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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 259$^{\text{th}}$ issue of the AGB Newsletter. In case you wondered why Adam Ginsburg posted their paper on a protostellar disc, it is because the molecular species detected in that disc have previously only been seen in AGB star atmospheres.

Congratulations to Andrea Chiavassa for his Habilitation thesis!

Various workshops and schools are being organised: an evolved stars session at the European Week of Astronomy and Space Science in Lyon, a school on proposal preparation, data analysis and publication in the Slovak Republic, and a Cloudy workshop in Kentucky, USA.

Last month's Food for Thought asked "What fraction of stars evolve as single stars all the way to the PN phase?" One response was received: *Between 1% and 99%, but closer to 60% since at least 25% of all stars are multiple.* Reactions to the question and this response remain welcome!

The next issue is planned to be distributed around the 1$^{\text{st}}$ of March.

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

Food for Thought

This month's thought-provoking statement is:

How large will the Sun really become?

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

Models of the mass-ejection histories of pre-planetary nebulæ – III. The shaping of lobes by post-AGB winds

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We develop a physical framework for interpreting high-resolution images of pre-planetary nebulæ ("prePNe") with pairs of candle shaped lobes. We use hydrodynamical models to infer the historical properties of the flows injected from the nucleus that shape the lobes into standard forms. First, we find a suitable set of parameters of a fast, collimated, tapered flow that is actively reshaped by an exterior slow AGB wind and that nicely fits the basic shape, kinematics, mass, and momenta of this class of prePNe. Next we vary the most influential parameters of this "baseline" model-such as density, speed, and geometry-to see how changes in the flow parameters affect the nebular observables after 900 yr. Several generic conclusions emerge, such as the injected flows that create the hollow candle-shaped lobes must be light, "tapered", and injected considerably faster than the lobe expansion speed. Multi-polar and starfish prePNe probably evolve from wide angle flows in which thin-shell instabilities corrugate their leading edges. We show how the common linear relationship of Doppler shift and position along the lobe is a robust outcome the interaction of tapered diverging streamlines with the lobes' curved walls. Finally we probe how magnetic fields affect the baseline model by adding a toroidal field to the injected baseline flow. Examples of prePNe and PNe that may have been magnetically shaped are listed. We conclude that the light, field-free, tapered baseline flow model is an successful and universal paradigm for unravelling the histories of lobe formation in prePNe.

Submitted to ApJ
Available from https://arxiv.org/abs/1901.00926
and from https://faculty.washington.edu/balick/Balick.arXiv.pdf

Constraining theories of SiO maser polarization: multi-epoch analysis of a $\pi/2$ electric vector rotation feature

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The detailed polarization mechanisms of SiO masers originating from the near circumstellar environment of Asymptotic Giant Branch stars are not yet definitively known. Prevailing theories are broadly classified as either Zeeman or non-Zeeman in origin, the latter including effects such as anisotropic pumping or anisotropic resonant scattering. The predicted behavior of the linear and circular polarization fractions and electric vector position angle vary by theory. In particular, individual maser features that exhibit a rotation in linear polarization of $\sim \pi/2$ as a function of frequency over their extent can be utilized as a test of several maser polarization transport theories. In this paper, we analyze one SiO ($\nu = 1$, $J = 1$–0) maser feature toward the Mira variable, TX Cam that exhibits this internal polarization rotation and persists across five epochs (spanning ~ 3 months). We compare our results to the predictions by several maser polarization theories and find that the linear polarization across the feature is consistent with a geometric effect for a saturated maser originating when the angle between the projected magnetic field and the line of sight (θ) crosses the Van Vleck angle $\theta_F \sim 55°$. However, the electric vector position angle (EVPA) exhibits a smooth rotation across the spatial extent of the feature rather than the expected abrupt $\pi/2$ flip. We discuss possible explanations for this discrepancy and alternative theories. Circular polarization across the feature is also analyzed and it is the most accurately described by Zeeman effects giving rise to a circular polarization fraction of the form m_c is approximately proportional to $\cos\theta$.

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Available from https://arxiv.org/abs/1812.09631

Energy budget and core-envelope motion in common envelope evolution

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We analyze a 3D hydrodynamic simulation of common envelope evolution to understand how energy is transferred between various forms, leading to the partial unbinding of the envelope. We find that 13–14% of the envelope is unbound during the simulation. Virtually all of the unbinding occurs before the end of the rapid plunge-in phase, here defined to coincide with the first periastron passage. In contrast, the total envelope energy is nearly constant during this time because positive energy transferred to the gas is counterbalanced by the negative binding energy from the closer proximity of the inner layers to the plunged-in secondary. During the subsequent slow spiral-in phase, energy continues to transfer to the envelope from the red giant core and secondary core particles. In our analysis, we critically assess the commonly used $\alpha_{\rm CE}$-energy formalism, and suggest an alternative that more cleanly separates core particles and gas. Applying this formalism, we discuss that overcoming current limitations of existing simulations with respect to both the accessible parameter regime and the giant model may enable complete envelope ejection from orbital evolution even without new energy sources. We also propose that relative motion between the centre of mass of the envelope and the centre of mass of the particles could account for the offsets of planetary nebula central stars from the nebula's geometric centre.

