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Editorial

Dear Colleagues,

It is a pleasure to present you the 242nd issue of the AGB Newsletter.

You will no doubt remember Mike Jura’s life having come to an end last year. Christine Chen, Mark Morris and Ben Zuckerman kindly wrote a beautiful obituary, reflecting on the scientist and the person Mike was – and continues to be.

Also take note of the Subaru telescope meeting to promote its use for the study of Planetary Nebulae.

Last month’s Food for Thought (“Planetary Nebulae are cool – or hot?”) generated a response about language and culture. True. Though the provocative statement was also meant seriously, regarding the physics of PNe. The central star is hot, and so is the radiation field, ionising the circumstellar medium. But there is often cold dust in the outskirts, and sometimes molecular hydrogen skirting around the star. So there are cool places in the hot nebula, too. We’d welcome further discussion on this topic.

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

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

Food for Thought

This month’s thought-provoking statement is:

What do the surface abundances of white dwarfs tell us about the planets that orbited its progenitor Sun?

Reactions to this statement or suggestions for next month’s statement can be e-mailed to astro.agbnews@keele.ac.uk (please state whether you wish to remain anonymous)
A tribute to Mike Jura

Michael Alan Jura, outstanding astrophysicist and a human being concerned about the future of humanity and our planet, died in Los Angeles on 31 January 2016, as a consequence of a rare neuromuscular disease.

Michael was born in Oakland, California on 11 September 1947. After obtaining his bachelor’s degree in physics from UC Berkeley in 1967, Michael moved across the country to pursue a PhD degree in astronomy at Harvard University. His early papers, a few written in collaboration with his thesis advisor Alex Dalgarno, but mostly as sole author, focused on the theory of the diffuse phases of the interstellar medium. Already at the outset of his career, Michael established a pattern of sole authorship that characterized his research career to the very end. This is quite unusual given that sole authorship in astronomical research has become almost a lost art.

Michael's PhD degree, received in 1971, was followed by a two-year stint in the army. He then went to Princeton as a postdoctoral scholar and then to UCLA in 1974 as an assistant professor where he remained for the rest of his career. It is safe to say he had more influence on building UCLA Astronomy to its prominent position today than anyone else in the history of the department.

Michael's early, fundamental papers describe the formation, destruction, and excitation of interstellar molecular hydrogen that is, along with atomic hydrogen, the dominant constituent of the interstellar medium. These papers are still regularly cited more than 40 years after publication. More generally, during the 1970s Michael’s principal research interests were the gas and dust in the interstellar medium of our Milky Way Galaxy and of other galaxies.

Beginning in the mid-1970s, Michael’s focus shifted toward mass loss from giant stars about which, over a period spanning 32 years, he published ~70 papers. His expertise on dust properties and dust emissivity served him well, as he used the infrared spectral energy distributions of evolved stars to draw inferences about the role of dust in driving their winds, about the return by those winds of nucleosynthetically enriched material to the interstellar medium, and about the long-term evolution of the mass-loss rate of many individual stars and classes of stars.

One of Michael’s most lasting contributions has been, and will continue to be, his use of infrared all-sky surveys to systematically characterize the lifetimes, space densities, and mass-loss characteristics of red giants of all types. Using catalogues resulting from the Two Micron Sky Survey and the IRAS survey, as well as optical catalogues, he and his collaborators published a series of landmark papers on the winds and circumstellar environments of all the important classes of long-period variable stars and evolved stars having high mass-loss rates, including Mira
variables, carbon stars, S stars, semi-regular variables, irregular variables, and RV Tauri stars. All these categories, and in general, evolved stars having enough circumstellar dust to display strong infrared excesses, are asymptotic giant branch (AGB) stars. Michael also investigated whether first-ascent red giants could form significant amounts of dust, and concluded that, while some such stars do have a substantial abundance of circumstellar dust, that dust can be attributed to the inevitable disintegration of comets that must occur as the stellar luminosity rises.

Other categories of evolved stars that Michael investigated individually with dedicated papers include red supergiants such as VY CMa, NML Cyg, HD179821 and α Ori, as well as bipolar nebulae, including AFGL 2688, the Red Rectangle, OH231.8+4.2, V Hya and the young planetary NGC7027.

In his extensive work on carbon stars, Michael was able to conclude from his flux-limited samples that the progenitors of such stars typically have masses in the range from 1.2 to 1.6 solar masses, and that the duration of the C-star evolutionary phase is $10^5$ to $10^6$ years. He found that the amorphous carbon dust that forms at the base of a carbon star wind is accelerated by stellar radiation and drives the wind via momentum coupling, to the extent that essentially all the initial photon momentum from the star is transferred to the wind. This leads in many cases to very dusty winds with high mass loss rates. Indeed, Michael concluded that the carbon stars with the highest mass loss rates are responsible for half of the mass returned locally by AGB stars to the interstellar medium. Far more numerous oxygen-rich AGB stars are responsible for the other half. Michael’s work confirmed that carbon stars constitute an increasingly large fraction of all AGB stars with increasing distance from the Galactic center because of the metallicity-dependence of the C/O abundance ratio in AGB star atmospheres, coupled with the decline of metallicity at increasing galactocentric radii. He noted that the relative importance of C-star mass loss for the chemical enrichment of the interstellar medium therefore increases with distance from the Galactic center.

