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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 281st issue of the AGB Newsletter, in which Leen Decin announces her invited review article – don't miss it! There is more work on Betelgeuse, too, as well as two "similar" papers on M 31 and M 33 (how coincidental!). And lots more.

Some of you, or your students, will certainly be interested in the fantastic job opportunities at STScI and ESO, both great places to develop your career and flourish as a person.

With the IAU General Assembly postponed to 2022 and Cool Stars going online (see end of Newsletter), it will be interesting to see – in another year's time – what we think about travelling to attend work meetings, and how this changes especially the experiences and opportunities of junior scientists and scientists from disadvantaged backgrounds – there will be negatives but also positives, and it is important that we take this moment to reflect and make our practices more inclusive and fair to all.

The next issue is planned to be distributed around the 1st of January. We hope you are able to take a small break from what has been a very difficult year for many, and to look forward to next year with optimism and kindness.

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

Food for Thought

This month's thought-provoking statement is:

When will Betelgeuse experience its next "Great Dimming" – or "Great Brightening"?

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

The impact of Coulomb diffusion of ions on the pulsational properties of DA white dwarfs

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Element diffusion is a key physical process that substantially impacts the superficial abundances, internal structure, pulsation properties, and evolution of white dwarfs. We study the effect of Coulomb separation of ions in the cooling times of evolving white dwarfs, their chemical profiles, the Brunt–Väisälä (buoyancy) frequency, and the pulsational periods at the ZZ Ceti instability strip. We follow the full evolution of white-dwarf models in the range 0.5–1.3 $M_\odot$ derived from their progenitor history on the basis of a time-dependent element diffusion scheme that incorporates the effect of gravitational settling of ions due to Coulomb interactions at high densities. We compare the results for the evolution and pulsation periods of ZZ Ceti stars with the case where this effect is neglected. We find that Coulomb sedimentation profoundly alters the chemical profiles of ultra-massive ($M_\star \gtrsim 1$ $M_\odot$) white dwarfs along their evolution, preventing helium from diffusing inward toward the core, and thus leading to much narrower chemical transition zones. As a result, significant changes in the g-mode pulsation periods as high as 15% are expected for ultra-massive ZZ Ceti stars. For less-massive white dwarfs, the impact of Coulomb separation is much less noticeable, inflicting period changes in ZZ Ceti stars that are below the period changes that result from uncertainties in progenitor evolution, albeit larger than typical uncertainties of observed periods. Coulomb diffusion of ions profoundly affects the diffusion flux in ultra-massive white dwarfs, driving the gravitational settling of ions with the same A/Z (mass to charge number). We show that it strongly alters the period spectrum of such white dwarfs, which should be taken into account in detailed asteroseismological analyses of ultra-massive ZZ Ceti stars.

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Available from https://arxiv.org/abs/2010.11131

Heavy element abundances in P-rich stars: A new site for the s-process?

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The recently discovered phosphorus-rich stars pose a challenge to stellar evolution and nucleosynthesis theory, as none of the existing models can explain their extremely peculiar chemical abundances pattern. Apart from the large phosphorus enhancement, such stars also show enhancement in other light (O, Mg, Si, Al) and heavy (e.g., Ce) elements. We have obtained high-resolution optical spectra of two optically bright phosphorus-rich stars (including a new P-rich star), for which we have determined a larger number of elemental abundances (from C to Pb). We confirm the unusual light-element abundance pattern with very large enhancements of Mg, Si, Al, and P, and possibly some Cu enhancement, but the spectra of the new P-rich star is the only one to reveal some C(+N) enhancement. When compared to other appropriate metal-poor and neutron-capture enhanced stars, the two P-rich stars show heavy-element overabundances similar to low neutron density s-process nucleosynthesis, with high first- (Sr, Y, Zr) and second-peak (Ba, La, Ce, Nd) element enhancements (even some Pb enhancement in one star) and a negative [Rb/Sr] ratio. However, this s-process is distinct from the one occurring in asymptotic giant branch (AGB) stars. The notable distinctions encompass larger [Ba/La] and lower Eu and Pb than their AGB counterparts. Our observations should guide stellar nucleosynthesis theoreticians and observers to identify the P-rich star progenitor, which represents a new site for s-process nucleosynthesis, with important implications for the chemical evolution of our Galaxy.