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Infrared spectroscopy of symbiotic stars. XII. The neutron star SyXB system 4U 1700+24 = V934 Herculis

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V934 Her = 4U 1700+24 is an M giant–neutron star (NS) X-ray symbiotic (SyXB) system. Employing optical and infrared radial velocities spanning 29 years combined with the extensive velocities in the literature, we compute the spectroscopic orbit of the M giant in that system. We determine an orbital period of 4391 days or 12.0 yr, the longest for any SyXB, and far longer than the 404 day orbit commonly cited for this system in the literature. In addition to the 12.0 yr orbital period we find a shorter period of 420 days, similar to the one previously found. Instead of orbital motion, we attribute this much shorter period to long secondary pulsation of the M3 III SRb variable. Our new orbit supports earlier work that concluded that the orbit is seen nearly pole on, which is why X-ray pulsations associated with the NS have not been detected. We estimate an orbital inclination of $11.3^\circ \pm 0.4^\circ$. Arguments are made that this low inclination supports a pulsation origin for the 420 day long secondary period. We also measure CNO and Fe peak abundances of the M giant and find it to be slightly metal poor compared to the Sun with no trace of the NS forming SN event. Basic properties of the M giant and NS are derived. We discuss the possible evolutionary paths that this system has taken to get to its current state.

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The discovery of a Li-Na-rich giant star in ω Centauri: formed from the pure ejecta of super-AGB stars?

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We report the discovery of two Li-rich giant stars (fainter than the red giant branch bump) in the stellar system ω Centauri using GIRAFFE-FLAMES spectra. These two stars have A(Li) = 1.65 and 2.40 dex and they belong to the main population of the system ([Fe/H] = −1.70 and −1.82, respectively). The most Li-rich of them (#25664) has [Na/Fe] = +0.87 dex that is $\sim$ 0.5 dex higher than those measured in the most Na-rich stars of ω Centauri of similar metallicity. The chemical abundances of Li and Na in #25664 can be qualitatively explained by deep extra mixing efficient within the star during its RGB evolution or by super-asymptotic giant branch (AGB) stars with masses between $\sim$ 7 and 8 $M_\odot$. In the latter scenario, this Li-Na-rich star could be formed from the pure ejecta of super-AGB stars before the dilution with pristine material occurs, or, alternatively, be part of a binary system and experienced mass transfer from the companion when this latter evolved through the super-AGB phase. In both these cases, the chemical composition of this unique object could allow to look for the first time at the chemical composition of the gas processed in the interior of super-AGB stars.

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Condensation of SiC stardust in CO nova outbursts

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This study on presolar grains compares high-precision isotopic compositions of individual SiC grains with low $^{12}C/^{13}C$ ratios, low $^{14}N/^{15}N$ ratios, large ^{30}Si excesses and high $^{26}Al/^{27}Al$ ratios, available in the presolar grain database, to new CO nova models with white dwarf (WD) masses from 0.6–1.35 $M_\odot$. The models were designed to match the Large Binocular Telescope (LBT) high dispersion spectra acquired for nova V5668 Sgr (Starrfield et al. 2018). These CO nova models provide elemental abundances up to calcium and include mixing of WD material into the accreted material in a binary star system under several scenarios, including one where mixing occurs only after temperatures $> 7 \times 10^7$ K are achieved during a thermonuclear runaway (TNR). The 0.8–1.35 $M_\odot$ simulations where 25% of the WD core matter mixes with 75% of the accreted material (assumed solar) from its binary companion after the TNR has begun, provide the best fits to the measured isotopic data in four presolar grains. One grain matches the 50% accreted 50% solar 1.35 $M_\odot$ simulation. For these five presolar grains, less than 25% of solar system material is required to be mixed with the CO nova ejecta to account for the grains' compositions. Thus, our study reports evidence of *pure* CO nova ejecta material in meteorites. Finally, we speculate that SiC grains can form in the winds of cool and dense CO novæ, where the criterion C > O may not be locally imposed, and thus nova winds can be chemically inhomogeneous.

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The morpho-kinematics of the circumstellar envelope around the AGB star EP Aqr

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ALMA observations of CO(1–0) and CO(2–1) emissions of the circumstellar envelope of EP Aqr, an oxygen-rich AGB star, are reported. A thorough analysis of their properties is presented using an original method based on the separation of the data-cube into a low velocity component associated with an equatorial outflow and a faster component associated with a bipolar outflow. A number of important and new results are obtained concerning the distribution in space of the effective emissivity, the temperature, the density and the flux of matter. A mass loss rate of $(1.6 \pm 0.4) \times 10^{-7}$ $M_\odot$ yr^{-1} is measured. The main parameters defining the morphology and kinematics of the envelope are evaluated and uncertainties inherent to de-projection are critically discussed. Detailed properties of the equatorial region of the envelope are presented including a measurement of the line width and a precise description of the observed inhomogeneity of both morphology and kinematics. In particular, in addition to the presence of a previously observed spiral enhancement of the morphology at very small Doppler velocities, a similarly significant but uncorrelated circular enhancement of the expansion velocity is revealed, both close to the limit of sensitivity. The results of the analysis place significant constraints on the parameters of models proposing descriptions of the mass loss mechanism, but cannot choose among them with confidence.