Michael’s investigations of S stars, which represent a spectroscopically intermediate stage between carbon stars and oxygen-rich AGB stars, led him to conclude that they are distributed like carbon stars, and that their dust properties are more like those of carbon stars than oxygen-rich stars. He concluded that S stars represent a slightly different evolutionary stage of the same population of stars as C stars, but with lower mass loss rates, so that their contribution of mass return to the interstellar medium is only about 10% that of C stars.

In addition to drawing broad conclusions about the mass loss characteristics of various classes of stars, Michael’s work on the circumstellar environments of evolved stars included studies of photochemistry, dust formation and growth, accretion onto binary companions, systems having bound, dusty disks, and elemental and isotopic abundances.
By the early 1990’s, Michael’s scientific interests began to shift toward extrasolar planetary systems that orbit main-sequence stars. His focus was on dusty debris disks; these are the observational manifestations of the collisional destruction of Kuiper Belt and asteroid-like objects. This was Michael’s first serious encounter with extrasolar asteroids; as described below, his later world-leading investigations of asteroids orbiting white dwarf stars led to an asteroid – 6406 Mikejura – being named in his honor.

Michael identified the dustiest main sequence A-type star in the IRAS catalog, the iconic HR 4796A. His series of papers laying out the HR 4796 planetary system architecture and the properties of its constituent grains served as an essential guide for those entering the field on how to think about debris disks. Michael demonstrated the decay of small-body populations via collisional grinding by examining the infrared excess properties of A-type stars in the Bright Star Catalog. He was an early proponent of the role of stellar winds in clearing debris disks around low mass (M-type) stars and young solar-like stars.

Because of his wide-ranging astronomical expertise, Michael was heavily involved in the design of various NASA space missions. Already in 1976, as a young Assistant Professor, he was invited to join a Goddard Space Flight Center proposal team led by Jack Brandt as a Co-Investigator to help develop a concept for a first-generation Hubble Space Telescope instrument, the then High-Resolution Spectrograph. Blair Savage recruited Michael to write a chapter describing the interstellar medium (ISM) science case. His chapter was so excellent that the proposal team put it at the beginning of the proposal with no changes. Indeed, the Goddard High Resolution Spectrograph was selected over other possible science instruments in no small part because the ISM science case was so strong. Subsequently, in 1984, Michael was selected to be an Interdisciplinary Scientist planning for the then Space Infrared Telescope Facility that later morphed into the fabulously successful Spitzer Space Telescope that is still operational today.

In the mid-2000s Michael’s principal research interest shifted from planetary systems around main-sequence stars and giant stars to planetary systems that orbit white dwarf stars – these represent the final stage of stellar evolution for most stars. During the last decade of his life Michael devoted almost all of his research efforts to the study of white dwarfs that are accreting minor planets (mostly asteroid analogs) from their surrounding planetary systems. Michael demonstrated that the consequent “pollution” of white dwarf atmospheres provides an exceptionally sensitive method for studying the compositions of rocky planets in extrasolar planetary systems. The information so gathered is not accessible to other astronomical techniques, and was completely unanticipated. We think that Michael found this combination of surprise and sensitivity to be supremely attractive and thus his love for, and total devotion to, such research. Arguably, Michael has contributed more to our understanding of white dwarf planetary systems – and what such systems can tell us about all planetary systems including our own – than anyone else in astronomy.
Michael’s nature as a sensitive, caring person was manifested in many ways. His concern for and encouragement of his peers, junior colleagues, and students was remarked upon over and over by participants in a September 2016 scientific symposium held at UCLA in his honor. Michael was also deeply concerned about the damage our species is doing to the biosphere. At a personal level he walked the walk. He and his wife Martha were early adopters of solar PV panels and an electric car and they early-on removed thirsty plants from their outside yard. Michael walked and used public transportation whenever possible – he was expert on getting around Los Angeles on buses and trains. Michael’s departmental website included an “Energy” component where he gave qualitative and quantitative advice to anyone who happened to log on. For years he argued for implementation of more environmentally friendly measures on the UCLA campus. Michael taught a wide variety of astronomy and physics courses, as well as environmental/energy courses. He is greatly missed by his colleagues at UCLA and around the world.

Mike Jura 1947 – 2016

Christine Chen
Space Telescope Science Institute
Baltimore

Mark Morris
Ben Zuckerman
UCLA
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Referred Journal Papers

The kinematical behaviour of ORLs and CELs in Galactic PNe

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The kinematics of the plasma in 14 PNe is analysed by measuring the expansion velocities (v_{exp}) of different ions as derived from their collisionally excited lines (CELs) and optical recombination lines (ORLs). v_{exp} are analysed as a function of the ionisation potential of ions that at first approximation represents the distance of the ion to the central star. In most cases the kinematics of ORLs is incompatible with the kinematics of CELs at the same ionisation potential, specially if CELs and ORLs of the same ion are considered. In general v_{exp} from ORLs is lower than v_{exp} from CELs indicating that, if the gas is in ionisation equilibrium, ORLs are emitted by a gas located closer to the central star. The velocity field derived from CELs shows a gradient accelerating outwards as predicted from hydrodynamic modelling of PNe ionisation structures. The velocity field derived from ORLs is different, in many cases the velocity gradient is flatter or non-existent and high and low ionised species present nearly the same v_{exp}. In addition, the FWHM/ORLs) is usually smaller that the FWHM(CELs). Our interpretation is that ORLs are mainly emitted by a plasma that coexists with the plasma emitting CELs, but does not fit the ionisation structures predicted by models. Such a plasma should have been ejected in a different event that the plasma emitting CELs.

