to have collaborative experiences. It's an assumption, not a fact. We're more than a century past Solvay, and I think we should look for ways to create *new* kinds of valuable and useful collaborative experiences, not just focusing on *replicating* the meeting experience, because you can't. (And maybe shouldn't!)
Like meetings, we do not need on-site observing at ground-based facilities anymore. Again the hands-on experience is useful for training but it is not necessary. Travel is (often) fun and exciting, and in-person time with colleagues is valuable but we need to realize it's a luxury and a privilege, not an *entitlement*. And science doesn't (or certainly shouldn't) depend on it to happen.
But I think the Astronomy community should be thinking of changing *all* of what we do, not just meetings. Do we each need a workstation on our desk, that's on and connected/connectable 24 hours a day, in addition to other centralized computing resources? That's the norm here at my institution and many others. Likewise astronomy departments exist within the frameworks of educational infrastructure. Do we need physical footprints on campuses separate from other departments open and available 24/7? Can we scale down what we have and make it more efficient? Can we spend time and effort working with our host institutions to become more energy efficient? I think all of these are *professional* questions we need to be asking, just as important as how we address other issues like funding.
Astronomy is a relatively small global society, and whatever we do collectively will have a small physical impact. But I think the moral impact of our actions can be significantly higher, and I think we need to act with that in mind."

...or in a nutshell, the following message from Nye Evans:
"The planet doesn't need saving!! It is perfectly capable of looking after itself and will be here long after humanity, astrophysicists and AGB aficionados have gone. In the past it has survived far greater catastrophes than insignificant humanity can ever inflict on it.
The question is 'Will we continue to replace face-to-face meetings by on-line meetings to save ourselves and the environment in which we and other species live?' As citizens of the planet we should all take responsibility to do what we can to this end, for example by resourcing what we need to live (food, clothing etc.) locally, by avoiding using materials that damage the environment (e.g., plastics, palm oil), minimising air travel, and so on.
Vivat planetæ!"

..and Roberto Viotti's advocacy:
"On-line scientifc meetings do now and will in the future represent a unique opportunity of a worldwide participation,

especially from researchers from developing countries, and from young or unemployed researchers, that both have had in the past little possibility to participate to international meetings. Since the main constructive points of a meeting is first to give an update overview of a given theme, and secondly to allow for wide participation to the discussions following the talks and to stimulate future collaborations, as well, these points must be crucial in the future meetings, not forgetting the needs for online participation of blind and deaf researchers.
As far as the AGB Newsletter (and other Scientific Newsletters), I suggest the Editors to encourage the production of articles concerning the synthetic description of the present state of art of a given topic (such as that on the nebula of R Aqr as in the 1st April AGB Newsletter), artiche that could be easily and freely downloaded from astro-ph or from online journals or else. For instance I will be glad to read a comprehensive synthesis on one of my pet objects, AG Dra without running around the large literature so far published on this system. Thank you for your attention."

You may have – just as we have – admired the stunning pictures that so often ornated the front of the Newsletter, suggested by Sakib Rasool. These are the remarkable products of amateur astronomers' dedication and craftship. Please consider the following appeal:
"A small consortium of amateur astronomers led by Marcel Drechsler have made a number of planetary nebula candidates discoveries in the past few years. A crowdfunding petition has been started to raise funds to rent a 1 meter observatory to photograph some of the newly discovered planetary nebula candidates. If you are interested, you could donate! The petition is here: https://www.startnext.com/astro-joint-venture One newly discovered planetary nebula that has been imaged can be seen here: https://www.astrobin.com/8lnkug/B/"

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

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

Food for Thought

This month's thought-provoking statement is:

Referees have too much, unchallenged power and editors/panels side with them.

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

Chemical equilibrium in AGB atmospheres: successes, failures, and prospects for small molecules, clusters, and condensates

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Chemical equilibrium has proven extremely useful to predict the chemical composition of AGB atmospheres. Here we use a recently developed code and an updated thermochemical database, including gaseous and condensed species involving 34 elements, to compute the chemical equilibrium composition of AGB atmospheres of M-, S-, and C-type stars. We include for the first time Ti_xC_y clusters, with x = 1–4 and y = 1–4, and selected larger clusters ranging up to $Ti_{13}C_{22}$, for which thermochemical data is obtained from quantum chemical calculations. We find that in general chemical equilibrium reproduces well the observed abundances of parent molecules in circumstellar envelopes of AGB stars. There are however severe discrepancies, of various orders of magnitude, for some parent molecules: HCN, CS, NH_3, and SO_2 in M-type stars, H_2O and NH_3 in S-type stars, and the hydrides H_2O, NH_3, SiH_4, and PH_3 in C-type stars. Several molecules not yet observed in AGB atmospheres, like SiC_5, SiNH, SiCl, PS, HBO, and the metal-containing molecules MgS, CaS, CaOH, CaCl, CaF, ScO, ZrO, VO, FeS, CoH, and NiS, are good candidates for detection with observatories like ALMA. The first condensates predicted are carbon, TiC, and SiC in C-rich atmospheres and Al_2O_3 in O-rich outflows. The most probable gas-phase precursors of dust are acetylene, atomic carbon, and/or C_3 for carbon dust, SiC_2 and Si_2C for SiC dust, and atomic Al and AlOH, AlO, and Al_2O for Al_2O_3 dust. In the case of TiC dust, atomic Ti is probably the main supplier of titanium. However, chemical equilibrium predicts that clusters like Ti_8C_{12} and $Ti_{13}C_{22}$ become the major reservoirs of titanium at the expense of atomic Ti in the region where condensation of TiC is expected to occur, suggesting that the assembly of large Ti_xC_y clusters could be related to the formation of the first condensation nuclei of TiC.