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First stellar spectroscopy in Leo P

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We present the first stellar spectroscopy in the low-luminosity ($M_V \sim -9.3$ mag), dwarf galaxy Leo P. Its significantly low oxygen abundance (3% solar) and relative proximity ($\sim$ 1.6 Mpc) make it a unique galaxy to investigate the properties of massive stars with near-primordial compositions akin to those in the early Universe. From our VLT-MUSE spectroscopy we find the first direct evidence for an O-type star in the prominent H II region. The spectroscopic confirmation of such a massive star supports arguments that the upper limit to the initial mass function, even if sparsely sampled, is not significantly influenced by the low star-formation rate of Leo P. We classify 14 further sources as massive stars (and 17 more as candidate massive stars), most likely B-type objects. From comparisons with published evolutionary models we argue that the absolute visual magnitudes of massive stars in very metal-poor systems such as Leo P and I Zw 18 may be fainter by ~ 0.5 mag compared to Galactic stars. We also present spectroscopy of two carbon stars identified previously as candidate asymptotic-giant-branch stars. Two of three further candidate asymptotic-giant-branch stars display Ca II absorption, confirming them as cool, evolved stars; we also recover Ca II absorption in the stacked data of the next brightest 16 stars in the upper red giant branch. These discoveries will provide targets for future observations to investigate the physical properties of these objects and to calibrate evolutionary models of luminous stars at such low metallicity. The MUSE data also reveal two 100-pc-scale ring structures in Hα emission, with the H II region located on the Northern edge of the Southern ring. Lastly, we report serendipitous observations of 20 galaxies, with redshifts ranging from $z = 0.39$, to a close pair of star-forming galaxies at $z = 2.5$.

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Hen 3-160 – the first symbiotic binary with Mira variable S star

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Hen 3-160 is reported in Belczyński et al.'s (2000) catalog as a symbiotic binary system with M7 giant donor. Using V- and I-band photometry collected over 20 years we have found that the giant is a Mira variable pulsating with 242.5-day period. The period–luminosity relation locates Hen 3-160 at the distance of about 9.4 kpc, and its Galactic coordinates ($l = 267.^{\circ}7$, $b = -7.^{\circ}9$) place it ~ 1.3 kpc above the disc. This position combined with relatively high proper motions ($pm_{\rm RA} = -1.5$ mas yr^{-1}, $pm_{\rm DEC} = +2.9$ mas yr^{-1}, Gaia DR2) indicates that Hen 3-160 has to be a Galactic extended thick-disc object. Our red optical and infrared spectra show the presence of ZrO and YO molecular bands that appear relatively strong compared to the TiO bands. Here we propose that the giant in this system is intrinsic S star, enriched in products of slow neutron capture processes occurring in its interior during an AGB phase which would make Hen 3-160 the first symbiotic system with Mira variable S star.

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The SPIRITS sample of luminous infrared transients: uncovering hidden supernovæ and dusty stellar outbursts in nearby galaxies

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We present a systematic study of the most luminous ($M_{\rm IR}$ [Vega magnitudes] brighter than -14) infrared (IR) transients discovered by the *SPitzer* InfraRed Intensive Transients Survey (SPIRITS) between 2014–2018 in nearby galaxies ($D < 35$ Mpc). The sample consists of 9 events that span peak IR luminosities of $M_{[4.5],\rm peak}$ between -14 and -18.2 mag, show IR colors between $0.2 < ([3.6]-[4.5]) < 3.0$ mag, and fade on timescales between $55 < t_{\rm fade} < 480$ days. The two reddest events ($A_V > 12$ mag) show multiple, luminous IR outbursts over several years and have directly detected, massive progenitors in archival imaging. With analyses of extensive, multi-wavelength follow-up, we infer the following likely classifications: 5 obscured core-collapse supernovæ (CCSNe), 2 erupting massive stars, 1 massive stellar merger, and 1 possible electron capture SN. We define a control sample of all optically discovered transients recovered in SPIRITS galaxies and satisfying the same selection criteria. The control sample consists of 8 CCSNe and 1 Type Iax SN. We find that 7 of the 13 CCSNe in the SPIRITS sample have lower bounds on extinction of $2 < A_V < 8$ mag, suggesting that a large population of CCSNe is heavily obscured. We estimate a nominal fraction of CCSNe in nearby galaxies that are missed by optical surveys of $38.5^{+26.0}_{-21.9}$% (90% confidence). This may resolve long-standing discrepancies between measurements of the CCSN rate and the cosmic star-formation rate.

Available from https://arxiv.org/abs/1901.00871

On the desert between neutron star and black hole remnants

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The occurrence of a desert between neutron star (NS) and black hole (BH) remnants is reviewed. The dependence of stellar remnants on the zero age main sequence (ZAMS) progenitor mass for solar metallicity is taken from a recent investigation and further effort is devoted to NS and BH remnants. In particular, a density parameter is defined and related to NS mass and radius. Spinning BHs in Kerr metrics are considered as infinitely thin, homogeneous, rigidly rotating disks in Newtonian mechanics. Physical parameters for nonrotating (TOV) and equatorial breakup (EQB) configurations are taken or inferred from a recent investigation with regard to 4 NS and 3 quark star (QS) physically motivated equation of state (EOS) kinds. A comparison is performed with counterparts related to nonrotating and maximally rotating BHs. The results are also considered in the light of empirical relations present in literature. With regard to J–M relation, EQB configurations are placed on a sequence of similar slope in comparison to maximally rotating BHs, but shifted downwards due to lower angular momentum by a factor of about 3.6. Under the assumption heavy baryons are NS constituents and instantaneously undergo quark-level reactions, the energy released (or adsorbed) is calculated using results from a recent investigation. Even if NSs exclusively host heavy baryons of the kind considered, the total amount cannot exceed about 10% of the binding energy, which inhibits supernova explosions as in supramassive white dwarf (WD) remnants or implosions into BH. Alternative channels for submassive ($2 \leq M/\mathrm{M}_\odot \leq 4$) BH formation are shortly discussed.