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Observations of the ultraviolet-bright star Y 453 in the globular cluster M 4 (NGC 6121)

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We present a spectral analysis of the UV-bright star Y 453 in M4. Model fits to the star’s optical spectrum yield T_{eff} ≈ 56,000 K. Fits to the star’s FUV spectrum, obtained with the Cosmic Origins Spectrograph (COS) on board the Hubble Space Telescope, reveal it to be considerably hotter, with T_{eff} ≈ 72,000 K. We adopt T_{eff} = 72,000±2000 K and log g = 5.7 ± 0.2 as our best-fit parameters. Scaling the model spectrum to match the star’s optical and near-infrared magnitudes, we derive a mass \( M_\star = 0.53 ± 0.24 \, M_\odot \) and luminosity \( \log L/L_\odot = 2.84 ± 0.05 \), consistent with the values expected of an evolved star in a globular cluster. Comparing the star with post-horizontal branch evolutionary tracks, we conclude that it most likely evolved from the blue horizontal branch, departing the AGB before third dredge-up. It should thus exhibit the abundance pattern (O-poor and Na-rich) characteristic of the second-generation (SG) stars in M4. We derive the star’s photospheric abundances of He, C, N, O, Si, S, Ti, Cr, Fe, and Ni. CNO abundances are roughly 0.25 dex greater than those of the cluster’s SG stars, while the Si and S abundances agree match the cluster values. Abundances of the iron-peak elements (except for iron itself) are enhanced by 1 to 3 dex. Rather than revealing the star’s origin and evolution, this pattern reflects the combined effects of diffusive and mechanical processes in the stellar atmosphere.

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How much mass and angular momentum can the progenitors of carbon-enriched stars accrete?

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The chemically peculiar barium stars, CH stars, and most CEMP stars are all believed to be the products of mass transfer in binary systems from a now extinct AGB primary star. The mass of the AGB star and the orbital parameters of the system are the key factors usually considered when determining how much mass is transferred onto the lower-mass main-sequence companion. What is usually neglected, however, is the angular momentum of the accreted material, which should spin up the accreting star. If the star reaches critical rotation, further accretion should cease until the excess angular momentum is somehow dealt with. If the star cannot redistribute or lose the angular momentum while the primary is on the AGB, the amount of mass accreted could be much lower than otherwise expected. Here we present calculations, based on detailed stellar evolution models, of the mass that can be accreted by putative progenitors of Ba and CEMP stars before they reach critical rotation under the assumption that no angular momentum loss occurs during the mass transfer. We consider different accretion rates and values of specific angular momentum. The most stringent limits on the accreted masses result from considering accretion from a Keplerian accretion disk, which is likely present during the formation of most extrinsically-polluted carbon-enriched stars. Our calculations indicate that in this scenario only \(\sim 0.05\, M_\odot\) of material can be added to the accreting star before it reaches critical rotation, which is much too low to explain the chemical enrichment of many Ba and CEMP stars. Either the specific angular momentum of the accreted material has to effectively be lower by about a factor of ten than the Keplerian value, or significant angular momentum losses must occur for substantial accretion to take place.

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Rotational mixing in carbon-enhanced metal-poor stars with \(s\)-process enrichment

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Carbon-enhanced metal-poor stars with \(s\)-process enrichment (CEMP-\(s\)) are believed to be the products of mass transfer from an AGB companion, which has long since become a white dwarf. The surface abundances of CEMP-\(s\) stars are thus commonly assumed to reflect the nucleosynthesis output of the first AGB stars. We have previously shown that, for this to be the case, some physical mechanism must counter atomic diffusion in these nearly fully radiative stars, which otherwise leads to surface abundance anomalies clearly inconsistent with observations. Here we take into account angular momentum accretion by these stars. We compute in detail the evolution of typical CEMP-\(s\) stars from the ZAMS, through the mass accretion, and up the RGB for a wide range of specific angular momentum of the accreted material, corresponding to rotation velocities between \(\sim 0.3\text{–}300\, \text{km}\, \text{s}^{-1}\). We find that only for specific angular momentum \(> 10^{17}\, \text{cm}^2\, \text{s}^{-1}\) (rotation velocities \(> 20\, \text{km}\, \text{s}^{-1}\)) angular momentum accretion directly causes chemical dilution of the accreted material. This could nevertheless be relevant to CEMP-\(s\) stars, which are observed to rotate more slowly, if they undergo continuous angular momentum loss akin to solar-like stars. In models with rotation velocities characteristic of CEMP-\(s\) stars, rotational mixing primarily serves to inhibit atomic diffusion, such that the maximal surface abundance variations (with respect to the composition of the accreted material) prior to first dredge-up remain within \(\sim 0.4\, \text{dex}\) without thermohaline mixing or \(\sim 0.5\text{–}1.5\, \text{dex}\) with thermohaline mixing. Even in models with the lowest rotation velocities (under a km s\(^{-1}\)), rotational mixing is able to severely inhibit atomic diffusion, compared to non-rotating models. We thus conclude that it offers a natural solution to the problem posed by atomic diffusion and cannot be neglected in models of CEMP-\(s\) stars.