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Chandra observations of the planetary nebula IC 4593

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The ACIS-S camera on board the *Chandra* X-ray Observatory has been used to discover a hot bubble in the planetary nebula (PN) IC 4593, the most distant PN detected by *Chandra* so far. The data are used to study the distribution of the X-ray-emitting gas in IC 4593 and to estimate its physical properties. The hot bubble has a radius of $\sim 2''$ and is found to be confined inside the optically-bright innermost cavity of IC 4593. The X-ray emission is mostly consistent with that of an optically-thin plasma with temperature $kT \approx 0.15$ keV (or $T_X \approx 1.7 \times 10^6$ K), electron density $n_e \approx 15$ cm^{-3}, and intrinsic X-ray luminosity in the 0.3–1.5 keV energy range $L_X = 3.4 \times 10^{30}$ erg s^{-1}. A careful analysis of the distribution of hard ($E > 0.8$ keV) photons in IC 4593 suggests the presence of X-ray emission from a point source likely associated with its central star (CSPN). If this were the case, its estimated X-ray luminosity would be $L_{X,CSPN} = 7 \times 10^{29}$ erg s^{-1}, fulfilling the $\log(L_{X,CSPN}/L_{bol}) \approx -7$ relation for self-shocking winds in hot stars. The X-ray detection of the CSPN helps explain the presence of high-ionisation species detected in the UV spectra as predicted by stellar atmosphere models.

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An isolated white dwarf with 317s rotation and magnetic emission

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We report the discovery of short-period photometric variability and modulated Zeeman-split hydrogen emission in SDSS J125230.93−023417.72 (EPIC 228939929), a variable white dwarf star observed at long cadence in K2 Campaign 10. The behavior is associated with a magnetic ($B = 5.0$ MG) spot on the stellar surface, making the 317.278-second period a direct measurement of the stellar rotation rate. This object is therefore the fastest-rotating, apparently isolated (without a stellar companion) white dwarf yet discovered, and the second found to exhibit chromospheric Balmer emission after GD 356, in which the emission has been attributed to a unipolar inductor mechanism driven by a possible rocky planet. We explore the properties and behavior of this object, and consider whether its evolution may hold implications for white dwarf mergers and their remnants.

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Precision angular diameters for 16 southern stars with VLTI/PIONIER

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In the current era of Gaia and large, high signal to noise stellar spectroscopic surveys, there is an unmet need for a reliable library of fundamentally calibrated stellar effective temperatures based on accurate stellar diameters. Here we present a set of precision diameters and temperatures for a sample of 6 dwarf, 5 sub-giant, and 5 giant stars observed with the PIONIER beam combiner at the VLTI. Science targets were observed in at least two sequences with five unique calibration stars each for accurate visibility calibration and to reduce the impact of bad calibrators. We use the standard PIONIER data reduction pipeline, but bootstrap over interferograms, in addition to employing a Monte-Carlo approach to account for correlated errors by sampling stellar parameters, limb darkening coefficients, and fluxes, as well as predicted calibrator angular diameters. The resulting diameters were then combined with bolometric fluxes derived from broadband *Hipparcos–Tycho* photometry and MARCS model bolometric corrections, plus parallaxes from Gaia to produce effective temperatures, physical radii, and luminosities for each star observed. Our stars have mean angular diameter and temperatures uncertainties of 0.8% and 0.9% respectively, with our sample including diameters for 10 stars with no pre-existing interferometric measurements. The remaining stars are consistent with previous measurements, with the exception of a single star which we observe here with PIONIER at both higher resolution and greater sensitivity than was achieved in earlier work.

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The Isaac Newton Telescope monitoring survey of Local Group dwarf galaxies. I. Survey overview and first results for Andromeda I

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An optical monitoring survey in the nearby dwarf galaxies was carried out with the 2.5-m Isaac Newton Telescope (INT). 55 dwarf galaxies and four isolated globular clusters in the Local Group (LG) were observed with the Wide Field Camera (WFC). The main aims of this survey are to identify the most evolved asymptotic giant branch (AGB) stars and red supergiants at the end-point of their evolution based on their pulsational instability, use their distribution over luminosity to reconstruct the star formation history, quantify the dust production and mass loss from modelling the multi-wavelength spectral energy distributions, and relate this to luminosity and radius variations. In this first of a series of papers, we present the methodology of the variability survey and describe the photometric catalogue of Andromeda I (And I) dwarf galaxy as an example of the survey, and discuss the identified long period variable (LPV) stars. We detected 5581 stars and identified 59 LPV candidates within two half-light radii of the centre of And I. The amplitudes of these candidates range from 0.2 to 3 mag in the i-band. 75% of detected sources and 98% of LPV candidates are detected at mid-infrared wavelengths. We show evidence for the presence of dust-producing AGB stars in this galaxy including five extreme AGB (x-AGB) stars, and model some of their spectral energy distributions. A distance modulus of 24.41 mag for And I was determined based on the tip of the red giant branch (RGB). Also, a half-light radius of 3.2 arcmin is calculated.