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The evolution toward electron-capture supernovæ: the flame propagation and the pre-bounce electron-neutrino radiation

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A critical mass ONe core with a high ignition density is considered to end in gravitational collapse leading to neutron star formation. Being distinct from a Fe core collapse, the final evolution involves combustion flame propagation, in which complex phase transition from ONe elements into the nuclear-statistical-equilibrium (NSE) state takes place. We simulate the core evolution from the O+Ne ignition until the bounce shock penetrates the whole core, using a state-of-the-art 1D Lagrangian neutrino-radiation-hydrodynamic code, in which important nuclear burning, electron capture, and neutrino reactions are taken into account. Special care is also taken in making a stable initial condition by importing the stellar EOS, which is used for the progenitor evolution calculation, and by improving the remapping process. We find that the central ignition leads to intense ν_e radiation with $L_{\nu_\mathrm{e}} \gtrsim 10^{51}$ erg s^{-1} powered by fast electron captures onto NSE isotopes. This pre-bounce ν_e radiation heats the surroundings by the neutrino-electron scattering, which acts as a new driving mechanism of the flame propagation together with the adiabatic contraction. The resulting flame velocity of $\sim 10^8$ cm s^{-1} will be more than one-order-of-magnitude faster than that of laminar flame driven by heat conduction. We also find that the duration of the pre-bounce ν_e radiation phase depends on the degree of the core hydrostatic/dynamical stability. Therefore, the future detection of the pre-bounce neutrino is important not only to discriminate the ONe core collapse from the Fe core collapse but also to constrain the progenitor hydrodynamical stability.

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Physical properties of Galactic RV Tauri stars from Gaia DR2 data

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We present the first period–luminosity and period–radius relation of Galactic RV Tauri variable stars. We have surveyed the literature for all variable stars belonging to this class and compiled the full set of their photometric and spectroscopic measurements. We cross-matched the final list of stars with the Gaia DR2 database and took the parallaxes, G-band magnitudes and effective temperatures to calculate the distances, luminosities and radii using a probabilistic approach. As it turned out, the sample was very contaminated and thus we restricted our study to those

objects for which the RV Tau-nature was securely confirmed. We found that several stars are located outside the red edge of the classical instability strip, which implies a wider pulsational region for RV Tau stars. The period–luminosity relation of galactic RV Tauri stars is steeper than that of the shorter-period Type II Cepheids, in agreement with previous result obtained for the Magellanic Clouds and globular clusters. The median masses of RVa and RVb stars were calculated to be 0.45–0.52 $M_\odot$ and 0.83 $M_\odot$, respectively.

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Study of lithium-rich giants with the GALAH spectroscopic survey

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In this article, we speculate on the possible mechanisms for Li enhancement origin in RGB stars based on a large data set of around 340,299 stars collected from the GALAH survey combined with the Gaia astrometry. Data has 51,982 low mass ($M \leq 2$ $M_\odot$) RGB stars with reliable atmospheric parameters. The data set shows a well populated RGB with well-defined luminosity bump and red clump with significant number of stars at each of these two key phases. We found 335 new Li-rich RGB stars with Li abundance, A(Li) $\geq 1.80 \pm 0.14$ dex, of which 20 are super Li-rich with A(Li) ≥ 3.20 dex. Most of them appear to be in the red clump region which, when combined with stellar evolutionary timescales on RGB, indicates that the Li enhancement origin may lie at RGB tip during He-flash rather than by external source of merging of sub-stellar objects or during luminosity bump evolution. Kinematic properties of sample stars suggest that Li-rich giants are relatively more prevalent among giants of thin disk compared to thick disk and halo.

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Discovery of stars surrounded by iron dust in the LMC

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We consider a small sample of oxygen-rich, asymptotic giant branch stars in the Large Magellanic Cloud, observed by the *Spitzer* Space Telescope, exhibiting a peculiar spectral energy distribution, which can be hardly explained by the common assumption that dust around AGB stars is primarily composed of silicate grains. We suggest that this uncommon class of objects are the progeny of a metal-poor generation of stars, with metallicity $Z \sim 1$–2×10^{-3}, formed ~ 100 Myr ago. The main dust component in the circumstellar envelope is solid iron. In these stars the poor formation of silicates is set by the strong nucleosynthesis experienced at the base of the envelope, which provokes a scarcity of magnesium atoms and water molecules, required to the silicate formation. The importance of the present results to interpret the data from the incoming *James Webb* Space Telescope is also discussed.