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Organic molecules, ions, and rare isotopologues in the remnant of the stellar-merger candidate, CK Vulpeculae (Nova 1670)

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Context: CK Vul is an enigmatic star whose outburst was observed in 1670–72. A stellar-merger event was proposed to explain its ancient eruption.

Aims: We aim to investigate the composition of the molecular gas recently discovered in the remnant of CK Vul. Deriving the chemical, elemental, and isotopic composition is crucial for identifying the nature of the object and obtaining clues on its progenitor(s).

Methods: We observed millimeter and submillimeter-wave spectra of CK Vul using the IRAM 30-m and APEX telescopes. Radiative-transfer modeling of the observed molecular features was performed to yield isotopic ratios for various elements.

Results: The spectra of CK Vul reveal a very rich molecular environment of low excitation \(T_{\text{ex}} \lesssim 12\) K. Atomic carbon and twenty-seven different molecules, including two ions, were identified. They range from simple diatomic to complex polyatomic species of up to seven atoms large. The chemical composition of the molecular gas is indicative of carbon and nitrogen-driven chemistry but oxides are also present. Additionally, the abundance of fluorine may be enhanced. The spectra are rich in isotopologues that are very rare in most known sources. All stable isotopes of C, N, O, Si, and S are observed and their isotopic ratios are derived.

Conclusions: The composition of the remnant’s molecular gas is most peculiar and gives rise to a very unique millimeter and submillimeter spectrum. The observation of ions and complex molecules suggests the presence of a photoionizing source but its nature (a central star or shocks) remains unknown. The elemental and isotopic composition of the gas cannot be easily reconciled with standard stellar nucleosynthesis but processing in hot CNO cycles and partial helium burning can explain most of the chemical peculiarities. The isotopic ratios of CK Vul are remarkably close to those of presolar "nova grains" but the link of Nova 1670 to objects responsible for these grains is unclear. The accuracy of isotopic ratios can be improved by future observations at higher angular resolutions and with realistic models of the kinematical structure of the remnant.

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Three-dimensional hydrodynamical simulations of mass transfer in binary systems by a free wind

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A large fraction of stars in binary systems are expected to undergo mass and angular momentum exchange at some point in their evolution, which can drastically alter the chemical and dynamical properties and fates of the systems. Interaction by stellar wind is an important process in wide binaries. However, the details of wind mass transfer are still not well understood. We perform three-dimensional hydrodynamical simulations of wind mass transfer in binary systems to explore mass accretion efficiencies and geometries of mass outflows, for a range of mass ratios from 0.05 to 1.0. In particular, we focus on the case of a free wind, in which some physical mechanism accelerates the expelled wind material balancing the gravity of the mass-losing star with the wind velocity comparable to the orbital velocity of the system. We find that the mass accretion efficiency and accreted specific angular momentum increase with the mass ratio of the system. For an adiabatic wind, we obtain that the accretion efficiency onto the secondary star varies from about 0.1% to 8% for mass ratios between 0.05 and 1.0.

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Spectral properties and variability of BIS objects

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Through the analysis and interpretation of newly obtained and of literature data we have clarified the nature of poorly investigated IRAS point sources classified as late type stars, belonging to the Byurakan IRAS Stars catalog. From medium resolution spectroscopy of 95 stars we have strongly revised 47 spectral types and newly classified 31 sources. Nine stars are of G or K types, four are N carbon stars in the Asymptotic Giant Branch, the others being M-type stars. From literature and new photometric observations we have studied their variability behaviour. For the regular variables we determined distances, absolute magnitudes and mass loss rates. For the other stars we estimated the distances, ranging between 1.3 and 10 kpc with a median of 2.8 kpc from the galactic plane, indicating that BIS stars mostly belong to the halo population.

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Infrared characteristics of the BIS catalog objects

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We studied several color–color infrared diagrams of the 276 late type stars of the BIS catalog. For 95 of these stars we derived spectral classification from our slit spectroscopy. From the 2MASS color diagram we derive that none of the sample stars is a dwarf. The WISE [3.4]–[12] vs [12]–[22] plot is the best to discriminate the variability type (Mira, irregular and not-variable), as well as Carbon stars: IRAS colors are less useful due to the poor quality of the data for most of the BIS stars. Mixed plots involving 2MASS, AKARI and WISE were also explored: the 2MASS–AKARI J–[S09] vs [S09]–[L18] plot is efficient to discriminate Carbon and Mira stars. From the color plots and our spectroscopy we can statistically predict that in whole BIS catalog no other dusty Carbon star is present, while a few Miras and CH or R Carbon stars could be discovered. Only about 15 percent of the BIS stars are of early M type.

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Common continuum polarization properties: a possible link between proto-planetary nebulae and Type Ia Supernova progenitors

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The lines of sight to highly reddened SNe Ia show peculiar continuum polarization curves, growing towards blue wavelengths and peaking at $\lambda_{max}\lesssim 0.4$ $\mu$m, like no other sightline to any normal Galactic star. We examined continuum polarization measurements of a sample of asymptotic giant branch (AGB) and post-AGB stars from the literature, finding that some proto-planetary nebulae (PPNe) have polarization curves similar to those observed along SN Ia
sightlines. These polarization curves are produced by scattering on circumstellar dust. We discuss the similarity and the possibility that at least some SNe Ia might explode during the post-AGB phase of their binary companion. Furthermore, we speculate that the peculiar SN Ia polarization curves might provide observational support to the core-degenerate progenitor model.