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On rare core collapse supernovæ inside planetary nebulæ

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We conduct simulations of white dwarf (WD) – neutron star (NS) reverse evolution, and conclude that a core collapse supernova (CCSN) explosion might occur inside a planetary nebula (PN) only if a third star forms the PN. In the WD–NS reverse evolution the primary star evolves and transfers mass to the secondary star, forms a PN, and leaves a WD remnant. If the mass transfer brings the secondary star to have a mass of $> 8\ M_\odot$ before it develops a helium core, it explodes as a CCSN and leaves a NS remnant. Using the Modules for Experiments in Stellar Astrophysics (MESA) we find that in the reverse evolution the time period from the formation of the PN by the primary star to the explosion of the secondary star is longer than a million years. By that time the PN has long dispersed into the interstellar medium. If we start with two stars that are too close in mass to each other, then the mass transfer takes

place after the secondary star has developed a helium core and it ends forming a PN and a WD. The formation of a CCSN inside a PN (so called CCSNIP) requires the presence of a third star, either as a tertiary star in the system or as a nearby member in an open cluster. The third star should be less massive than the secondary star but by no more than few 0.01 $M_\odot$. We estimate that the rate of CCSNIP is about 0.0001 times the rate of all CCSNe.

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Fluorine in the solar neighborhood: the need for several cosmic sources

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The cosmic origin of fluorine is still not well constrained. Several nucleosynthetic channels at different phases of stellar evolution have been suggested, but these must be constrained by observations. For this, the fluorine abundance trend with metallicity spanning a wide range is required. Our aim is to determine stellar abundances of fluorine for $-1.1 <$ [Fe/H] $< +0.4$. We determine the abundances from HF lines in infrared K-band spectra ($\sim 2.3\ \mu$m) of cool giants, observed with the IGRINS and Phoenix high-resolution spectrographs. We derive accurate stellar parameters for all our observed K giants, which is important since the HF lines are very temperature sensitive. We find that [F/Fe] is flat as a function of metallicity at [F/Fe] ~ 0, but increases as the metallicity increases. The fluorine slope shows a clear secondary behavior in this metallicity range. We also find that the [F/Ce] ratio is relatively flat for $-0.6 <$ [Fe/H] < 0, and that for two metal-poor ([Fe/H] < -0.8), s-process element enhanced giants, we do not detect an elevated fluorine abundance. We interpret all these observational constraints to indicate that several major processes are at play for the cosmic budget of fluorine over time; from those in massive stars at low metallicities, through the asymptotic giant branch-star contribution at $-0.6 <$ [Fe/H] < 0, to processes with increasing yields with metallicity at super-solar metallicities. The origins of the latter, and whether or not Wolf–Rayet stars and/or novæ could contribute at super-solar metallicities, is currently not known. To quantify these observational results, theoretical modelling is required. More observations in the metal-poor region are required to clarify the processes there.

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Giants eating giants: mass loss and giant planets modifying the luminosity of the tip of the giant branch

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During the red giant phase, stars loose mass at the highest rate since birth. The mass-loss rate is not fixed, but varies from star-to-star by up to 5%, resulting in variations of the star's luminosity at the tip of the red giant branch (TRGB). Also, most stars, during this phase, engulf part of their planetary system, including their gas giant planets. Gas giant planet masses range between 0.1 to 2% of the host star mass. The engulfing of their gas giants planets can modify their luminosity at the TRGB, i.e. the point at which the He-core degeneracy is removed. We show that the increase in mass of the star by the engulfing of the gas giant planets only modifies the luminosity of a star at the TRGB by less than 0.1%, while metallicity can modify the luminosity of a star at the TRGB by up to 0.5%. However, the increase in turbulence of the convective envelope of the star, i.e. modification of the mixing length, has a more dramatic effect, on the star's luminosity, which we estimate could be as large as 5%. The effect is always in the direction to increase the turbulence and thus the mixing length which turns into a systematic decrease of the luminosity of the star at the TRGB. We find that the star-to-star variation of the mass-loss rate will dominate the variations in the luminosity of the TRGB with a contribution at the 5% level. If the star-to-star variation is driven by environmental effects – as it is reasonable to assume – the same effects can potentially create an environmentally-driven mean effect on the luminosity of the tip of the red giant branch of a galaxy. Finally, we touch upon how to infer the frequency, and identify the engulfment, of exoplanets in low-metallicity RGB stars through high resolution spectroscopy as well as how to quantify mass loss rate distributions from the morphology of the horizontal branch.