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The white dwarf mass–radius relation and its dependence on the hydrogen envelope

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We present a study of the dependence of the mass–radius relation for DA white dwarf stars on the hydrogen envelope mass and the impact on the value of $\log g$, and thus the determination of the stellar mass. We employ a set of full evolutionary carbon–oxygen core white dwarf sequences with white dwarf mass between 0.493 and 1.05 $M_\odot$. Computations of the pre-white dwarf evolution uncovers an intrinsic dependence of the maximum mass of the hydrogen envelope with stellar mass, i.e. it decreases when the total mass increases. We find that a reduction of the hydrogen envelope mass can lead to a reduction in the radius of the model of up to $\sim$ 12%. This translates directly into an increase in $\log g$ for a fixed stellar mass, that can reach up to 0.11 dex, mainly overestimating the determinations of stellar mass from atmospheric parameters. Finally, we find a good agreement between the results from the theoretical mass–radius relation and observations from white dwarfs in binary systems. In particular, we find a thin hydrogen mass of $M_{\rm H} \sim 2 \times 10^{-8}$ $M_\odot$, for 40 Eridani B, in agreement with previous determinations. For Sirius B, the spectroscopic mass is 4.3% lower than the dynamical mass. However, the values of mass and radius from gravitational redshift observations are compatible with the theoretical mass–radius relation for a thick hydrogen envelope of $M_{\rm H} = 2 \times 10^{-6}$ $M_\odot$.

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Organics in the Solar System

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Complex organics are now commonly found in meteorites, comets, asteroids, planetary satellites, and interplanetary dust particles. The chemical composition and possible origin of these organics are presented. Specifically, we discuss the possible link between Solar System organics and the complex organics synthesized during the late stages of stellar evolution. Implications of extraterrestrial organics on the origin of life on Earth and the possibility of existence of primordial organics on Earth are also discussed.

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A novel approach to constrain rotational mixing & convective-core overshoot in stars using the initial–final mass relation

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The semi-empirical initial–final mass relation (IFMR) connects spectroscopically analyzed white dwarfs in star clusters to the initial masses of the stars that formed them. Most current stellar evolution models, however, predict that stars will evolve to white dwarfs ~ 0.1 $M_\odot$ less massive than that found in the IFMR. We first look at how varying theoretical mass-loss rates, third dredge-up efficiencies, and convective-core overshoot may help explain the differences between models and observations. These parameters play an important role at the lowest masses ($M_{\rm initial} < 3$ $M_\odot$). At higher masses, only convective-core overshoot meaningfully affects white dwarf mass, but alone it likely cannot explain the observed white dwarf masses nor why the IFMR scatter is larger than observational errors predict. These higher masses, however, are also where rotational mixing in main sequence stars begins to create more massive cores, and hence more massive white dwarfs. This rotational mixing also extends a star's lifetime, making faster rotating progenitors appear like less massive stars in their semi-empirical age analysis. Applying the observed range of young B-dwarf rotations to the MIST or SYCLIST rotational models demonstrates a marked improvement in reproducing both the observed IFMR data and its scatter. The incorporation of both rotation and efficient convective-core overshoot significantly improves the match with observations. This work shows that the IFMR provides a valuable observational constraint on how rotation and convective-core overshoot affect the core evolution of a star.

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Unusual neutron-capture nucleosynthesis in a carbon-rich Galactic bulge star

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Metal-poor stars in the Galactic halo often show strong enhancements in carbon and/or neutron-capture elements. However, the Galactic bulge is notable for its paucity of these carbon-enhanced metal-poor (CEMP) and/or CH-stars, with only two such objects known to date. This begs the question whether the processes that produced their abundance distribution were governed by a comparable nucleosynthesis in similar stellar sites as for their more numerous counterparts in the halo.
Recently, two contenders of these classes of stars were discovered in the bulge, at [Fe/H] = −1.5 and −2.5 dex, both of which show enhancements in [C/Fe] of 0.4 and 1.4 dex (respectively), [Ba/Fe] in excess of 1.3 dex, and also elevated nitrogen. The more metal-poor of the stars can be well matched by standard *s*-process nucleosynthesis in low-mass asymptotic giant branch (AGB) polluters. The other star shows an abnormally high [Rb/Fe] ratio.
Here, we further investigate the origin of the abundance peculiarities in the Rb-rich star by new, detailed measurements of heavy element abundances and by comparing the chemical element ratios of 36 species to several models of neutron-capture nucleosynthesis.
The *i*-process with intermediate neutron densities between those of the slow (*s*-) and rapid (*r*)-neutron-capture processes has been previously found to provide good matches of CEMP stars with enhancements in both *r*- and *s*-process elements (class CEMP-r/s), rather than invoking a superposition of yields from the respective individual processes. However, the peculiar bulge star is incompatible with a pure *i*-process from a single ingestion event. Instead, it can, statistically, be better reproduced by more convoluted models accounting for two proton ingestion events, or by an *i*-process component in combination with *s*-process nucleosynthesis in low-to-intermediate mass (2–3 $M_\odot$) AGB stars, indicating multiple polluters. Finally, we discuss the impact of mixing during stellar evolution on the observed abundance peculiarities.

