THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 267th issue of the AGB Newsletter. Besides fantastic science, a couple of papers present new analytical techniques.

The Fizeau programme to support researchers with interferometry is inviting applications again.

The IAU Working Group on Red Giants and Supergiants has submitted a Letter of Intent for a Focus Meeting at the 2021 General Assembly in South Korea. The proposal is due 15th December – any suggestions are welcome, but the aim of the Focus Meeting is strategic: to help define future research directions. Also, volunteers to help with the Local Organising Committee are welcome – just e-mail us via the Newsletter.

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

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

Food for Thought

This month's thought-provoking statement is:

What is the lowest metallicity needed to form a red supergiant?

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

OH maser emission in the THOR survey of the northern Milky Way

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Context: OH masers trace diverse physical processes, from the expanding envelopes around evolved stars to star-forming regions or supernovae remnants. Providing a survey of the ground-state OH maser transitions in the northern hemisphere inner Milky Way facilitates the study of a broad range of scientific topics.
Aims: We want to identify the ground-state OH masers at $\sim$ 18 cm wavelength in the area covered by "The H I/OH/Recombination line survey of the Milky Way (THOR)". We will present a catalogue of all OH maser features and their possible associated environments.
Methods: The THOR survey covers longitude and latitude ranges of $14.^\circ3 < l < 66.^\circ8$ and $b < \pm1.^\circ25$. All OH ground state lines $^2\Pi_{3/2}(J = 3/2)$ at 1612 (F = 1–2), 1665 (F = 1–1), 1667 (F = 2–2) and 1720 MHz (F = 2–1) have been observed, employing the Very Large Array (VLA) in its C configuration. The spatial resolution of the data varies between $12.''5$ and $19''$, the spectral resolution is 1.5 km s^{-1}, and the rms sensitivity of the data is $\sim$ 10 mJy beam^{-1} per channel.
Results: We identify 1585 individual maser spots (corresponding to single spectral features) distributed over 807 maser sites (regions of size $\sim 10^3$–10^4 au). Based on different criteria from spectral profiles to literature comparison, we try to associate the maser sites with astrophysical source types. Approximately 51% of the sites exhibit the double-horned 1612 MHz spectra typically emitted from the expanding shells of evolved stars. The separations of the two main velocity features of the expanding shells typically vary between 22 and 38 km s^{-1}. In addition to this, at least 20% of the maser sites are associated with star-forming regions. While the largest fraction of 1720 MHz maser spots (21 out of 53) is associated with supernova remnants, a significant fraction of the 1720 MHz maser spots (17) are also associated with star-forming regions. We present comparisons to the thermal ^{13}CO(1–0) emission as well as to other surveys of class II CH_3OH and H_2O maser emission. The catalogue attempts to present associations to astrophysical sources where available, and the full catalogue is available in electronic form.
Concusions: This OH maser catalogue presents a unique resource of stellar and interstellar masers in the northern hemisphere. It provides the basis for a diverse range of follow-up studies from envelopes around evolved stars to star-forming regions and Supernova remnants.

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and from http://www.mpia.de/thor/Overview.html

Presolar silicon carbide grains of types Y and Z: Their molybdenum isotopic compositions and stellar origins

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We report Mo isotopic compositions of 37 presolar SiC grains of types Y (19) and Z (18), rare types commonly argued to have formed in lower-than-solar metallicity asymptotic giant branch (AGB) stars. Direct comparison of the Y and Z grain data with data for mainstream grains from AGB stars of close-to-solar metallicity demonstrates that the three types of grains have indistinguishable Mo isotopic compositions. We show that the Mo isotope data can be used to constrain the maximum stellar temperatures ($T_{\rm max}$) during thermal pulses in AGB stars. Comparison of FRUITY Torino AGB nucleosynthesis model calculations with the grain data for Mo isotopes points to an origin from low-mass ($\sim$ 1.5–3 $M_\odot$) rather than intermediate-mass ($>$ 3–9 $M_\odot$) AGB stars. Because of the low efficiency of ^{22}Ne(α, n)^{25}Mg at the low $T_{\rm max}$ values attained in low-mass AGB stars, model calculations cannot explain the large ^{30}Si excesses of Z grains as arising from neutron capture, so these excesses remain a puzzle at the moment.

Published in The Astrophysical Journal

Available from https://arxiv.org/abs/1906.10776

and from https://iopscience.iop.org/article/10.3847/1538-4357/ab2d27/meta

Supernova lightCURVE POPulation Synthesis II: Validation against supernovæ with an observed progenitor

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We use the results of a supernova light-curve population synthesis to predict the range of possible supernova light curves arising from a population of single-star progenitors that lead to type IIP supernovæ. We calculate multiple models varying the initial mass, explosion energy, nickel mass and nickel mixing and then compare these to type IIP supernovæ with detailed light curve data and pre-explosion imaging progenitor constraints. Where a good fit is obtained to observations, we are able to achieve initial progenitor and nickel mass estimates from the supernova lightcurve that are comparable in precision to those obtained from progenitor imaging. For two of the eleven IIP supernovæ considered our fits are poor, indicating that more progenitor models should be included in our synthesis or that our assumptions, regarding factors such as stellar mass loss rates or the rapid final stages of stellar evolution, may need to be revisited in certain cases. Using the results of our analysis we are able to show that most of the type IIP supernovæ have an explosion energy of the order of $\log(E_{\rm exp}/{\rm erg}) = 50.52 \pm 0.10$ and that both the amount of nickel in the supernovæ and the amount of mixing may have a dependence on initial progenitor mass.