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Available from https://arxiv.org/abs/2011.00460

The nearby magnetic cool DZ white dwarf PM J08186−3110

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We present an analysis of photometric, spectroscopic and spectropolarimetric data of the nearby, cool, magnetic DZ white dwarf PM J08186−3110. High dispersion spectra show the presence of Zeeman splitted spectral lines due to the presence of a surface average magnetic field of 92 kG. The strong magnesium and calcium lines show extended wings shaped by interactions with neutral helium in a dense, cool helium-rich atmosphere. We found that the abundance of heavy elements varied between spectra taken ten years apart but we could not establish a time-scale for these variations; such variations may be linked to surface abundance variations in the magnetized atmosphere. Finally, we show that volume limited samples reveal that about 40% of DZ white dwarfs with effective temperatures below 7000 K are magnetic.

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Detection of infrared fluorescence of carbon dioxide in R Leonis with SOFIA/EXES

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We report on the detection of hot CO_2 in the O-rich AGB star R Leo based on high spectral resolution observations in the range 12.8–14.3 μm carried out with the Echelon-cross-Echelle Spectrograph (EXES) mounted on the Stratospheric Observatory for Infrared Astronomy (SOFIA). We have found $\simeq$ 240 CO_2 emission lines in several vibrational bands. These detections were possible thanks to a favorable Doppler shift that allowed us to avoid contamination by telluric CO_2 features. The highest excitation lines involve levels at an energy of $\simeq$ 7000 K. The detected lines are narrow (average deconvolved width $\simeq 2.5$ km s^{-1}) and weak (usually $< 10\%$ the continuum). A ro-vibrational diagram shows that there are three different populations, warm, hot, and very hot, with rotational temperatures of $\simeq$ 550, 1150, and 1600 K, respectively. From this diagram, we derive a lower limit for the column density of $\simeq 2.2 \times 10^{16}$ cm^{-2}. Further calculations based on a model of the R Leo envelope suggest that the total column density can be as large as 7×10^{17} cm^{-2} and the abundance with respect to $H_2 \simeq 2.5 \times 10^{-5}$. The detected lines are probably formed due to de-excitation of CO_2 molecules from high energy vibrational states, which are essentially populated by the strong R Leo continuum at 2.7 and 4.2 μm.

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Water vapour masers in long-period variable stars – II. Semi-regular variables R Crt and RT Vir

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Within the 'Medicina/Effelsberg H_2O maser monitoring program' we have observed the maser emission of R Crt and RT Vir for more than two decades. To get insight in the distribution and longevity of maser spots in the circumstellar envelopes, we have collected interferometric data, taken in the same period, from the literature. We confirm short-time variations of individual maser features on timescales of months to up to 1.5 years. Also decade-long variations of the general brightness level independent from individual features were seen in both stars. These are due to brightness variations occurring independently from each other in selected velocity ranges, and are independent of the optical lightcurves. Expected drifts in velocity of individual features are usually masked by blending. However, in RT Vir we found an exceptional case of a feature with a constant velocity over 7.5 years (< 0.06 km s^{-1} yr^{-1}). We attribute the long-term brightness variations to the presence of regions with higher-than-average density in the stellar wind, which host several clouds which emit maser radiation on the short time scales. These regions typically need ~ 20 years to cross the H_2O maser shell, where the right conditions to excite H_2O masers are present. The constant velocity feature (11 km s^{-1}) is likely to come from a single maser cloud, which moved through about half of RT Vir's H_2O maser shell without changing velocity. From this we infer that its path was located in the outer part of the H_2O maser shell, where RT Vir's stellar wind apparently has already reached its terminal outflow velocity. This conclusion is corroborated by the observation that the highest H_2O maser outflow velocity in RT Vir approaches the terminal outflow velocity as given by OH and CO observations. This is generally not observed in other semi-regular variable stars.

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and from https://www.aanda.org/articles/aa/abs/2020/12/aa39157-20/aa39157-20.html

Near-infrared spectroscopy of CK Vulpeculæ: revealing a remarkably powerful blast from the past