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A pulsating white dwarf in an eclipsing binary

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White dwarfs are the burnt out cores of Sun-like stars and are the final fate of 97 per cent of all stars in our Galaxy. The internal structure and composition of white dwarfs are hidden by their high gravities, which causes all elements, apart from the lightest ones, to settle out of their atmospheres. The most direct method to probe the inner structure of stars and white dwarfs in detail is via asteroseismology. Here we present the first known pulsating white dwarf in an eclipsing binary system, enabling us to place extremely precise constraints on the mass and radius of the white dwarf from the light curve, independent of the pulsations. This 0.325 $M_\odot$ white dwarf – one member of SDSS J115219.99+024814.4 – will serve as a powerful benchmark to constrain empirically the core composition of low-mass stellar remnants and investigate the effects of close binary evolution on the internal structure of white dwarfs.

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Detailed abundances in the Galactic center: evidence of a metal-rich alpha-enhanced stellar population

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We present a detailed study of the composition of 20 M giants in the Galactic center with 15 of them confirmed to be in the nuclear star cluster. As a control sample we have also observed 7 M giants in the Milky Way disk with similar stellar parameters. All 27 stars are observed using the NIRSPEC spectrograph on the KECK II telescope in the K-band at a resolving power of $R = 23,000$. We report the first silicon abundance trends versus [Fe/H] for stars in the Galactic center. While finding a disk/bulge like trend at subsolar metallicities, we find that [Si/Fe] is enhanced at supersolar metallicities. We speculate on possible enrichment scenarios to explain such a trend. However, the sample size is modest and the result needs to be confirmed by additional measurements of silicon and other α-elements. We also derive a new distribution of [Fe/H] and find the most metal rich stars at [Fe/H] = +0.5 dex, confirming our earlier conclusions that the Galactic center hosts no stars with extreme chemical compositions.

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Facing the problems on the determination of stellar temperatures and gravities: Galactic globular clusters

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We analysed red giant branch stars in 16 Galactic globular clusters, computing their atmospheric parameters both from the photometry and from excitation and ionisation balances. The spectroscopic parameters are lower than the photometric ones and this discrepancy increases decreasing the metallicity, reaching, at [Fe/H] ~ -2.5 dex, differences of ~ 350 K in effective temperature and ~ 1 dex in surface gravity. We demonstrate that the spectroscopic parameters are inconsistent with the position of the stars in the colour–magnitude diagram, providing too low temperatures and gravities, and predicting that the stars are up to about 2.5 magnitudes brighter than the observed magnitudes. The parameter discrepancy is likely due to the inadequacies of the adopted physics, in particular the assumption of 1-dimensional geometry can be the origin of the observed slope between iron abundances and excitation potential that leads to low temperatures. However, the current modelling of 3D/NLTE radiative transfer for giant stars seems to be not able to totally erase this slope. We conclude that the spectroscopic parameters are wrong for metallicity lower than -1.5 dex and for these red giant stars photometric temperatures and gravities should be adopted. We provide a simple relation to correct the spectroscopic temperatures in order to put them onto a photometric scale.

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Spectral signatures of H-rich material stripped from a non-degenerate companion by a Type Ia supernova

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The single-degenerate scenario for Type Ia supernovæ (SNe Ia) should yield metal-rich ejecta that enclose some stripped material from the non-degenerate H-rich companion star. We present a large grid of non-local thermodynamic equilibrium steady-state radiative transfer calculations for such hybrid ejecta and provide analytical fits for the Hα luminosity and equivalent width. Our set of models covers a range of masses for ^{56}Ni and the ejecta, for the stripped material ($M_{\rm st}$), and post-explosion epochs from 100 to 300 d. The brightness contrast between stripped material and metal-rich ejecta challenges the detection of H I and He I lines prior to $\sim$ 100 d. Intrinsic and extrinsic optical depth effects also influence the radiation emanating from the stripped material. This inner denser region is marginally thick in the continuum and optically thick in all Balmer lines. The overlying metal-rich ejecta blanket the inner regions, completely below about 5000 Å, and more sparsely at longer wavelengths. As a consequence, Hβ should not be observed for all values of $M_{\rm st}$ through at least 300 days, while Hα should be observed after $\sim$ 100 d for all $M_{\rm st} \geq 0.01$ M$_\odot$. Observational non-detections capable of limiting the Hα equivalent width to < 1 Å set a formal upper limit of $M_{\rm st} < 0.001$ M$_\odot$. This contrasts with the case of circumstellar (CSM) interaction, not subject to external blanketing, which should produce Hα and Hβ lines with a strength dependent primarily on CSM density. We confirm previous analyses that suggest low values of order 0.001 M$_\odot$ for $M_{\rm st}$ to explain the observations of the two SNe Ia with nebular-phase Hα detection, in conflict with the much greater stripped mass predicted by hydrodynamical simulations for the single-degenerate scenario. A more likely solution is the double-degenerate scenario, together with CSM interaction, or enclosed material from a tertiary star in a triple system or from a giant planet.