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Variable hard X-ray emission from the central star of the Eskimo Nebula

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The central star of NGC 2392 shows the hardest X-ray emission among central stars of planetary nebulæ (CSPNe). The recent discovery of a spectroscopic companion with an orbital period of 1.9 days could provide an explanation for its hard X-ray emission, as well as for the collimation of its fast outflow. Here we analyse the available *Chandra* and XMM–*Newton* X-ray observations to determine accurately the spectral and temporal variation properties of the CSPN of NGC 2392. The X-ray emission can be described by an absorbed thermal plasma model with temperature 26^{+8}_{-5} MK and X-ray luminosity $(8.7 \pm 1.0) \times 10^{30}$ erg s^{-1}. No long-term variability is detected in the X-ray emission level, but the *Chandra* light curve is suggestive of short-term variations with a period ~ 0.26 days. The possible origins of this X-ray emission are discussed. X-ray emission from the coronal activity of a companion or shocks in the stellar wind can be ruled out. Accretion of material from an unseen main-sequence companion onto the CSPN or from the CSPN wind onto a white dwarf companion are the most plausible origins for its hard X-ray emission, although the mismatch between the rotational period of the CSPN and the modulation time-scale of the X-ray emission seems to preclude the former possibility.

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Asymmetric shocks in χ Cyg observed with linear spectropolarimetry

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Aims: From a coherent interpretation of the linear polarisation detected in the spectral lines of the Mira star χ Cyg, we derive information about the dynamics of the stellar photosphere, including pulsation.
Methods: From spectropolarimetric observations of χ Cyg, we perform careful analysis of the polarisation signals observed in atomic and molecular lines, both in absorption and emission, using the radiative transfer in the polarisation context, through two mechanisms: intrinsic polarisation and continuum depolarisation. We also explain the observed line doubling phenomenon in terms of an expanding shell in spherical geometry, which allows us to pinpoint the coordinates over the stellar disk with enhanced polarisation.
Results: We find that the polarised spectrum of χ Cyg is dominated by intrinsic polarisation, with a negligible continuum depolarisation. The observed polarised signals can only be explained by assuming that this polarisation is locally enhanced by velocity fields. During the pulsation, radial velocities are not homogeneous over the disk. We map these regions of enhanced velocities.
Conclusions: We have set an algorithm to distinguish in any stellar spectra of linear polarisation the origin of this polarisation and the way to increase signal by coherently adding many lines with an appropriated weight. Applied to the Mira star χ Cyg, we reached the unexpected result that during the pulsation, velocities are radial but not homogeneous over the disk. The reason for these local velocity enhancements are probably related to the interplay between the atmospheric pulsation dynamics and the underlying stellar convection.

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Radial pulsations of stars on the stage of the final helium flash

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Stellar evolution calculations to the stage of the cooling white dwarf were done for population I stars with masses on the main sequence 1 $M_\odot \le M_0 \le 1.5$ $M_\odot$. The final helium flash LTP is shown to occur in post-AGB stars with initial masses 1.3 $M_\odot \le M_0 \le 1.32$ $M_\odot$ for the overshooting parameter $f = 0.016$. In the case of more effective overshooting ($f = 0.018$) the final helium flash occurs at initial masses 1.28 $M_\odot \le M_0 \le 1.3$ $M_\odot$. Fivefold variations of the parameter responsible for the mass loss rate during the post-AGB stage do not affect occurrence of the final helium flash but lead to perceptible changes of the evolutionary time. Selected models of two evolutionary sequences with initial mass $M_0 = 1.3$ $M_\odot$ computed with overshooting parameters $f = 0.016$ and $f = 0.018$ were used as initial conditions in solution of the equations of hydrodynamics describing radial oscillations of stars on the stage of the final helium flash at effective temperatures $T_{\rm eff} < 10^4$ K. The maximum pulsation period $\Pi = 117$ day determined for the evolutionary sequence $M_0 = 1.3$ $M_\odot$, $f = 0.016$ is in a good agreement with observational estimates of the period of FG Sge. The mass, the radius and the effective temperature of the star are $M = 0.565$ $M_\odot$, $R = 126$ $R_\odot$ and $T_{\rm eff} = 4445$ K, respectively. At the same time the average period change rate of FG Sge from 1960 to 1990 is nearly three time larger than its theoretical estimate.