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CK Vulpeculæ, which erupted in AD 1670–71, was long considered to be a nova outburst; however, recent observations have required that alternative scenarios be considered. Long slit infrared spectroscopy of a forbidden line of iron reported here has revealed high line-of-sight velocities ($\sim \pm 900$ km s^{-1}) of the ansæ at the tips of the bipolar lobes imaged in Hα in 2010. The deprojected velocities of the tips are approximately ± 2130 km s^{-1} assuming the previously derived inclination angle of 65° for the axis of cylindrical symmetry of the bipolar nebula. Such high velocities are in stark contrast to previous reports of much lower expansion velocities in CK Vul. Based on the deprojected velocities

of the tips and their angular expansion measured over a 10-year baseline, we derive a revised estimate, with estimated uncertainties, of $3.2^{+0.9}_{-0.6}$ kpc for the distance to CK Vul. This implies that the absolute visual magnitude at the peak of the 1670 explosion was $M_V = -12.4^{+1.3}_{-2.4}$, indicating that the 1670 event was far more luminous than previous estimates and brighter than any classical nova or any Galactic stellar merger. We propose that CK Vul belongs to the class of Intermediate Luminosity Optical Transients (ILOTs), objects which bridge the luminosity gap between novæ and supernovæ. While eruptions in lower luminosity ILOTs are attributed to merger events, the origin of the highly luminous ILOT outbursts is currently not known.

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Wide binaries in planetary nebulæ with Gaia DR2

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Context: Gaia Data Release 2 (DR2) was used to select a sample of 211 central stars of planetary nebulæ (CSPNe) with good quality astrometric measurements, that we refer to as GAPN, Golden Astrometry Planetary Nebulæ. Gaia astrometric and photometric measurements allowed us to derive accurate distances and radii, and to calculate luminosities with the addition of self-consistent literature values. Such information was used to plot the position of these stars in a Hertzsprung–Russell (HR) diagram and to study their evolutionary status in comparison with CSPNe evolutionary tracks.
Aims: The extremely precise measurement of parallaxes and proper motions in Gaia DR2 has allowed us to search for wide binary companions in a region close to each of the central stars in the GAPN sample. We are interested in establishing the presence of binary companions at large separations which could allow to add further information on the influence of binarity on the formation and evolution of planetary nebulæ. We aim to study the evolutive properties of the binary pairs to check the consistency of spectral types and masses in order to better constrain the ages and evolutionary stage of the CSPNe.
Methods: We limited our search to a region around 20,000 au of each CSPN to minimise accidental detections, and only considered stars with good parallax and proper motions data, i.e. with errors below 30% in DR2. We determined that the hypothetical binary pairs should show a statistically significant agreement for the three astrometric quantities, i.e. parallax and both components of proper motions.
Results: We found 8 wide binary systems among our GAPN sample. One of them is in a triple system. We compiled the astrometric and photometric measurements of these binary systems and discussed them in comparison with previously published searches for binaries in PNe. By analysing the position in the HR diagram of the companion stars using Gaia photometry, we are able to estimate their temperatures, luminosities, masses and, for one star, the evolutionary age. The derived quantities yield a consistent scenario when compared with the corresponding values as obtained for the central stars using stellar evolutionary models in the post-AGB phase.

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The photospheric temperatures of Betelgeuse during the Great Dimming of 2019/2020: No new dust required

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The processes that shape the extended atmospheres of red supergiants, heat their chromospheres, create molecular reservoirs, drive mass loss, and create dust remain poorly understood. Betelgeuse's V-band "Great Dimming" event of 2019 September / 2020 February and its subsequent rapid brightening provides a rare opportunity to study these phenomena. Two different explanations have emerged to explain the dimming; new dust appeared in our line of sight attenuating the photospheric light, or a large portion of the photosphere had cooled. Here we present five years of Wing three-filter (A, B, and C band) TiO and near-IR photometry obtained at the Wasatonic Observatory. These reveal that parts of the photosphere had a mean effective temperature ($T_{\rm eff}$) significantly lower than that found by Levesque & Massey (2020). Synthetic photometry from MARCS-model photospheres and spectra reveal that the V band, TiO index, and C-band photometry, and previously reported 4000–6800Å spectra can be quantitatively reproduced if there are multiple photospheric components, as hinted at by Very Large Telescope (VLT)-SPHERE images (Montargès et al. 2020). If the cooler component has $\Delta T_{\rm eff} \geq 250$ K cooler than 3650 K, then no new dust is required to explain the available empirical constraints. A coincidence of the dominant short- ($\sim$ 430 day) and long-period ($\sim$ 5.8 yr) V-band variations occurred near the time of deep minimum (Guinan et al. 2019a). This is in tandem with the strong correlation of V mag and photospheric radial velocities, recently reported by Dupree et al. (2020b). These suggest that the cooling of a large fraction of the visible star has a dynamic origin related to the photospheric motions, perhaps arising from pulsation or large-scale convective motions.