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Jet creation in post-AGB binaries: the circum-companion accretion disc around BD +46°442

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We aim at describing and understanding binary interaction processes in systems with very evolved companions. Here, we focus on understanding the origin and determining the properties of the high-velocity outflow observed in one such system.

We present a quantitative analysis of BD +46°442, a post-AGB binary that shows active mass transfer that leads to the creation of a disk-driven outflow or jet. We obtained high-resolution optical spectra from the HERMES spectrograph, mounted on the 1.2-m Flemish Mercator Telescope. By performing a time-series analysis of the Hα profile, we identified the different components of the system. We deduced the jet geometry by comparing the orbital phased data with our jet model. In order to image the accretion disc around the companion of BD +46°442, we applied the technique of Doppler tomography.

The orbital phase-dependent variations in the Hα profile can be related to an accretion disk around the companion, from which a high-velocity outflow or jet is launched. Our model shows that there is a clear correlation between the inclination angle and the jet opening angle. The latitudinally dependent velocity structure of our jet model shows a good correspondence to the data, with outflow velocities higher than at least 400 km s⁻¹. The intensity peak in the Doppler map might be partly caused by a hot spot in the disk, or by a larger asymmetrical structure in the disk.

We show that BD +46°442, is a result of a binary interaction channel. The origin of the fast outflow in this system might be to a gaseous disk around the secondary component, which is most likely a main-sequence star. Our analysis suggests that the outflow has a rather wide opening angle and is not strongly collimated. Our time-resolved spectral monitoring reveals the launching site of the jet in the binary BD+46°442. Similar orbital phase-dependent Hα profiles are commonly observed in post-AGB binaries. Post-AGB binaries provide ideal test beds to study jet formation and launching mechanisms over a wide range of orbital conditions.

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IFU spectroscopy of Southern Planetary Nebulæ V: Low-ionization structures

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In this 5th paper of the series, we examine the spectroscopy and morphology of four southern Galactic planetary nebulae Hen 2-141, NGC 5307, IC 2553, and PB6 using new integral field spectroscopy data. The morphologies and ionization structures of the sample are given as a set of emission-line maps. In addition, the physical conditions, chemical compositions, and kinematical characteristics of these objects are derived. The results show that PB6 and
Hen 2-141 are of very high excitation classes and IC 2553 and NGC 5307 are mid to high excitation objects. The elemental abundances reveal that PB6 is of Type I, Hen 2-141 and IC 2553 are of Type IIa, and NGC 5307 of Type IIb. III. The observations unveil the presence of well-defined low-ionization structures or "knots" in all objects. The diagnostic diagrams reveal that the excitation mechanism of these knots is probably by photo-ionization of dense material by the nebular central stars. The physical analysis of six of these knots show no significant differences with their surrounding nebular gas, except their lower electron densities. In spite of the enhancement of the low-ionization emission lines of these knots, their chemical abundances are nearly comparable to their surrounding nebulae, with the exception of perhaps slightly higher nitrogen abundances in the NGC 5307 knots. The integrated spectrum of IC 2553 reveals that nearly all key lines that have led researchers to characterize its central star as a weak-emission line star type are in fact of nebular origin.

Accepted for publication in PASA

Where does galactic dust come from?
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Here we investigate the origin of the dust mass (\(M_{\text{dust}}\)) observed in the Milky Way (MW) and of dust scaling relations found in a sample of local galaxies from the DGS and KINGFISH surveys. To this aim, we model dust production from Asymptotic Giant Branch (AGB) stars and supernovae (SNe) in simulated galaxies forming along the assembly of a Milky Way-like halo in a well resolved cosmic volume of 4 cMpc using the GAMESH pipeline. We explore the impact of different sets of metallicity and mass-dependent AGB and SN dust yields on the predicted \(M_{\text{dust}}\). Our results show that models accounting for grain destruction by the SN reverse shock predict a total dust mass in the MW that is a factor of ~4 lower than observed, and can not reproduce the observed galaxy-scale relations between dust and stellar masses, and dust-to-gas ratios and metallicity, with a smaller discrepancy in galaxies with low metallicity (12 + log(O/H) < 7.5) and low stellar masses (\(M_{\text{star}} < 10^7 M_\odot\)). In agreement with previous studies, we suggest that competing processes in the interstellar medium must be at play to explain the observed trends. Our result reinforces this conclusion by showing that it holds independently of the adopted AGB and SN dust yields.

Submitted to MNRAS

A SITEELLE view of M31’s central region – I: Calibrations and radial velocity catalogue of nearly 800 emission-line point-like sources
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We present a detailed description of the wavelength, astrometric and photometric calibration plan for SITEELLE, the
imaging Fourier transform spectrometer attached to the Canada–France–Hawaii telescope, based on observations of a red (647 – 685 nm) data cube of the central region (11′ × 11′) of M 31. The first application, presented in this paper, is a radial-velocity catalogue (with uncertainties of ∼ 2–6 km s⁻¹) of nearly 800 emission-line point-like sources, including ∼ 450 new discoveries. Most of the sources are likely planetary nebulae, although we also detect five novae (having erupted in the first 8 months of 2016) and one new supernova remnant candidate.