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A comprehensive study of NGC 2345, a young open cluster with a low metallicity

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NGC 2345 is a young open cluster hosting seven blue and red supergiants, low metallicity and a high fraction of Be stars which makes it a privileged laboratory to study stellar evolution.
We aim to improve the determination of the cluster parameters and study the Be phenomenon. Our objective is also to characterise its seven evolved stars by deriving their atmospheric parameters and chemical abundances.
We performed a complete analysis combining for the first time *ubvy* photometry with spectroscopy as well as Gaia Data Release 2. We obtained spectra with classification purposes for 76 stars and high-resolution spectroscopy for an in-depth analysis of the blue and red evolved stars.
We identify a new red supergiant and 145 B-type likely members within a radius of $18'.7 \pm 1'.2$, which implies an initial mass, $M_{\rm cl} \approx 5\,200$ $M_\odot$. We find a distance of 2.5 ± 0.2 kpc for NGC 2345, placing it at $R_{\rm GC} = 10.2 \pm 0.2$ kpc. Isochrone fitting supports an age of 56 ± 13 Ma, implying masses around 6.5 $M_\odot$ for the supergiants. A high fraction of Be stars ($\approx 10\%$) is found. From the spectral analysis we estimate for the cluster an average $v_{\rm rad} = +58.6 \pm 0.5$ km s^{-1} and a low metallicity [Fe/H] $= -0.28 \pm 0.07$. We also have determined chemical abundances for Li, O, Na, Mg, Si, Ca, Ti, Ni, Rb, Y, and Ba for the evolved stars. The chemical composition of the cluster is consistent with that of the Galactic thin disc. One of the K supergiants, S50, is a Li-rich star, presenting an A(Li) ≈ 2.1. An overabundance of Ba is found, supporting the enhanced *s*-process.
NGC 2345 has a low metallicity for its Galactocentric distance, comparable to typical LMC stars. It is massive enough to serve as a testbed for theoretical evolutionary models for massive intermediate-mass stars.

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Period–luminosity diagram of long period variables in the Magellanic Clouds. New aspects revealed from Gaia Data Release 2

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Context: The period–luminosity diagram (PLD) has proven to be a powerful tool for studying populations of pulsating red giants. Gaia Data Release 2 (DR2) provides a large data set including many long-period variables (LPVs) on which this tool can be applied.
Aims: We investigate the location of LPVs from the Large and Small Magellanic Clouds in the PLD using various optical and infrared luminosity indicators from Gaia and 2MASS, respectively. We thereby distinguish between stars of different masses and surface chemistry.
Methods: The data set taken from the Gaia DR2 catalogue of LPVs allows for a homogeneous study from low- to high-mass LPVs. These sources are divided into sub-populations of asymptotic giant branch (AGB) stars according to their mass and their O- or C-rich nature using the Gaia–2MASS diagram developed by our group. This diagram uses a Wesenheit index $W_{\rm rp}$ based on Wesenheit functions in the Gaia and 2MASS photometric bands. Four different luminosity indicators are used to study the period–luminosity (P–L) relations.
Results: We provide the first observational evidence of a P–L relation offset for both fundamental and 1O pulsators between low- and intermediate-mass O-rich stars, in agreement with published pulsation predictions. Among the luminosity indicators explored, sequence C′ is the narrowest in the P–$W_{\rm rp}$ diagram, and is thus to be preferred over the other PLDs for the determination of distances using LPVs. The majority of massive asymptotic giant branch (AGB) stars and red supergiants form a smooth extension of sequence C of low- and intermediate-mass AGB stars in the P–$W_{\rm rp}$ diagram, suggesting that they pulsate in the fundamental mode. All results are similar in the two Magellanic Clouds.

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Random Forest identification of the thin disk, thick disk and halo Gaia-DR2 white dwarf population

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Gaia-DR2 has provided an unprecedented number of white dwarf candidates of our Galaxy. In particular, it is estimated that Gaia-DR2 has observed nearly 400 000 of these objects and close to 18 000 up to 100 pc from the Sun. This large quantity of data requires a thorough analysis in order to uncover their main Galactic population properties, in particular the thin and thick disk and halo components. Taking advantage of recent developments in artificial intelligence techniques, we make use of a detailed Random Forest algorithm to analyse an 8-dimensional space (equatorial coordinates, parallax, proper motion components and photometric magnitudes) of accurate data provided by Gaia-DR2 within 100 pc from the Sun. With the aid of a thorough and robust population synthesis code we simulated the different components of the Galactic white dwarf population to optimize the information extracted from the algorithm for disentangling the different population components. The algorithm is first tested in a known simulated sample achieving an accuracy of 85.3%. Our methodology is thoroughly compared to standard methods based on kinematic criteria demonstrating that our algorithm substantially improves previous approaches. Once trained, the algorithm is then applied to the Gaia-DR2 100 pc white dwarf sample, identifying 12 227 thin disk, 1410 thick disk and 95 halo white dwarf candidates, which represent a proportion of 74:25:1, respectively. Hence, the numerical spatial densities are $(3.6 \pm 0.4) \times 10^{-3}$ pc^{-3}, $(1.2 \pm 0.4) \times 10^{-3}$ pc^{-3} and $(4.8 \pm 0.4) \times 10^{-5}$ pc^{-3} for the

thin disk, thick disk and halo components, respectively. The populations thus obtained represent the most complete and volume-limited samples to date of the different components of the Galactic white dwarf population.