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Simulations of multiple nova eruptions induced by wind accretion in symbiotic systems

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We use a combined binary evolution code including dynamical effects to study nova eruptions in a symbiotic system. Following the evolution, over $\sim 10^5$ years, of multiple consecutive nova eruptions on the surface of a 1.25-$M_\odot$ white dwarf (WD) accretor, we present a comparison between simulations of two types of systems. The first is the common, well known, cataclysmic variable (CV) system in which a main sequence donor star transfers mass to its WD companion via Roche-lobe overflow. The second is a detached, widely separated, symbiotic system in which an asymptotic giant branch donor star transfers mass to its WD companion via strong winds. For the latter we use the Bondi–Hoyle–Lyttleton prescription along with orbital dynamics to calculate the accretion rate. We use the combined stellar evolution code to follow the nova eruptions of both simulations including changes in mass, accretion rate and orbital features. We find that while the average accretion rate for the CV remains fairly constant, the symbiotic system experiences distinct epochs of high and low accretion rates. The examination of epochs for which the accretion rates of both simulations are similar, shows that the evolutionary behaviors are identical. We obtain that for a given WD mass, the rate that mass is accreted ultimately determines the development, and that the stellar class of the donor is of no significance to the development of novæ. We discuss several observed systems and find that our results are consistent with estimated parameters of novæ in widely separated symbiotic systems.

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Interstellar extinction and elemental abundances

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Elements in the interstellar medium (ISM) exist in the form of gas or dust. The interstellar extinction and elemental abundances provide crucial constraints on the composition, size and quantity of interstellar dust. Most of the extinction modeling efforts have assumed the total abundances (both in gas and in dust) of the dust-forming elements – known as the "interstellar abundances", the "interstellar reference abundances", or the "cosmic abundances" – to be solar and the gas-phase abundances to be independent of the interstellar environments. However, it remains unclear if the solar abundances are an appropriate representation of the interstellar abundances. Meanwhile, the gas-phase abundances are known to exhibit appreciable variations with the local interstellar environments. In this work we explore the viability of the abundances of B stars, the solar and protosolar abundances, and the protosolar abundances augmented by Galactic chemical enrichment (GCE) as an appropriate representation of the interstellar abundances by quantitatively examining the extinction and elemental abundances of ten interstellar lines of sight for which both the extinction curves and the gas-phase abundances of all the major dust-forming elements (i.e. C, O, Mg, Si and Fe) have been observationally determined. Instead of assuming a specific dust model and then fitting the observed extinction curves, for each sightline we apply the model-independent Kramers–Kronig relation, which relates the wavelength-integrated extinction to the total dust volume, to place a lower limit on the dust depletion. This, together with the observationally-derived gas-phase abundances, allows us to rule out the B-star, solar, and protosolar abundances as the interstellar reference standard. We conclude that the GCE-augmented protosolar abundances are a viable representation of the interstellar abundances.

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On the nature of VX Sagitarii: Is it a TŻO, a RSG or a high-mass AGB star?

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Aims: We present a spectroscopic analysis of the extremely luminous red star VX Sgr based on high-resolution observations combined with AAVSO light curve data. Given the puzzling characteristics of VX Sgr, we explore three scenarios for its nature: a massive red supergiant (RSG) or hypergiant (RHG), a Thorne Żytkow object (TŻO), and an extreme Asymptotic Giant Branch (AGB) star.
Methods: Sampling more than one whole cycle of photometric variability, we derive stellar atmospheric parameters by using state-of-the-art PHOENIX atmospheric models. We compare them to optical and near infrared spectral types. We report on some key features due to neutral elemental atomic species such as Li I, Ca I, and Rb I.
Results: We provide new insights into its luminosity, evolutionary stage as well as its pulsation period. Based on all the data, there are two strong reasons to believe that VX Sgr is some sort of extreme AGB star. Firstly, its Mira-like behaviour during active phases. VX Sgr shows light variations with amplitudes much larger than any known RSG and clearly larger than all RHGs. In addition, it displays Balmer line emission and, as shown here for the first time, line doubling of its metallic spectrum at maximum light, both characteristics typical of Miras. Secondly, unlike any

known RSG or RHG, VX Sgr displays strong Rb I lines. In addition to the photospheric lines that are sometimes seen, it always shows circumstellar components whose expansion velocity is compatible with that of the OH masers in the envelope, demonstrating a continuous enrichment of the outer atmosphere with s-process elements, a behaviour that can only be explained by third dredge up during the thermal pulse phase.