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NGC 6752 AGB stars revisited: I. Improved AGB temperatures remove apparent overionisation of Fe

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A recent study reported a strong apparent depression of Fe, relative to FeII, in the AGB stars of NGC 6752. This depression is much greater than that expected from the neglect of non-local thermodynamic equilibrium effects, in particular the dominant effect of overionisation. The iron abundances derived from FeI were then used to scale all other neutral species in the study. Here we attempt to reproduce the apparent Fe discrepancy, and investigate differences in reported sodium abundances. We compare in detail the methods and results of the recent study with those of an earlier study of NGC 6752 AGB stars. Iron and sodium abundances are derived using FeI, FeII, and NaI lines. We explore various uncertainties to test the robustness of our abundance determinations. We reproduce the large FeI depression found by the recent study, using different observational data and computational tools. Further investigation shows that the degree of the apparent FeI depression is strongly dependent on the adopted stellar effective temperature. To minimise uncertainties in FeI we derive temperatures for each star individually using the infrared flux method (IRFM). We find that the T-eff scales used by both the previous studies are cooler, by up to 100 K, such underestimated temperatures amplify the apparent FeI depression. Our IRFM temperatures result in negligible apparent depression, consistent with theory. We also re-derived sodium abundances and, remarkably, found them to be unaffected by the new temperature scale. [Na/H] in the AGB stars is consistent between all studies. Since Fe is constant, it follows that [Na/Fe] is also consistent between studies, apart from any systematic offsets in Fe. We recommend the use of (V – K) relations for AGB stars, based on comparisons with our individually-derived IRFM temperatures, and their inherently low uncertainties. We plan to investigate the effect of the improved temperature scale on other elements, and re-evaluate the subpopulation distributions on the AGB, in the next paper of this series.

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Investigating the diversity of supernovae type Iax: A MUSE and NOT spectroscopic study of their environments

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SN 2002cx-like Type Ia supernovae (also known as SNe Iax) represent one of the most numerous peculiar SN classes. They differ from normal SNe Ia by having fainter peak magnitudes, faster decline rates and lower photospheric velocities, displaying a wide diversity in these properties. We present both integral-field and long-slit visual-wavelength spectroscopy of the host galaxies and explosion sites of SNe Iax to provide constraints on their progenitor formation scenarios. The SN Iax explosion site metallicity distribution is similar to that of core-collapse (CC) SNe and metal-poor compared to either normal SNe Ia or SN 1991T-like events. Fainter members, speculated to form distinctly from brighter SN Iax, are found at a range of metallicities, extending to very metal-poor environments. Although the SN Iax explosion sites’ ages and star-formation rates are comparatively older and less intense than the distribution of star forming regions across their host galaxies, we confirm the presence of young stellar populations (SP) at explosion environments for most SNe Iax, expanded here to a larger sample. Ages of the young SP (several ×107 to 108 yr) are consistent with predictions for young thermonuclear and electron-capture SN progenitors. The lack of extremely young SP at the explosion sites disfavours very massive progenitors such as Wolf-Rayet explosions with significant fallback. We find weak ionised gas in the only SN Iax host without obvious signs of star-formation. The source of the ionisation remains ambiguous but appears unlikely to be mainly due to young, massive stars.

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Chemical content of the circumstellar envelope of the oxygen-rich AGB star R Dor: Non-LTE abundance analysis of CO, SiO, and HCN

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Context: The stellar outflows of low- to intermediate-mass stars are characterised by a rich chemistry. Condensation of molecular gas species into dust grains is a key component in a chain of physical processes that leads to the onset of a stellar wind. In order to improve our understanding of the coupling between the micro-scale chemistry and macro-scale dynamics, we need to retrieve the abundance of molecules throughout the outflow.

Aims: Our aim is to determine the radial abundance profile of SiO and HCN throughout the stellar outflow of R Dor,
an oxygen-rich AGB star with a low mass-loss rate. SiO is thought to play an essential role in the dust-formation process of oxygen-rich AGB stars. The presence of HCN in an oxygen-rich environment is thought to be due to non-equilibrium chemistry in the inner wind.

Methods: We have analysed molecular transitions of CO, SiO, and HCN measured with the APEX telescope and all three instruments on the Herschel Space Observatory, together with data available in the literature. Photometric data and the infrared spectrum measured by ISO-SWS were used to constrain the dust component of the outflow. Using both continuum and line radiative transfer methods, a physical envelope model of both gas and dust was established. We have performed an analysis of the SiO and HCN molecular transitions in order to calculate their abundances.

Results: We have obtained an envelope model that describes the dust and the gas in the outflow, and determined the abundance of SiO and HCN throughout the region of the stellar outflow probed by our molecular data. For SiO, we find that the initial abundance lies between $5.5 \times 10^{-5}$ and $6.0 \times 10^{-5}$ with respect to H$_2$. The abundance profile is constant up to $60 \pm 10$ $R_*$, after which it declines following a Gaussian profile with an $e$-folding radius of $3.5 \pm 0.5 \times 10^{13}$ cm or $1.4 \pm 0.2$ $R_*$. For HCN, we find an initial abundance of $5.0 \times 10^{-7}$ with respect to H$_2$. The Gaussian profile that describes the decline starts at the stellar surface and has an $e$-folding radius $r_e$ of $1.85 \pm 0.05 \times 10^{15}$ cm or $74 \pm 2$ $R_*$. Conclusions: We cannot unambiguously identify the mechanism by which SiO is destroyed at $60 \pm 10$ $R_*$. The initial abundances found are larger than previously determined (except for one previous study on SiO), which might be due to the inclusion of higher-$J$ transitions. The difference in abundance for SiO and HCN compared to high mass-loss rate Mira star IK Tau might be due to different pulsation characteristics of the central star and/or a difference in dust condensation physics.