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Enrichment of the Galactic disc with neutron-capture elements: Mo and Ru

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We present new observational data for the heavy elements molybdenum (Mo, $Z = 42$) and ruthenium (Ru, $Z = 44$) in F-, G-, and K-stars belonging to different substructures of the Milky Way. The range of metallicity covered is $-1.0 <$ [Fe/H] $< +0.3$. The spectra of Galactic disc stars have a high resolution of 42,000 and 75,000 and signal-to-noise ratio better than 100. Mo and Ru abundances were derived by comparing the observed and synthetic spectra in the region of Mo I lines at 5506, 5533 Å for 209 stars and Ru I lines at 4080, 4584, 4757 Å for 162 stars using the LTE approach. For all the stars, the Mo and Ru abundance determinations are obtained for the first time with an average error of 0.14 dex. This is the first extended sample of stellar observations for Mo and Ru in the Milky Way disc, and together with earlier observations in halo stars it is pivotal in providing a complete picture of the evolution of Mo and Ru across cosmic timescales. The Mo and Ru abundances were compared with those of the neutron-capture elements (Sr, Y, Zr, Ba, Sm, Eu). The complex nucleosynthesis history of Mo and Ru is compared with different Galactic Chemical Evolution (GCE) simulations. In general, present theoretical GCE simulations show underproduction of Mo and Ru at all metallicities compared to observations. This highlights a significant contribution of nucleosynthesis processes not yet considered in our simulations. A number of possible scenarios are discussed.

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Partly burnt runaway stellar remnants from peculiar thermonuclear supernovæ

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We report the discovery of three stars that, along with the prototype LP 40-365, form a distinct class of chemically peculiar runaway stars that are the survivors of thermonuclear explosions. Spectroscopy of the four confirmed LP 40-365 stars finds ONe-dominated atmospheres enriched with remarkably similar amounts of nuclear ashes of partial O- and Si-burning. Kinematic evidence is consistent with ejection from a binary supernova progenitor; at least two stars have rest-frame velocities indicating they are unbound to the Galaxy. With masses and radii ranging between 0.20 and 0.28 $M_{\odot}$ and between 0.16 and 0.60 $R_{\odot}$, respectively, we speculate these inflated white dwarfs are the partly burnt remnants of either peculiar Type Iax or electron-capture supernovæ. Adopting supernova rates from the literature, we estimate that ~ 20 LP 40-365 stars brighter than 19 mag should be detectable within 2 kpc from the Sun at the end of the Gaia mission. We suggest that as they cool, these stars will evolve in their spectroscopic appearance, and eventually become peculiar O-rich white dwarfs. Finally, we stress that the discovery of new LP 40-365 stars will be useful to further constrain their evolution, supplying key boundary conditions to the modelling of explosion mechanisms, supernova rates, and nucleosynthetic yields of peculiar thermonuclear explosions.

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The quadratic programming method for extracting emission line maps from line- blended narrowband images

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We present a method to separate blended line emission from a set of narrowband (NB) images whose distinct throughput profiles overlap with each other. This method, based on the principle of quadratic programming (QP), treats line blending as a linearly constrained quadratic optimization problem and finds the solution by imposing a condition that the desired individual line intensities are always positive while allowing measurement uncertainties. We demonstrate the method for the quintessential example of line blending in the Hα complex by the Hα and [N II] lines using the archived *Hubble* Space Telescope WFPC2 and WFC3 NB images of the planetary nebula NGC 6720, in comparison with its genuine line maps extracted from a spectral cube obtained by our own long-slit scan mapping observations with the Gemini Multi-Object Spectrograph at Gemini-North. Such line-blended NB images typically permit only qualitative line diagnostics, which can lead to a factor of a few difference in the line flux ratios. This novel QP method, however, can extract individual line emission maps as long as the number of line-blended but well-calibrated NB images of differing throughputs is equal to or greater than the number of emission line maps to be extracted. The proposed QP method provides a viable alternative to the existing line emission calibration methods: a simple but innovative way to enable quantitative fully 2D plasma diagnostics at the pixel scale of input NB images available from various instruments, telescopes, and archives.

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How much graphene in space?

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The possible presence of graphene in the interstellar medium (ISM) is examined by comparing the interstellar extinction curve with the ultraviolet absorption of graphene calculated from its dielectric functions experimentally obtained with the electron energy loss spectroscopy (EELS) method. Based on the absence in the interstellar extinction curve of the ~ 2755 Å π–π^* electronic interband transition of graphene, we place an upper limit of ~ 20 ppm of C/H on the interstellar graphene abundance, exceeding the previous estimate by a factor of ~ 3 which made use of the dielectric functions measured with the spectroscopic ellipsometry (SE) method. Compared with the SE method which measures graphene in air (and hence its surface is contaminated) in a limited energy range of ~ 0.7–5 eV, the EELS probes a much wider energy range of ~ 0–50 eV and is free of contamination. The fact that the EELS dielectric functions are substantially smaller than that of SE naturally explains why a higher upper limit on the graphene abundance is derived with EELS. Inspired by the possible detection of C_{24}, a planar graphene sheet, in several Galactic and extragalactic planetary nebulæ, we also examine the possible presence of C_{24} in the diffuse ISM by comparing the model IR emission of C_{24} with the observed IR emission of the Galactic cirrus and the diffuse ISM toward $l = 44°20'$ and $b = -0°20'$. An upper limit of ~ 20 ppm on C_{24} is also derived from the absence of the characteristic vibrational bands of C_{24} at ~ 6.6, 9.8 and 20 μm in the observed IR emission.