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Two newly imaged, faint protoplanetary nebulæ from contrast enhanced *Hubble* archival observations

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Studying the asymmetries of Protoplanetary Nebulæ (PPNe) is important to understanding the processes breaking the spherical symmetry of the envelopes of Asymptotic Giant Branch stars and the formation of asymmetric planetary nebulæ. Previous imaging of PPNe with the *Hubble* Space Telescope has revealed prominent, resolved nebulosity around two third of the targets, but the other third showed no obvious nebulosity despite having infrared excesses indicating the presence of PPNe. We present the first, preliminary results from our efforts to enhance the contrast and improve the inner working angles of archival HST images of PPNe. We reveal nebulosities that were not seen in previous analyses of images of HD 133656 (IRAS 15039−4806) and HD 158616 (V340 Ser, IRAS 17279−1119). HD 133656 is a likely single post-AGB star that is not enriched with *s*-process elements, suggesting it failed the third dredge-up. HD 158616 is an RV Tauri star with a near infrared excess indicative of a circumbinary disk. Both PPNe have similar angular sizes but higher contrasts compared to previously imaged ones, suggesting that contrast, not angular size, may be the reason for many other non-detections in *Hubble* images.

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Resolved imaging of the AR Puppis circumbinary disk

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Circumbinary disks are common around post-asymptotic giant branch (post-AGB) stars with a stellar companion on orbital time scales of a few 100 to few 1000 days. The presence of a disk is usually inferred from the system's spectral energy distribution (SED), and confirmed, for a sub-sample, by interferometric observations. We used the Spectro-Polarimetric High contrast Exoplanet REsearch (SPHERE) instrument on the Very Large Telescope to obtain extreme adaptive optics assisted scattered light images of the post-AGB binary system AR Puppis. Data have been obtained in the V, I, and H bands. Our observations have produced the first resolved images of AR Puppis' circumbinary disk and confirm its edge-on orientation. In our high angular-resolution and high dynamic-range images we identify several structural components such as a dark mid-plane, the disk surface, and arc-like features. We discuss the nature of these components and use complementary photometric monitoring to relate them to the orbital phase of the binary system. Because the star is completely obscured by the disk at visible wavelengths, we conclude that the long-term photometric variability of the system must be caused by variable scattering, not extinction, of star light by the disk over the binary

orbit. Finally, we discuss how the short disk life times and fast evolution of the host stars compared to the ages at which protoplanetary disks are typically observed make systems like AR Puppis valuable extreme laboratories to study circumstellar disk evolution and constrain the time scale of dust grain growth during the planet formation process.

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Search for sodium rich stars among metal-poor stars

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Sodium rich stars are often found in globular clusters giants. However, some sodium rich stars have been found among field metal-poor stars. These stars are considered as evaporated from globular clusters. Identified such kind of stars among the field stars in the Galaxy may provide insights of which mechanism was responsible for the ejection from a globular cluster and may reveal some chemical peculiarity. Therefore, we started a search, using high-resolution spectroscopy, among metal-poor stars from several sources of the literature to find a sodium rich star. Here we present the results for the temperature, gravity, metallicity and sodium abundances for the stars of our sample. For many of them we determined the temperature, gravity, metallicity and sodium abundances for the first time. As a result of our search we found one star, CD $-23°16310$, which has a [Na/Fe] ratio of +1.09. We also show that CD $-23°16310$ is not a CEMP star since carbon is not enriched but is nitrogen rich. We did not detect any variation of the radial velocity that would support the hypothesis of mass transfer Thus, the high sodium and nitrogen abundance could be due to a strong internal mixing process, suggesting that CD $-23°16310$ is an early-AGB star.

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ExoMol line lists XXXI: Spectroscopy of lowest eights electronic states of C_2

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Accurate line lists for the carbon dimer, C_2, are presented. These line lists cover ro-vibronic transitions between the eight lowest electronic states: $X\,^1\Sigma_g^+$, $a\,^3\Pi_u$, $A\,^1\Pi_u$, $b\,^3\Sigma_g^-$, $c\,^3\Sigma_u^+$, $d^3\Pi_g$, $B\,^1\Delta_g$ and $B'\,^1\Sigma_g^+$. Potential energy curves (PECs) and transition dipole moment curves are computed on a large grid of geometries using the aug-cc-pwCVQZ-DK/MRCI level of theory including core and core-valence correlations and scalar relativistic energy corrections. The same level of theory is used to compute spin-orbit and electronic angular momentum couplings. The PECs and couplings are refined by fitting to the empirical (MARVEL) energies of $^{12}C_2$ using the nuclear-motion program Duo. The transition dipole moment curves are represented as analytical functions to reduce the numerical noise when computing transition line strengths. Partition functions, full line lists, Landé-factors and lifetimes for three main isotopologues of C_2 ($^{12}C_2$,$^{13}C_2$ and $^{12}C^{13}C$) are made available in electronic form from the CDS (http://cdsarc.u-strasbg.fr) and ExoMol (www.exomol.com) databases.