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The evolution of Galactic planetary nebula progenitors through the comparison of their nebular abundances with AGB yields

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We study the chemical abundances of a wide sample of 142 Galactic planetary nebulae (PNe) with good quality observations, for which the abundances have been derived more or less homogeneously, thus allowing a reasonable comparison with stellar models. The goal is the determination of mass, chemical composition and formation epoch of their progenitors, through comparison of the data with results from AGB evolution. The dust properties of PNe, when available, were also used to further support our interpretation.

We find that the majority ($\sim 60\%$) of the Galactic PNe studied has nearly solar chemical composition, while $\sim 40\%$ of the sources investigated have sub-solar metallicities. About half of the PNe have carbon star progenitors, in the 1.5 $M_\odot$ < $M$ < 3 $M_\odot$ mass range, which have formed between 300 Myr and 2 Gyr ago. The remaining PNe are almost equally distributed among PNe enriched in nitrogen, which we interpret as the progeny of $M > 3.5$ $M_\odot$ stars, younger than 250 Myr, and a group of oxygen-rich PNe, descending from old ($> 2$ Gyr) low-mass ($M < 1.5$ $M_\odot$) stars that never became C-stars.

This analysis confirms the existence of an upper limit to the amount of carbon which can be accumulated at the surface of carbon stars, probably due to the acceleration of mass loss in the late AGB phases. The chemical composition of the present sample suggests that in massive AGB stars of solar (or slightly sub-solar) metallicity, the effects of third dredge up combine with hot bottom burning, resulting in nitrogen-rich – but not severely carbon depleted – gaseous material to be ejected.

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On the production of He, C and N by low and intermediate mass stars: A comparison of observed and model-predicted planetary nebula abundances

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The primary goal of this paper is to make a direct comparison between the measured and model-predicted abundances of He, C and N in a sample of 35 well-observed Galactic planetary nebulae (PN). All observations, data reductions, and abundance determinations were performed in house to ensure maximum homogeneity. Progenitor star masses (M < 4 M☉) were inferred using two published sets of post-AGB model tracks and L and Teff values. We conclude the following: 1) the mean values of N/O across the progenitor mass range exceed the solar value, indicating significant N enrichment in the majority of our objects; 2) the onset of hot bottom burning appears to begin around 2 solar masses, i.e., lower than ~ 5 M☉ implied by theory; 3) most of our objects show a clear He enrichment, as expected from dredge-up episodes; 4) the average sample C/O value is 1.23, consistent with the effects of third dredge-up; and 5) model grids used to compare to observations successfully span the distribution over metallicity space of all C/O and many He/H data points but mostly fail to do so in the case of N/O. The evident enrichment of N in PN and the general discrepancy between the observed and model-predicted N/O abundance ratios signal the need for extra-mixing as an effect of rotation and/or thermohaline mixing in the models. The unexpectedly high N enrichment that is implied here for low mass stars, if confirmed, will likely impact our conclusions about the source of N in the Universe.

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A remarkable oxygen-rich asymptotic giant branch variable in the Sagittarius dwarf irregular galaxy

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We report and discuss JHKs photometry for Sgr dIG, a very metal-deficient galaxy in the Local Group, obtained over 3.5 years with the Infrared Survey Facility in South Africa. Three large amplitude asymptotic giant branch variables are identified. One is an oxygen-rich star that has a pulsation period of 950 days, that was until recently undergoing hot bottom burning, with MBol ~ −6.7 mag. It is surprising to find a variable of this sort in Sgr dIG, given their rarity in other dwarf irregulars. Despite its long period the star is relatively blue and is fainter, at all wavelengths shorter than 4.5 μm, than anticipated from period-luminosity relations that describe hot bottom burning stars. A comparison with models suggests it had a main sequence mass M ∼ 5 M☉ and that it is now near the end of its AGB evolution. The other two periodic variables are carbon stars with periods of 670 and 503 days (MBol ~ −5.7 and −5.3 mag). They are very similar to other such stars found on the AGB of metal deficient Local Group Galaxies and a comparison with models suggests M ∼ 3 M☉. We compare the number of AGB variables in Sgr dIG to those in NGC 6822 and IC 1613, and suggest that the differences may be due to the high specific star formation rate and low metallicity of Sgr dIG.

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Monitoring survey of pulsating giant stars in the Local Group galaxies: survey description, science goals, target selection

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The population of nearby dwarf galaxies in the Local Group constitutes a complete galactic environment, perfect suited for studying the connection between stellar populations and galaxy evolution. In this study, we are conducting an optical monitoring survey of the majority of dwarf galaxies in the Local Group, with the Isaac Newton Telescope (INT), to identify long period variable stars (LPVs). These stars are at the end points of their evolution and therefore their luminosity can be directly translated into their birth masses; this enables us to reconstruct the star formation history. By the end of the monitoring survey, we will have performed observations over ten epochs, spaced approximately three months apart, and identified long period, dust-producing AGB stars; five epochs of data have been obtained already. LPVs are also the main source of dust; in combination with Spitzer Space Telescope images at mid-IR wavelengths we will quantify the mass loss, and provide a detailed map of the mass feedback into the interstellar medium. We will also use the amplitudes in different optical passbands to determine the radius variations of the stars, and relate this to their mass loss.