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SiO maser astrometry of the red transient V838 Monocerotis

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We present multiepoch observations with the Very Long Baseline Array (VLBA) of SiO maser emission in the $v = 1$, $J = 1$–0 transition at 43 GHz from the remnant of the red nova V838 Mon. We modeled the positions of maser spots to derive a parallax of 0.166 ± 0.060 mas. Combining this parallax with other distance information results in a distance of 5.6 ± 0.5 kpc, which is in agreement with an independent geometric distance of 6.1 ± 0.6 kpc from modeling polarimetry images of V838 Mon's light echo. Combining these results, and including a weakly constraining Gaia parallax, yields a best estimate of distance of 5.9 ± 0.4 kpc. The maser spots are located close to the peaks of continuum at $\sim$ 225 GHz and SiO $J = 5$–4 thermal emission detected with the Atacama Large (sub)Millimeter Array (ALMA). The proper motion of V838 Mon confirms its membership in a small open cluster in the Outer spiral arm of the Milky Way.

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Fornax 3D project: Automated detection of planetary nebulæ in the centres of early-type galaxies and first results

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Extragalactic planetary nebulæ (PNe) are detectable through relatively strong nebulous [O III] emission and act as direct probes into the local stellar population. Because they have an apparently universal invariant magnitude cut-off, PNe are also considered to be a remarkable standard candle for distance estimation. Through detecting PNe within the galaxies, we aim to connect the relative abundances of PNe to the properties of their host galaxy stellar population. By removing the stellar background components from FCC 167 and FCC 219, we aim to produce PN luminosity functions (PNLF) of these galaxies, and thereby also estimate the distance modulus to these two systems. Finally, we test the reliability and robustness of our novel detection and analysis method. It detects unresolved point sources by their [O III] 5007Å emission within regions that have previously been unexplored. We model the [O III] emissions in the spatial and spectral dimensions together, as afforded to us by the Multi Unit Spectroscopic Explorer (MUSE), and we draw on data gathered as part of the Fornax3D survey. For each source, we inspect the properties of the nebular emission lines to remove other sources that might hinder the safe construction of the PNLF, such as supernova remnants and H II regions. As a further step, we characterise any potential limitations and draw conclusions about the reliability of our modelling approach through a set of simulations. By applying this novel detection and modelling approach to integral field unit observations, we report for the distance estimates and luminosity-specific PNe frequency values for the two galaxies. Furthermore, we include an overview of source contamination, galaxy differences, and possible effects on the PNe populations in the dense stellar environments.

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Evolving grain-size distributions embedded in gas flows

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We present a numerical approach for accurately evolving a dust grain-size distribution undergoing number-conserving (such as sputtering) and/or mass-conserving (such as shattering) processes. As typically observed interstellar dust distributions follow a power-law, our method adopts a power-law discretisation and uses both the grain mass and number densities in each bin to determine the power-law parameters. This power-law method is complimentary to piecewise-constant and linear methods in the literature. We find that the power-law method surpasses the other two approaches, especially for small bin numbers. In the sputtering tests the relative error in the total grain mass remains below 0.01 per cent independent of the number of bins N, while the other methods only achieve this for $N > 50$ or higher. Likewise, the shattering test shows that the method also produces small relative errors in the total grain numbers while conserving mass. Not only does the power-law method conserve the global distribution properties, it also preserves the inter-bin characteristics so that the shape of the distribution is recovered to a high degree. This does not always happen for the constant and linear methods, especially not for small bin numbers. Implementing the power-law method in a hydrodynamical code thus minimises the numerical cost whilst maintaining high accuracy. The method is not limited to dust grain distributions, but can also be applied to the evolution of any distribution function, such as a cosmic-ray distribution affected by synchrotron radiation or inverse-Compton scattering.

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Stellar wind models of central stars of planetary nebulæ

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Fast line-driven stellar winds play an important role in the evolution of planetary nebulæ, even though they are relatively weak. We provide global (unified) hot star wind models of central stars of planetary nebulæ. The models predict wind structure including the mass-loss rates, terminal velocities, and emergent fluxes from basic stellar parameters. We applied our wind code for parameters corresponding to evolutionary stages between the asymptotic giant branch and white dwarf phases for a star with a final mass of 0.569 $M_\odot$. We study the influence of metallicity and wind inhomogeneities (clumping) on the wind properties. Line-driven winds appear very early after the star leaves the asymptotic giant branch (at the latest for $T_{\rm eff} \approx 10$ kK) and fade away at the white dwarf cooling track (below $T_{\rm eff} = 105$ kK). Their mass-loss rate mostly scales with the stellar luminosity and, consequently, the mass-loss rate only varies slightly during the transition from the red to the blue part of the Hertzsprung–Russell diagram. There are the following two exceptions to the monotonic behavior: a bistability jump at around 20 kK, where the mass-loss rate decreases by a factor of a few (during evolution) due to a change in iron ionization, and an additional maximum at about $T_{\rm eff} = 40$–50 kK. On the other hand, the terminal velocity increases from about a few hundreds of km s^{-1} to a few thousands of km s^{-1} during the transition as a result of stellar radius decrease. The wind terminal velocity also significantly increases at the bistability jump. Derived wind parameters reasonably agree with observations. The effect of clumping is stronger at the hot side of the bistability jump than at the cool side. Derived fits to wind parameters can be used in evolutionary models and in studies of planetary nebula formation. A predicted bistability jump in mass-loss rates can cause the appearance of an additional shell of planetary nebula.