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Evolutionary status of W Vir pulsating variables

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Stellar evolution calculations for population II stars with initial composition $Y_0 = 0.25$, $Z_0 = 10^{-3}$ and the initial stellar mass $M_0 = 0.82\ \mathrm{M}_\odot$ were carried out from the main sequence to the white dwarf stage. Twelve AGB and post-AGB evolutionary sequences were computed with different values of the parameter in the Blöcker mass loss rate formula ($0.01 \le \eta_\mathrm{B} \le 0.12$). Selected models of evolutionary sequences with masses $M = 0.536\ \mathrm{M}_\odot$, $0.530\ \mathrm{M}_\odot$ and $0.526\ \mathrm{M}_\odot$ that experience the loop in the Hertzsprung–Russell diagram due to the final helium flash were used as initial conditions for solution of the equations of hydrodynamics describing radial stellar oscillations. The region of instability to radial fundamental mode pulsations is shown to extend from the asymptotic giant branch to effective temperatures as high as $T_\mathrm{eff} \approx 6 \times 10^3$ K. Pulsation periods of hydrodynamic models are in the range from 15 to 50 day and agree with periods of W Vir pulsating stars. The models of intermediate spectral type fundamental mode pulsators with periods $\Pi > 50$ day locate in the upper part of the Hertzsprung–Russell diagram in the region of semiregular pulsating variables. We conclude that W Vir pulsating variables are the low-mass post-AGB stars that experience the final helium flash.

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Long-term X-ray variability of the symbiotic system RT Cru based on *Chandra* spectroscopy

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RT Cru belongs to the rare class of hard X-ray emitting symbiotics, whose origin is not yet fully understood. In this work, we have conducted a detailed spectroscopic analysis of X-ray emission from RT Cru based on observations taken by the *Chandra* Observatory using the Low Energy Transmission Grating (LETG) on the High-Resolution Camera Spectrometer (HRC-S) in 2015 and the High Energy Transmission Grating (HETG) on the Advanced CCD Imaging Spectrometer S-array (ACIS-S) in 2005. Our thermal plasma modeling of the time-averaged HRC-S/LETG spectrum suggests a mean temperature of $kT \sim 1.3$ keV, whereas $kT \sim 9.6$ keV according to the time-averaged ACIS-S/HETG. The soft thermal plasma emission component (~ 1.3 keV) found in the HRC-S is heavily obscured by dense materials ($> 5 \times 10^{23}\ \mathrm{cm}^{-2}$). The aperiodic variability seen in its light curves could be due to changes in either absorbing material covering the hard X-ray source or intrinsic emission mechanism in the inner layers of the accretion disk. To understand the variability, we extracted the spectra in the "low/hard" and "high/soft" spectral states, which indicated higher plasma temperatures in the low/hard states of both the ACIS-S and HRC-S. The source also has a fluorescent iron emission line at 6.4 keV, likely emitted from reflection off an accretion disk or dense absorber, which was twice as bright in the HRC-S epoch compared to the ACIS-S. The soft thermal component identified in the HRC-S might be an indication of a jet that deserves further evaluations using high-resolution imaging observations.

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Chemical modelling of dust–gas chemistry within AGB outflows – III. Photoprocessing of the ice and return to the ISM

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To explain the properties of dust in the interstellar medium (ISM), the presence of a refractory organic mantle is necessary. The outflows of AGB stars are among the main contributors of stellar dust to the ISM. We present the first study of the refractory organic contribution of AGB stars to the ISM. Based on laboratory experiments, we included a new reaction in our extended chemical kinetics model: the photoprocessing of volatile complex ices into inert refractory organic material. The refractory organic feedback of AGB outflows to the ISM is estimated using observationally motivated parent species and grids of models of C-rich and O-rich outflows. Refractory organic material is mainly inherited from the gas phase through accretion onto the dust and subsequent photoprocessing. Grain-surface chemistry, initiated by photodissociation of ices, produces only a minor part and takes place in a sub-monolayer regime in almost all outflows. The formation of refractory organic material increases with outflow density and depends on the initial gas-phase composition. While O-rich dust is negligibly covered by refractory organics, C-rich dust has an average coverage of 3–9%, but can be as high as 8–22%. Although C-rich dust does not enter the ISM bare, its average coverage is too low to influence its evolution in the ISM or significantly contribute to the coverage of interstellar dust. This study opens up questions on the coverage of other dust-producing environments. It highlights the need for an improved understanding of dust formation and for models specific to density structures within the outflow.