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Probing the missing link between the Diffuse Interstellar Bands and the total-to-selective extinction ratio R_V – I. Extinction versus reddening

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The carriers of the still (mostly) unidentified diffuse interstellar bands (DIBs) have been a long-standing mystery ever since their first discovery exactly 100 years ago. In recent years, the ubiquitous detection of a large number of DIBs in a wide range of Galactic and extragalactic environments has led to renewed interest in connecting the occurrence and properties of DIBs to the physical and chemical conditions of the interstellar clouds, with particular attention paid to whether the DIB strength is related to the shape of the interstellar extinction curve. To shed light on the nature and origin of the DIB carriers, we investigate the relation between the DIB strength and R_V, the total-to-selective extinction ratio, which characterizes how the extinction varies with wavelength (i.e. the shape of the extinction curve). We find that the DIB strength and R_V are not related if we represent the strength of a DIB by its reddening-normalized equivalent width (EW), in contrast to the earlier finding of an anti-correlation in which the DIB strength is measured by the extinction-normalized EW. This raises a fundamental question about the appropriate normalization for the DIB EW.

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Chemical modelling of dust-gas chemistry within AGB outflows I. Effect on the gas-phase chemistry

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Chemical modelling of AGB outflows is typically focused on either non-thermodynamic equilibrium chemistry in the inner region or photon-driven chemistry in the outer region. We include, for the first time, a comprehensive dust-gas chemistry in our AGB outflow chemical kinetics model, including both dust-gas interactions and grain-surface chemistry. The dust is assumed to have formed in the inner region, and follows an interstellar-like dust-size distribution. Using radiative transfer modelling, we obtain dust temperature profiles for different dust types in an O-rich and a C-rich outflow. We calculate a grid of models, sampling different outflow densities, drift velocities between the dust and gas, and dust types. Dust-gas chemistry can significantly affect the gas-phase composition, depleting parent and daughter species and increasing the abundance of certain daughter species via grain-surface formation followed by desorption/sputtering. Its influence depends on four factors: outflow density, dust temperature, initial composition, and drift velocity. The largest effects are for higher density outflows with cold dust and O-rich parent species, as these species generally have a larger binding energy. At drift velocities larger than ~ 10 km s^{-1}, ice mantles undergo sputtering; however, they are not fully destroyed. Models with dust-gas chemistry can better reproduce the observed depletion of species in O-rich outflows. When including colder dust in the C-rich outflows and adjusting the binding energy of CS, the depletion in C-rich outflows is also better reproduced. To best interpret high-resolution molecular line observations from AGB outflows, dust-gas interactions are needed in chemical kinetics models.

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Planet and star synergy at high spectral resolution. A rationale for the characterisation of exoplanet atmospheres. I. The infrared

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Context: Spectroscopy of exoplanet atmospheres at high resolving powers is rapidly gaining popularity to measure the presence of atomic and molecular species. While this technique is particularly robust against contaminant absorption in the Earth's atmosphere, the non stationary stellar spectrum, in the form of either Doppler shift or distortion of the line profile during planetary transits, creates a non-negligible source of noise that can alter or even prevent detection.
Aims: We aim at using state-of-the art three-dimensional stellar simulations to directly remove the signature of the star from observations, and prior to cross correlation with templates for the planet's atmosphere, commonly used to extract the faint exoplanet signal from noisy data.
Methods: We compute synthetic spectra from 3D simulations of stellar convection resolved both spatially and temporally, and we couple them with an analytical model reproducing the correct geometry of a transiting exoplanet. We apply the method to the early K-dwarf, HD 189733, and re-analyse transmission and emission spectroscopy of its hosted exoplanet. In addition, we also analyse emission spectroscopy of the non transiting exoplanet 51 Pegasi b, orbiting a solar-type star.
Results: We find a significant improvement in the planet detectability when removing the stellar spectrum with our method. In all cases, we show that the method is superior to a simple parametrisation of the stellar line profile or to the use of one-dimensional stellar models. We show that this is due to the intrinsic treatment of convection in 3D simulations, which allows us to correctly reproduce asymmetric and/or blue-shifted spectral lines, and intrinsically model center-to-limb variation and Rossiter–McLaughlin effect potentially altering the interpretation of exoplanet transmission spectra. In the case of 51 Pegasi b, we succeed at confirming a previous tentative detection of the planet's K-band spectrum due to the improved suppression of stellar residuals.
Conclusions: Future high-resolution observations will benefit from the synergy with stellar spectroscopy, and can be used to test the correct modelling of physical processes in stellar atmospheres. We highlight key improvements in modelling techniques and knowledge of opacity sources to extend this work to shorter wavelengths and later-type stars.