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Integral field spectroscopy of planetary nebulæ with MUSE

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The Multi-Unit Spectroscopic Explorer (MUSE) is a large integral field unit mounted on the ESO Very Large Telescope.

Its spatial (60 arcsecond field) and wavelength (4800–9300 Å) coverage is well suited to detailed imaging spectroscopy of extended planetary nebulæ, such as in the Galaxy. An overview of the capabilities of MUSE applied to planetary nebulæ (PNe) is provided together with the specific advantages and disadvantages. Some examples of archival MUSE observations of PNe are provided. MUSE datacubes for two targets (NGC 3132 and NGC 7009) have been analysed in detail and they are used to show the advances achievable for planetary nebula studies. Prospects for further MUSE observations of PNe and a broader analysis of existing datasets are outlined.

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Common dynamo scaling in slowly rotating young and evolved stars

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One interpretation of the activity and magnetism of late-type stars is that these both intensify with decreasing Rossby number up to a saturation level, suggesting that stellar dynamos depend on both rotation and convective turbulence. Some studies have claimed, however, that rotation alone suffices to parametrise this scaling adequately. Here, we tackle the question of the relevance of turbulence to stellar dynamos by including evolved, post main sequence stars in the analysis of the rotation-activity relation. These stars rotate very slowly compared with main sequence stars, but exhibit similar activity levels. We show that the two evolutionary stages fall together in the rotation-activity diagram and form a single sequence in the unsaturated regime in relation only to Rossby numbers derived from stellar models, confirming earlier preliminary results that relied on a more simplistic parametrisation of the convective turnover time. This mirrors recent results of fully convective M dwarfs, which likewise fall on the same rotation-activity sequence as partially convective solar-type stars. Our results demonstrate that turbulence plays a crucial role in driving stellar dynamos and suggest that there is a common turbulence-related dynamo mechanism explaining the magnetic activity of all late-type stars.

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Abundance analyses of Li-enriched and normal giants in the GALAH survey

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Compositions of lithium-enriched and normal giants among the GALAH survey are compared. Except for Li, the only detectable abundance difference between lithium-enriched and normal giants among the investigated elements from carbon to europium occurs for carbon. Among Li-rich giants with $A(\mathrm{Li}) = 1.8$ to 3.1, the C deficiency is very similar to that reported for the normal giants (with $A(\mathrm{Li}) < 1.8$) where the slight C deficiency arises from the first dredge-up. Carbon is slightly under abundant relative to normal giants among the super Li-rich giants where the Li abundance exceeds $A(\mathrm{Li}) = 3.2$. The C abundance as well as the $^{12}\mathrm{C}/^{13}\mathrm{C}$ ratios from the literature suggest that the addition of Li to create a Li-rich giant may occur independently of the abundance changes wrought by the first dredge-up. Creation of a super Li-rich giant, however, appears to occur with additional CN-cycle conversion of C to N. The probability of

becoming a Li-rich giant is approximately independent of a star's mass, although the majority of the Li-rich giants are found to be low mass ($M \leq 2$ M$_\odot$). The frequency of occurrence of Li-enriched giants among normal giants is about one percent and slightly dependent on metallicity ([Fe/H]). Li-enriched and normal giants are found to have similar projected rotational velocity which suggests that Li-enrichment in giants is not linked to scenarios such as mergers and tidal interaction between binary stars.

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Evolutionary models for 43 Galactic supernova remnants with distances and X-ray spectra

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The X-ray emission from a supernova remnant (SNR) is a powerful diagnostic of the state of the shocked plasma. The temperature (kT) and the emission measure (EM) of the shocked-gas are related to the energy of the explosion, the age of the SNR, and the density of the surrounding medium. Progress in X-ray observations of SNRs has resulted in a significant sample of Galactic SNRs with measured kT and EM values. We apply spherically symmetric SNR evolution models to a new set of 43 SNRs to estimate ages, explosion energies, and circumstellar medium densities. The distribution of ages yields a SNR birth rate. The energies and densities are well fit with log-normal distributions, with wide dispersions. SNRs with two emission components are used to distinguish between SNR models with uniform ISM and with stellar wind environment. We find type Ia SNRs to be consistent with a stellar wind environment. Inclusion of stellar wind SNR models has a significant effect on estimated lifetimes and explosion energies of SNRs. This reduces the discrepancy between the estimated SNR birthrate and the SN rate of the Galaxy.

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Searching for globular cluster chemical anomalies on the main sequence of a young massive cluster

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The spectroscopic and photometric signals of the star-to-star abundance variations found in globular clusters seem to be correlated with global parameters like the cluster's metallicity, mass and age. Understanding this behaviour could bring us closer to the origin of these intriguing abundance spreads. In this work we use deep HST photometry to look for evidence of abundance variations in the main sequence of a young massive cluster NGC 419 ($\sim 10^5$ M$_\odot$, ~ 1.4 Gyr). Unlike previous studies, here we focus on stars in the same mass range found in old globulars ($\sim$ 0.75–1

$M_\odot$), where light elements variations are detected. We find no evidence for N abundance variations among these stars in the $Un–B$ and $U–B$ CMD of NGC 419. This is at odds with the N-variations found in old globulars like 47 Tuc, NGC 6352 and NGC 6637 with similar metallicity to NGC 419. Although the signature of the abundance variations characteristic of old globulars appears to be significantly smaller or absent in this young cluster, we cannot conclude if this effect is mainly driven by its age or its mass.