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Orion Source I's disk is salty

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We report the detection of NaCl, KCl, and their ^{37}Cl and ^{41}K isotopologues toward the disk around Orion Src I. About 60 transitions of these molecules were identified. This is the first detection of these molecules in the interstellar medium not associated with the ejecta of evolved stars. It is also the first ever detection of the vibrationally excited states of these lines in the ISM above $v = 1$, with firm detections up to $v = 6$. The salt emission traces the region just above the continuum disk, possibly forming the base of the outflow. The emission from the vibrationally excited transitions is inconsistent with a single temperature, implying the lines are not in LTE. We examine several possible explanations of the observed high excitation lines, concluding that the vibrational states are most likely to be radiatively excited via ro-vibrational transitions in the 25–35 μm (NaCl) and 35–45 μm (KCl) range. We suggest that the molecules are produced by destruction of dust particles. Because these molecules are so rare, they are potentially unique tools for identifying high-mass protostellar disks and measuring the radiation environment around accreting young stars.

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Circumstellar CO in metal-poor stellar winds: the highly irradiated globular cluster star 47 Tucanæ V3

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We report the first detection of circumstellar CO in a globular cluster. Observations with ALMA have detected the CO $J = 3$–2 and SiO $v = 1$ $J = 8$–7 transitions at 345 and 344 GHz, respectively, around V3 in 47 Tucanæ (NGC 104; [Fe/H] = -0.72 dex), a star on the asymptotic giant branch. The CO line is detected at 7 σ at a rest velocity $v_{\rm LSR} = -40.6$ km s^{-1} and expansion velocity of 3.2 ± 0.4 km s^{-1}. The brighter, asymmetric SiO line may indicate a circumstellar maser. The stellar wind is slow compared to similar Galactic stars, but the dust opacity remains similar to Galactic comparisons. We suggest that the mass-loss rate is set by the levitation of material into the circumstellar environment by pulsations, but that the terminal wind-expansion velocity is determined by radiation pressure on the dust: a pulsation-enhanced dust-driven wind. We suggest the metal-poor nature of the star decreases the grain size, slowing the wind and increasing its density and opacity. Metallic alloys at high altitudes above the photosphere could also provide an opacity increase. The CO line is weaker than expected from Galactic AGB stars, but its strength confirms a model that includes CO dissociation by the strong interstellar radiation field present inside globular clusters.

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The onset of the AGB wind tied to a transition between sequences in the period–luminosity diagram

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We link the onset of pulsation-enhanced, dust-driven winds from asymptotic giant branch (AGB) stars in the Magellanic Clouds to the star's transition between period–luminosity sequences (from B to C′). This transition occurs at ~ 60 days for solar-mass stars, which represent the bulk of the AGB population: this is the same period at which copious dust production starts in solar-neighbourhood AGB stars. It is contemporaneous with the onset of long-secondary period (LSP) variability on sequence D. The combined amplitude of the first-overtone (B+C′) and fundamental (C) modes and (perhaps) long-secondary period (D; LSP) variability appears to drive a sudden increase in mass-loss rate to a stable plateau, previously identified to be a few $\times 10^{-7}$ $M_\odot$ yr^{-1}. We cite this as evidence that pulsations are necessary to initiate mass loss from AGB stars and that these pulsations are significant in controlling stars' mass-loss rates. We also show evidence that LSPs may evolve from long to short periods as the star evolves, counter to the other period–luminosity sequences.

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A machine learning approach for identification and classification of symbiotic stars using 2MASS and WISE

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In this second paper in a series of papers based on the most-up-to-date catalogue of symbiotic stars (SySts), we present a new approach for identifying and distinguishing SySts from other Hα emitters in photometric surveys using machine learning algorithms such as classification tree, linear discriminant analysis, and K-nearest neighbour. The motivation behind of this work is to seek for possible colour indices in the regime of near- and mid-infrared covered by the 2MASS and WISE surveys. A number of diagnostic colour–colour diagrams are generated for all the known Galactic SySts and several classes of stellar objects that mimic SySts such as planetary nebulæ, post-AGB, Mira, single K and M giants, cataclysmic variables, Be, AeBe, YSO, weak and classical T Tauri stars, and Wolf–Rayet. The classification tree algorithm unveils that primarily J–H, W1–W4 and K_s–W3 and secondarily H–W2, W1–W2 and W3–W4 are ideal colour indices to identify SySts. Linear discriminant analysis method is also applied to determine the linear combination of 2MASS and AllWISE magnitudes that better distinguish SySts. The probability of a source being a SySt is determined using the K-nearest neighbour method on the LDA components. By applying our classification tree model to the list of candidate SySts (Paper I), the IPHAS list of candidate SySts, and the DR2 VPHAS+ catalogue, we find 125 (72 new candidates) sources that pass our criteria while we also recover 90 per cent of the known Galactic SySts.

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High velocity string of knots in the outburst of the planetary nebula Hb 4

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The bipolar collimated outflows of the Hb 4 planetary nebula (PN) exhibit an evident decrease in their expansion velocity with respect to the distance from the central star. So far, similar velocity law has also been found in Herbig–Haro objects. The interpretation of this peculiar velocity law and the classification of the outflows is the main focal point of this paper. High dispersion long-slit échelle spectra along with high resolution images from *Hubble* Space Telescope (HST) are applied in the astronomical code SHAPE in order to reproduce a three-dimensional morpho-kinematical model for the core and the bipolar outflows. Its central part shows a number of low-ionization filamentary structures (knots and jets) indicative of common-envelope PNe evolution and it is reconstructed assuming a toroidal structure. The high-resolution HST [N II] image of Hb 4 unveils the fragmented structure of outflows. The northern and southern outflows are composed by four and three knots, respectively, and each knot moves outwards with its own expansion velocity. They are reconstructed as string of knots rather than jets.This string of knots is formed by ejection events repeated every 200–250 years. Hb 4 displays several indirect evidence for a binary central system with a [WR] companion evolved through the common envelopes channel.The observed deceleration of the knots is likely associated with shock collisions between the knots and the interstellar medium or nebular material.