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Structure and properties of nanosilicates with olivine $(Mg_2SiO_4)_N$ and pyroxene $(MgSiO_3)_N$ compositions

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Magnesium-rich silicates are ubiquitous both terrestrially and astronomically, where they are often present as small particles. Nanosized Mg-rich silicate particles are likely to be particularly important for understanding the formation, processing, and properties of cosmic dust grains. Although astronomical observations and laboratory studies have revealed much about such silicate dust, our knowledge of this hugely important class of nanosolids largely rests on top-down comparisons with the properties of bulk silicates. Herein, we provide a foundational bottom-up study of the structure and properties of Mg-rich nanosilicates based on carefully procured atomistic models. Specifically, we employ state-of-the-art global optimization methods to search for the most stable structures of silicate nanoclusters with olivine $(Mg_2SiO_4)_N$ and pyroxene $(MgSiO_3)_N$ compositions with N = 1–10. To ensure the reliability of our searches, we develop a new interatomic potential that has been especially tuned for nanosilicates. Subsequently, we refine these searches and calculate a range of physicochemical properties of the most stable nanoclusters using accurate density functional theory based electronic structure calculations. We report a detailed analysis of structural and energy properties, charge distributions, and infrared vibrational spectra, where in all cases we compare our finding for nanosilicates with those of the corresponding bulk silicate crystals. For most properties considered, we find large differences with respect to the bulk limit, underlining the limitations of a top-down approach for describing these species. Overall, our work provides a new platform for an accurate and detailed understanding of nanoscale silicates.

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Fluorine abundances in the Galactic disk

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The chemical evolution of fluorine is investigated in a sample of Milky Way red giant stars that span a significant range in metallicity from [Fe/H] ~ -1.3 to 0.0 dex. Fluorine abundances are derived from vibration-rotation lines of HF in high-resolution infrared spectra near $\lambda 2.335$ μm. The red giants are members of the thin and thick disk / halo, with two stars being likely members of the outer disk Monoceros overdensity. At lower metallicities, with [Fe/H] < -0.4 to -0.5, the abundance of F varies as a primary element with respect to the Fe abundance, with a constant subsolar value of [F/Fe] ~ -0.3 to -0.4 dex. At larger metallicities, however, [F/Fe] increases rapidly with [Fe/H] and displays a near-secondary behavior with respect to Fe. Comparisons with various models of chemical evolution suggest that in the low-metallicity regime (dominated here by thick disk stars), a primary evolution of ^{19}F with Fe, with a subsolar [F/Fe] value that roughly matches the observed plateau can be reproduced by a model incorporating neutrino nucleosynthesis in the aftermath of the core collapse in supernovæ of type II (SN II). A primary behavior for [F/Fe] at low metallicity is also observed for a model including rapid rotating low metallicity massive stars but this overproduces [F/Fe] at low metallicity. The thick disk red giants in our sample span a large range of galactocentric distance ($R_g \sim$ 6–13.7 kpc), yet display a ~constant value of [F/Fe], indicating a very flat gradient (with a slope of

0.02 ± 0.03 dex kpc^{-1}) of this elemental ratio over a significant portion of the Galaxy having $|Z| > 300$ pc away from the Galaxy mid-plane.

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The Bulge Asymmetries and Dynamical Evolution (BAaDE) SiO maser survey at 86 GHz with ALMA

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We report on the first 1432 sources observed using the Atacama Large Millimeter/submillimeter Array, from the Bulge Asymmetries and Dynamical Evolution survey, which aims to obtain tens of thousands of line-of-sight velocities from SiO masers in Asymptotic Giant Branch (AGB) stars in the Milky Way. A 71% detection rate of 86 GHz SiO masers is obtained from the infrared color-selected sample and increases to 80% when considering the likely oxygen-rich stars using Midcourse Space Experiment colors isolated in a region where [D]–[E] $\leq$ 1.38 mag. Based on Galactic distributions, the presence of extended CS emission, and likely kinematic associations, the population of sources with [D]–[E] $>$ 1.38 mag probably consists of young stellar objects, or alternatively, of planetary nebulæ. For the SiO detections, we examined whether individual SiO transitions provide comparable stellar line-of-sight velocities and found that any SiO transition is suitable for determining a stellar AGB line-of-sight velocity. Finally, we discuss the relative SiO detection rates and line strengths in the context of current pumping models.

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The *s* process in rotating low-mass AGB stars. Nucleosynthesis calculations in models matching asteroseismic constraints

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Aims: We investigate the *s* process during the AGB phase of stellar models whose cores rotate at rates consistent with asteroseismology observations of their progenitors and successors.
Methods: We calculate 2 $M_{\odot}$, $Z = 0.01$ models, rotating at 0, 125, and 250 km s^{-1} at the ZAMS. An artificial, additional viscosity is added to enhance the transport of angular momentum in order to reduce the core rotation rates to be in agreement with asteroseismology observations. We compare rotation rates of our models with observed rotation rates during the MS up to the end of core He burning, and the white dwarf phase.
Results: For the first time, we present nucleosynthesis calculations for rotating AGB models that match the asteroseismic constraints on rotation rates of MS, RGB, He-burning and WD stars. In particular, we calculated one model that

matches the upper limit of observed rotation rates of core He-burning stars. We also included a model that rotates one order of magnitude faster than the upper limit of the observations. The *s*-process production in both of these models is comparable to that of non-rotating models.
Conclusions: Slowing down the star through artificial, additional viscosity to match the slow internal rotation rates observed by means of asteroseismology reduces the rotation-induced mixing processes to the point that they have no effect on the *s*-process nucleosynthesis in the ^{13}C pocket. This result is independent of initial rotation rate of the stellar evolution model. However, there are uncertainties remaining in the treatment of rotation in stellar evolution, which need to be reduced in order to confirm our conclusions. In addition, magnetic processes need further investigation.