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Revealing new features of the millimetre emission of the circumbinary envelope of Mira Ceti

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We study the morpho-kinematics of the circumbinary envelope of Mira Ceti between $\sim$ 100 and $\sim$ 350 au from the stars using ALMA observations of the SiO (ν = 0, J = 5–4) and CO (ν = 0, J = 3–2) emissions with the aim of presenting an accurate and reliable picture of what cannot be ignored when modelling the dynamics at stake. A critical study of the uncertainties attached to imaging is presented. The line emissions are shown to be composed of a few separated fragments. They are described in detail and plausible interpretations of their genesis are discussed. Evidence for a focusing effect of the Mira A wind by Mira B over the past century is presented; it accounts for only a small fraction of the overall observed emission but its accumulation over several orbital periods may have produced an enhancement of CO emission in the orbital plane of Mira B. We identify a south–western outflow and give arguments for the anti-correlation observed between CO and SiO emissions being the result of a recent mass ejection accompanied by a shock wave. We discuss the failure of simple scenarios that have been proposed earlier to explain some of the observed features and comment on the apparent lack of continuity between the present observations and those obtained in the close environment of the stars. Evidence is obtained for the presence of large Doppler velocity components near the line of sight aiming to the star, possibly revealing the presence of important turbulence at $\sim$ 5 to 10 au away from Mira A.

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Rings and arcs around evolved stars – II. The carbon star AFGL 3068 and the planetary nebulæ NGC 6543, NGC 7009 and NGC 7027

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We present a detailed comparative study of the arcs and fragmented ring-like features in the haloes of the planetary nebulæ (PNe) NGC 6543, NGC 7009, and NGC 7027 and the spiral pattern around the carbon star AFGL 3068 using high-quality multi-epoch HST images. This comparison allows us to investigate the connection and possible evolution between the regular patterns surrounding AGB stars and the irregular concentric patterns around PNe. The radial proper motion of these features, $\sim$ 15 km s^{-1}, are found to be consistent with the AGB wind and their linear sizes and inter-lapse times (500–1900 yr) also agree with those found around AGB stars, suggesting a common origin. We find evidence using radiative hydrodynamic simulations that regular patterns produced at the end of the AGB phase

become highly distorted by their interactions with the expanding PN and the anisotropic illumination and ionization patterns caused by shadow instabilities. These processes will disrupt the regular (mostly spiral) patterns around AGB stars, plausibly becoming the arcs and fragmented rings observed in the haloes of PNe.

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Conference Papers

Modeling the formation of the ^{13}C neutron source in AGB stars

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A major source of uncertainty in AGB models is the partial-mixing process of hydrogen, required for the formation of the so-called ^{13}C pocket. Among the attempts to derive a self-consistent treatment of this physical process, there are 2D and 3D simulations of magnetic buoyancy. The ^{13}C pocket resulting from mixing induced by magnetic buoyancy extends over a region larger than those so far assumed, showing an almost flat ^{13}C distribution and a negligible amount of ^{14}N. Recently, it has been proved to be a good candidate to match the records of isotopic abundance ratios of s-elements in presolar SiC grains. However, up to date such a magnetic mixing has been applied in post-process calculations only, being never implemented in a stellar evolutionary code. Here we present new stellar models, performed with the 1-d hydrostatic FUNS evolutionary code, which include magnetic buoyancy. We comment the resulting s-process distributions and show preliminary comparisons to spectroscopic observations and pre-solar grains measurements.

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Molecular hydrogen microstructures in planetary nebulæ

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Molecular hydrogen (H_2) emission is commonly detected in planetary nebulæ (PNe), specially in objects with bipolar morphologies. New studies showed that H_2 gas is also packed in microstructures embedded in PNe of any morphological type. Despite the presence of H_2 in cometary knots being known for years, only in the last five years, much deeper imagery of PNe have revealed that H_2 also exists in other types of low-ionisation microstructures (LISs). Significant differences are found between the host PNe of cometary knots and other types of LISs, such as nebula age, central star temperature (evolutionary stage) and the absolute sizes of the microstructure itself.

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X-ray observations of planetary nebulæ since WORKPLANS I and beyond

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Planetary nebulæ (PNe) were expected to be filled with hot pressurized gas driving their expansion. ROSAT hinted at the presence of diffuse X-ray emission from these hot bubbles and detected the first sources of hard X-ray emission from their central stars, but it was not until the advent of *Chandra* and XMM–*Newton* that we became able to study in detail their occurrence and physical properties. Here I review the progress in the X-ray observations of PNe since the first WORKshop for PLAnetary Nebulæ observationS (WORKPLANS) and present the perspective for future X-ray missions with particular emphasis on eROSITA.