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Conference Paper

The evolution of DARWIN: current status of wind models for AGB stars

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The slow, dense winds observed in evolved asymptotic giant branch (AGB) stars are usually attributed to a combination of dust formation in the dynamical inner atmosphere and momentum transfer from stellar photons interacting with the newly formed dust particles. Wind models calculated with the DARWIN code, using this mass-loss scenario, have successfully produced outflows with dynamical and photometric properties compatible with observations, for both C-type and M-type AGB stars. Presented here is an overview of the DARWIN models currently available and what output these models produce, as well as future plans.

Oral contribution, published in IAU Symposium no. 343, 2018: "Why Galaxies Care about AGB Stars: A Continuing Challenge through Cosmic Time"
Available from https://arxiv.org/abs/1901.10954

Thesis

A journey across the Hertzsprung–Russell diagram with 3D hydrodynamical simulations of cool stars

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In this manuscript I summarise the work I have carried out in the last 10 years. My research projects are articulated around various fields in astrophysics having, as unifying theme, the 3D modelling and the observation of stellar atmospheres. In particular, my field of research covers all late type stars, from the Main Sequence stars to the advanced stages (red giant and supergiant stars). My work is based on the quantitative analysis of images, synthetic spectra, bolometric luminosity, planetary transits of different types of stars and on the modeling of their atmospheres. They include the use and development of 3D simulations that are necessary for the interpretation of the data obtained with the new instruments equipping the space borne and ground telescopes. Interferometry and spectroscopy hold a privileged place in my research. My research themes concern interdisciplinary aspects by addressing questions related to atmospheric physics in relation to 3D hydrodynamic models. The predictions thus obtained are used to drive a vast campaign of interferometric, astrometric, photometric, spectroscopic and imaging observations. Finally, 3D simulations are also directly used to drive the development of new generation instrument at the VLTI, as well as very large future observatories and are directly linked to the ESA Gaia and PLATO missions.

French Habilitation Thesis, defended at the Observatory of Nice (19-12-2018). Text is in English
Available from https://arxiv.org/abs/1812.11002

Announcements

Evolved stars (SS19) at EWASS2019

Dear all,

I would like to advertise the Special Session 19 on Evolved Stars at the "European Week of Astronomy and Space Science" (EWASS) from the 24^{th} to 28^{th} of June in Lyon (France).

We plan to focus on their multi-technique observations and subsequent modeling.

We hope to see you in Lyon.

Miguel Montargès
On behalf of the SOC of SS19/EWASS2019

See also https://eas.unige.ch//EWASS2019/session.jsp?id=SS19

OPTICON and ERASMUS+ School
"Observational Astrophysics: from proposals to publication"

The school "Observational Astrophysics: from proposals to publication" will take place 17–27 June 2019 at the Astronomical Institute of Slovak Academy of Sciences in Stará Lesná, Slovak Republic (Deadline for applications Sunday March 31). This school is mainly meant for Ph.D. students in astronomy, but also M.Sc. students in the later stages of their studies and young postdocs can be considered.

The school consists of two parts: hands-on project using archival data, and observing time proposal evaluation. In the first part the students will learn about the basics of data reduction and will work on archival data – reducing and analysing them with a help of an experienced tutor. During the second part the students will learn about proposal writing and will participate in a 'Telescope Time Allocation Committee meeting' where they will evaluate real observing time proposals. Additionally, the school also includes sessions on writing articles and careers in astronomy.

This school is jointly organised by OPTICON and ERASMUS+ programme 'Per aspera ad astra simul'. The local costs (accommodation and meals) are covered by OPTICON and ERASMUS+, and some limited travel support is also available (and needs to be applied for on the application form).

See also https://opticon-schools.nbi.ku.dk/other-schools/from-proposals-to-publication/

Cloudy **workshop 2019**

Registration is now open for the Cloudy workshop to be held from 2019 May 20 to May 24 at the University of Kentucky.

Cloudy is a large-scale code that simulates the microphysics of matter exposed to ionizing radiation. It calculates the atomic physics, chemistry, radiation transport, and dynamics problems simultaneously and self-consistently, building from a foundation of individual atomic and molecular processes. The result is a prediction of the conditions in the material and its observed spectrum.

The workshop will cover observations, theory, and application of Cloudy to a wide variety of astronomical environments. This includes the theory of diffuse matter and quantitative spectroscopy, the science of using spectra to make physical measurements. We will use Cloudy to simulate such objects as AGB stars, Active Galactic Nuclei, Starburst galaxies, and the intergalactic medium.

The sessions will consist of a mix of textbook study, using Osterbrock & Ferland, "Astrophysics of Gaseous Nebulæ and Active Galactic Nuclei", application of Cloudy to a variety of astrophysical problems, and projects organized by the participants. No prior experience with Cloudy is assumed although some knowledge of spectroscopy and the physics of the interstellar medium is useful.

See also http://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/