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Infrared-excess white dwarfs in the Gaia 100 pc sample

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We analyse the 100 pc Gaia white dwarf volume-limited sample by means of VOSA (Virtual Observatory SED Analyser) with the aim of identifying candidates for displaying infrared excesses. Our search focuses on the study of the spectral energy distribution (SED) of 3,733 white dwarfs with reliable infrared photometry and GBP-GRP colours below 0.8 mag, a sample which seems to be nearly representative of the overall white dwarf population. Our search results in 77 selected candidates, 52 of which are new identifications. For each target we apply a two-component SED fitting implemented in VOSA to derive the effective temperatures of both the white dwarf and the object causing the excess. We calculate a fraction of infrared-excess white dwarfs due to the presence of a circumstellar disk of $1.6 \pm 0.2\%$, a value which increases to $2.6 \pm 0.3\%$ if we take into account incompleteness issues. Our results are in agreement with the drop in the percentage of infrared excess detections for cool ($< 8,000$ K) and hot ($> 20,000$ K) white dwarfs obtained in previous analyses. The fraction of white dwarfs with brown dwarf companions we derive is ≈ 0.1–0.2%.

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VLTI/PIONIER survey of disks around post-AGB binaries. Dust sublimation physics rules

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Context: Post-asymptotic giant branch (pAGB) binaries are surrounded by circumbinary disks of gas and dust that are similar to protoplanetary disks found around young stars.
Aims: We aim to understand the structure of these disks and identify the physical phenomena at play in their very inner regions. We want to understand the disk-binary interaction and to further investigate the comparison with protoplanetary disks.
Methods: We conducted an interferometric snapshot survey of 23 post-AGB binaries in the near-infrared (H-band) using VLTI/PIONIER. We fit the multi-wavelength visibilities and closure phases with purely geometrical models with

an increasing complexity (including two point-sources, an azimuthally modulated ring, and an over-resolved flux) in order to retrieve the sizes, temperatures, and flux ratios of the different components.
Results: All sources are resolved and the different components contributing to the H-band flux are dissected. The environment of these targets is very complex: 13/23 targets need models with thirteen or more parameters to fit the data. We find that the inner disk rims follow and extend the size–luminosity relation established for disks around young stars with an offset toward larger sizes. The measured temperature of the near-infrared circumstellar emission of post-AGB binaries is lower ($T_{\rm sub} \sim 1200$ K) than for young stars, which is probably due to a different dust mineralogy and/or gas density in the dust sublimation region.
Conclusions: The dusty inner rims of the circumbinary disks around post-AGB binaries are ruled by dust sublimation physics. Additionally a significant amount of the circumstellar H-band flux is over-resolved (more than 10% of the non-stellar flux is overresolved in 14 targets). This hints that a source of unknown origin, either a disk structure or outflow. The amount of over-resolved flux is larger than around young stars. Due to the complexity of these targets, interferometric imaging is a necessary tool to reveal the interacting inner regions in a model-independent way.

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Evolutionary models for R Coronæ Borealis stars

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We use Modules for Experiments in Stellar Astrophysics (MESA) to construct stellar evolution models that reach a hydrogen-deficient, carbon-rich giant phase like the R Coronæ Borealis (R CrB) stars. These models use opacities from OPAL and AESOPUS that cover the conditions in the cool, H-deficient, CNO-enhanced envelopes of these stars. We compare models that begin from homogeneous He stars with models constructed to reproduce the remnant structure shortly after the merger of a He and a CO white dwarf (WD). We emphasize that models originating from merger scenarios have a thermal reconfiguration phase that can last up to ≈ 1 kyr post merger, suggesting some galactic objects should be in this phase. We illustrate the important role of mass loss in setting the lifetimes of the R CrB stars. Using AGB-like mass loss prescriptions, models with CO WD primaries $\lesssim 0.7$ $M_\odot$ typically leave the R CrB phase with total masses ≈ 0.6–0.7 $M_\odot$, roughly independent of their total mass immediately post-merger. This implies that the descendants of the R CrB stars may have a relatively narrow range in mass and luminosity as extreme He stars and a relatively narrow range in mass as single WDs.