Oral contribution, published in "WORKshop for PLAnetary Nebulæ observationS II"
Available from https://arxiv.org/abs/2003.06176

Review Paper

Binary central stars of planetary nebulæ

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It is now clear that a vast majority of intermediate-mass stars have stellar and/or sub-stellar companions, therefore it is no longer appropriate to consider planetary nebulæ as a single-star phenomenon, although some single, isolated stars may well lead to planetary nebulæ. As such, while understanding binary evolution is critical for furthering our knowledge of planetary nebulæ, the converse is also true: planetary nebulæ can be valuable tools with which to probe binary evolution. In this brief review, I attempt to summarise some of our current understanding with regards to the role of binarity in the formation of planetary nebulæ, and the areas in which continued study of planetary nebulæ may have wider ramifications for our grasp on the fundaments of binary evolution.

Published in Galaxies Special Issue "Workplans II: Workshop for Planetary Nebula Observations"
Available from https://www.mdpi.com/2075-4434/8/2/28

Job Advert

Ph.D. students in theoretical astrophysics
Winds of cool giant stars and red supergiants

Applications are invited for 2 Ph.D. student positions in theoretical astrophysics at the Department of Physics and Astronomy, Uppsala University, Sweden.

Project description: Evolved stars play a crucial role for the cosmic matter cycle and the origin of life. Critical chemical elements, like carbon, are produced inside luminous cool giant stars, transported to the surface by turbulent gas flows, and ejected into interstellar space by massive outflows of gas and dust. The current knowledge of stellar winds is incomplete, and does not allow us to fully understand their effects on the evolution of stars, and how they enrich their surroundings with newly produced elements and cosmic dust. Project EXWINGS, funded by an ERC Advanced Grant, aims at a breakthrough in understanding the winds of cool giant and supergiant stars by developing a new type of models: global dynamical star-and-wind-in-a-box simulations, in full 3D geometry. Astronomical instruments with high spatial resolution, which give images of the stellar atmospheres where the winds originate, will allow us to test the new models.

The Ph.D. students will work together with Susanne Höfner, Bernd Freytag, and other EXWINGS team members on producing and testing a new generation of wind models for AGB stars, comparing them to state-of-the-art observations, and deriving a new description of mass loss, based on first principles, which can be applied in stellar evolution models. Extending the new modelling approach to the warmer, more luminous red supergiant stars, the mechanisms which drive their still enigmatic winds will be explored. More information on project EXWINGS and the stellar winds research group at Uppsala University can be found at
https://www.physics.uu.se/research/research-funding/european-researchcouncil/exwings/
and https://www.physics.uu.se/research/astronomy-and-spacephysics/research/stars/Stellar+winds/

The positions are 4-year appointments and require a university degree in Astronomy or Physics at an advanced level (e.g., a M.Sc. degree), completed by the time of employment. The earliest starting date is 1 September 2020. Applications should include a brief description of research interests and relevant experience, CV, copies of university grades, certificates and diplomas, B.Sc./M.Sc. thesis (or draft thereof), and contact details for at least one reference person. Practical experience with numerical simulations of gas dynamics, or with observational data on AGB and RSG stars, will be considered a merit.

The official announcement and the link to the online application system will be posted at
https://www.physics.uu.se/aboutus/available-positions/ in early May and the application deadline is 1 June 2020. For further information, please contact Susanne Höfner (susanne.hoefner@physics.uu.se).

See also https://www.physics.uu.se/aboutus/available-positions/

Announcement

EAS 2020 VIRTUAL meeting
Abstract submission reopened, deadline May 3rd

Dear colleague,

due to the COVID-19 pandemic, the European Astronomical Society (EAS) 2020 meeting will move to a virtual meeting with attendance fees of 80 EUR (50 EUR for one-day attendance).

The Abstract Portal has been re-opened to collect new submissions both for Virtual Talk Contribution and e-posters, with deadline May 3rd and notification of acceptance by Mid May.

With this, we would like to invite submissions for our Special Session ”The Molecular Journey: from stars to disks”

Aim & scope
In this special session we will focus on the study of molecules and their isotopologues and what they can teach us about the journey of molecules in our Galaxy. The scope is to bring the community together to showcase molecular insights in the evolution of matter from old stars to the ISM and into newly formed planets, to highlight recent advances in molecular astrophysics, to design strategies to best exploit the new astronomical facilities, and to provide fertile ground for future, interdisciplinary collaborations.

Topics

- Molecules & Stellar Ejecta
- The molecular ISM & Star Formation
- Molecules & Protoplanetary Disks (and exoplanets)

Limited financial support may be available for early career researchers (Ph.D students and postdocs). For information and/or questions: a.candian@uva.nl

On behalf of the SOC
Alessandra Candian (UvA)
Annemieke Petrignani (UvA)
Marie Van de Sande (KU Leuven)
Serena Viti (UCL/Leiden)
Tom Millar (QUB)
Francesco Fontani (INAF)

See also https://eas.unige.ch/EAS2020/session.jsp?id=SS11