Finding evolved stars in the inner Galactic disk with Gaia


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The Bulge Asymmetries and Dynamical Evolution (BAaDE) survey will provide positions and line-of-sight velocities of ~20,000 evolved, maser bearing stars in the Galactic plane. Although this Galactic region is affected by optical extinction, BAaDE targets may have Gaia cross-matches, eventually providing additional stellar information. In an initial attempt to cross-match BAaDE targets with Gaia, we have found more than 5,000 candidates. Of these, we may expect half to show SiO emission, which will allow us to obtain velocity information. The cross-match is being refined to avoid false positives using different criteria based on distance analysis, flux variability, and color assessment in the mid- and near-IR. Once the cross-matches can be confirmed, we will have a unique sample to characterize the stellar population of evolved stars in the Galactic bulge, which can be considered fossils of the Milky Way formation.

Astrometric Galactic maser measurements cross-matched with Gaia

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Using the VLBA, the BeSSeL survey has provided distances and proper motions of young massive stars, allowing an accurate measure of the Galactic spiral structure. By the same technique, we are planning to map the inner Galaxy using positions and velocities of evolved stars (provided by the BAaDE survey). These radio astrometric measurements (BeSSeL and BAaDE) will be complementary to Gaia results and the overlap will provide important clues on the intrinsic properties and population distribution of the stars in the bulge.

Poster contribution, published in IAU Symposium No. 334: "Rediscovering our Galaxy"
Available from https://arxiv.org/abs/1708.05538

Review Papers

Type Iax Supernovae

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Type Iax supernovae (SN Iax), also called SN 2002cx-like supernovae, are the largest class of peculiar white dwarf (thermonuclear) supernovae, with over fifty members known. SN Iax have lower ejecta velocity and lower luminosities, and these parameters span a much wider range, than normal type Ia supernovae (SN Ia). SN Iax are spectroscopically similar to some SN Ia near maximum light, but are unique among all supernovae in their late-time spectra, which never become fully nebular. SN Iax overwhelmingly occur in late-type host galaxies, implying a relatively young population. The SN Iax 2012Z is the only white dwarf supernova for which a pre-explosion progenitor system has been detected. A variety of models have been proposed, but one leading scenario has emerged: a type Iax supernova may be a pure-deflagration explosion of a carbon-oxygen (or hybrid carbon-oxygen-neon) white dwarf, triggered by helium accretion to the Chandrasekhar mass, that does not necessarily fully disrupt the star.

Published in "Handbook of Supernovae", eds. A. Alsubti & P. Murdin, Springer
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Characterizing the chemistry of planetary materials around white dwarf stars

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Planetary systems that orbit white dwarf stars can be studied via spectroscopic observations of the stars themselves.
Numerous white dwarfs are seen to have accreted mostly rocky minor planets, the remnants of which are present in the stellar photospheres. The elemental abundances in the photospheres unveil the bulk compositions of the accreted parent bodies with a precision far greater than can be attained with any other technique currently available to astronomers. The most significant discovery, overall, is that rocky extrasolar planets have bulk elemental compositions similar to those of Earth and other rocky objects in our solar system. The white dwarf studies reveal that many extrasolar minor planets (asteroids) are differentiated, possessing analogs of terrestrial crust, mantle and core; this finding has important implications for the origin of our own solar system.

Published in "Handbook of Exoplanets", Springer Reference Works, eds. Juan Antonio Belmonte & Hans Deeg
Available from https://arxiv.org/abs/1707.03064

**Announcement**

**Planetary Nebula Research with Subaru Telescope in the Era of International Partnership**

*Subaru* Telescope, operated by National Astronomical Observatory of Japan (NAOJ), is transitioning into a joint operation mode with its potential partner countries in the pan-Pacific regions and beyond. *Subaru* is equipped with unique instruments for PN research. For example, High Dispersion Spectrograph (HDS) has been a workhorse to investigate faint emission lines of important elements in the nebulae and absorption lines of the central stars.

Presently, there are HDS projects at *Subaru* to (1) construct 2-D line emission maps aiming at revealing the electron density/temperature and elemental abundance distributions, and (2) study the diffuse interstellar bands and electronic transitions of fullerenes (C$_{60}$) aiming at investigating their origin. SCExAO is another workhorse in investigating the presence of a disk and companion objects to the central star. These are new initiatives that have just been initiated, and there exists a significant amount of potential interest toward PN research using *Subaru* Telescope. We have obtained some funding from NAOJ to hold a little workshop to promote PN science cases using *Subaru* Telescope, looking ahead into the era of joint operation of *Subaru* with international partners.

We are planning to gather at the University of Hong Kong for three days from Dec 11 to 13, 2017. While details are still being ironed out, you can have a glimpse of the workshop at the URL below. We plan to allow enough time for discussion and proposal preparation. If you are interested in participating, please sign up by sending an email to subarupnws2017@gmail.com. We hope to see you then.

Toshiya Ueta
on behalf of the *Subaru* PN Workshop SOC/LOC
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See also http://www.asiaa.sinica.edu.tw/~otsuka/subaruws/subaruws.html