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AGB stars in the nearby dwarf galaxy: Leo P

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We have conducted a highly sensitive census of the evolved-star population in the metal-poor dwarf galaxy Leo P and detected four asymptotic giant branch (AGB) star candidates. Leo P is one of the best examples of a nearby analog

of high-redshift galaxies because of its primitive metal content (2% of the solar value), proximity, and isolated nature, ensuring a less complicated history. Using medium-band optical photometry from the *Hubble* Space Telescope (HST), we have classified the AGB candidates by their chemical type. We have identified one oxygen-rich source which appears to be dusty in both the HST and *Spitzer* observations. Its brightness, however, suggests it may be a planetary nebula or post-AGB object. We have also identified three carbon-rich candidates, one of which may be dusty. Follow-up observations are needed to confirm the nature of these sources and to study the composition of any dust that they produce. If dust is confirmed, these stars would likely be among the most metal-poor examples of dust-producing stars known and will provide valuable insight into our understanding of dust formation at high redshift.

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A CO-multilayer outer atmosphere for eight evolved stars revealed with VLTI/AMBER

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We determine the physical parameters of the outer atmosphere of a sample of eight evolved stars, including the red supergiant α Scorpii, the red giant branch stars α Bootis and γ Crucis, the K giant γ Velorum, the normal M giants BK Virginis and SW Virginis, and the Mira star W Hydræ (in two different luminosity phases) by spatially resolving the stars in the individual carbon monoxide (CO) first overtone lines. We used the Astronomical Multi-BEam combineR (AMBER) instrument at the Very Large Telescope Interferometer (VLTI), in high-resolution mode ($\lambda/\Delta\lambda \approx 12\,000$) between 2.28 and 2.31 μm in the K band. The maximal angular resolution is 10 mas, obtained using a triplet telescope configuration, with baselines from 7 to 48 m. By using a numerical model of a molecular atmosphere in a spherical shells (MOLsphere), called PAMPERO (an acronym for the "Physical Approach of Molecular Photospheric Ejection at high-angular-Resolution for evOlved-stars"), we add multiple extended CO layers above the photospheric MARCS model at an adequate spatial resolution. We use the differential visibilities and the spectrum to estimate the size (R) of the CO MOLsphere, its column density ($N_{\rm CO}$) and temperature ($T_{\rm mol}$) distributions along the stellar radius. The combining of the χ^2 minimization and a fine grid approach for uncertainty analysis leads to reasonable $N_{\rm CO}$ and $T_{\rm mol}$ distributions along the stellar radius of the MOLsphere.

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Properties of central stars of planetary nebulæ with distances in Gaia DR2

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Context: We have compiled a catalogue of central stars of planetary nebulæ (CSPN) with reliable distances and positions obtained from Gaia Data Release 2 (DR2) astrometry. Distances derived from parallaxes allow us to analyse the galactic distribution and estimate other parameters such as sizes, kinematical ages, bolometric magnitudes, and luminosities.
Aims: Our objective is to analyse the information regarding distances together with other available literature data about photometric properties, nebular kinematics, and stellar effective temperatures to throw new light on this rapid and rather unknown evolutionary phase. We seek to understand how Gaia distances compare with other indirect methods commonly used and, in particular, with those derived from non-local thermodynamic equilibrium (non-LTE) models; how many planetary nebulæ (PNe) populate the Galaxy; and how are they spatially distributed. We also aim to comprehend their intrinsic luminosities, range of physical sizes of the nebulæ; how to derive the values for their kinematical ages; and whether those ages are compatible with those derived from evolutionary models.
Methods: We considered all PNe listed in catalogues from different authors and in Hong Kong/AAO/Strasbourg/Hα (HASH) database. By X-matching their positions with Gaia DR2 astrometry we were able to identify 1571 objects in Gaia second archive, for which we assumed distances calculated upon a Bayesian statistical approach. From those objects, we selected a sample of PNe with good quality parallax measurements and distance derivations, we which refer to as our Golden Astrometry PNe sample (GAPN), and obtained literature values of their apparent sizes, radial and expansion velocities, visual magnitudes, interstellar reddening, and effective temperatures.
Results: We found that the distances derived from DR2 parallaxes compare well with previous astrometric derivations of the United States Naval Observatory and *Hubble* Space Telescope, but that distances inferred from non-LTE model fitting are overestimated and need to be carefully reviewed. From literature apparent sizes, we calculated the physical radii for a subsample of nebulæ that we used to derive the so-called kinematical ages, taking into account literature expansion velocities. Luminosities calculated with DR2 distances were combined with literature central stars $T_{\rm eff}$ values in a Hertzsprung–Russell (HR) diagram to infer information on the evolutionary status of the nebulæ. We compared their positions with updated evolutionary tracks finding a rather consistent picture. Stars with the smallest associated nebular radii are located in the flat luminosity region of the HR diagram, while those with the largest radii correspond to objects in a later stage, getting dimmer on their way to become a white dwarf. Finally, we commented on the completeness of our catalogue and calculated an approximate value for the total number of PNe in the Galaxy.

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Announcement

Fizeau exchange visitors program – call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff), with priority given to Ph.D. students and young postdocs. Non-EU based missions will only be funded if considered essential by the Fizeau Committee. Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is November 15. Fellowships can be awarded for missions to be carried out between January 2020 and July 2020!

Further informations and application forms can be found at www.european-interferometry.eu

The program is funded by OPTICON/H2020.

Please distribute this message also to potentially interested colleagues outside of your community!

Looking forward to your applications,
Josef Hron & Péter Ábrahám (for the European Interferometry Initiative)

See also www.european-interferometry.eu