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Non-stoichiometric amorphous magnesium–iron silicates in circumstellar dust shells. Dust growth in outflows from supergiants

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The growth of dust in oxygen-rich stellar outflows is studied in order to find out to which extent dust growth models can quantitatively reconcile with the quantities and nature of dust as derived from observations of the infrared emission from circumstellar dust shells. A set of nine well observed massive supergiants with optically thin dust shells is used as testbeds because of the relatively simple properties of the outflows from massive supergiants, contrary to the case of AGB stars. Models of the infrared emission from their circumstellar dust shells are compared to their observed infrared spectra to derive essential parameters ruling dust formation in the extended envelope of these stars. The results are compared with a model for silicate dust condensation. For all objects the infrared emission in the studied wavelength range between 6 and 25 μm can be reproduced rather well by a mixture of non-stoichiometric iron-bearing silicates, alumina, and metallic iron dust particles. For three objects (μ Cep, RW Cyg, and RS Per) the observed spectra can be sufficiently well reproduced by a stationary and (essentially) spherically symmetric outflow in the instantaneous condensation approximation. For these objects the temperature at the onset of massive silicate dust growth is of the order of 920 K and the corresponding outflow velocity of order of the sound velocity. This condensation temperature suggests that the silicate dust grows on the corundum dust grains formed well inside of the silicate dust shell at much higher temperature. The low expansion velocity at the inner edge of the silicate dust shell suggests, that for these supergiants the region interior the silicate dust shell, though a high degree of supersonic turbulence is indicated by the widths of spectral lines, has an only subsonic average expansion velocity. Our results suggest that for the two major problems of dust formation in stellar outflows, i.e. (i) formation of seed nuclei and (ii) their growth to macroscopic dust grains, we gradually come close to a quantitative understanding of the second part.

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pyEQUIB Python package, an addendum to proEQUIB: IDL library for plasma diagnostics and abundance analysis

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pyEQUIB is a pure Python open-source package containing several application programming interface (API) functions that can be employed for plasma diagnostics and abundance analysis of nebular emission lines. This package is a Python implementation of the IDL library proEQUIB. The collisional excitation and recombination units of this package need to have the energy levels, collision strengths, transition probabilities, and recombination coefficients, which can be retrieved from the Python package AtomNeb for atomic data of ionized nebulæ. The API functions of this package can be used to deduce the electron temperature, electron concentration, chemical elements from CELs and Rls, and the interstellar extinction from the Balmer decrements emitted from ionized gaseous nebulæ. This package can simply be used by astronomers, who are familiar with the high-level, general-purpose programming language Python.

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Red supergiants in M 31 and M 33 – I. The complete sample

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The aim of this paper is to establish a complete sample of red supergiants (RSGs) in M 31 and M 33. The member stars of the two galaxies are selected from the near-infrared (NIR) point sources after removing the foreground dwarfs from their obvious branch in the $J–H/H–K$ diagram with the archival photometric data taken by the UKIRT/WFCAM. This separation by NIR colors of dwarfs from giants is confirmed by the optical/infrared color–color diagrams ($r–z/z–H$ and $B–V/V–R$), and the Gaia measurement of parallax and proper motion. The RSGs are then identified by their outstanding location in the members' $J–K/K$ diagram due to high luminosity and low effective temperature. The resultant sample has 5,498 and 3,055 RSGs in M 31 and M 33 respectively, which should be complete because the lower limiting K magnitude of RSGs in both cases is brighter than the complete magnitude of the UKIRT photometry. Analysis of the control fields finds that the pollution rate in the RSGs sample is less than 1%. The by-product is the complete sample of oxygen-rich asymptotic giant branch stars (AGBs), carbon-rich AGBs, thermally pulsing AGBs and extreme AGBs. In addition, the tip-RGB is determined together with its implication on the distance modulus to M 31 and M 33.

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The red supergiant content of M 31 and M 33

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We identify red supergiants (RSGs) in our spiral neighbors M 31 and M 33 using near-IR (NIR) photometry complete to a luminosity limit of $\log L/L_\odot = 4.0$. Our archival survey data cover 5 deg^2 of M 31, and 3 deg^2 for M 33, and are likely spatially complete for these massive stars. Gaia is used to remove foreground stars, after which the RSGs can be separated from asymptotic giant branch (AGB) stars in the color–magnitude diagram. The photometry is used to derive effective temperatures and bolometric luminosities via MARCS stellar atmosphere models. The resulting H–R diagrams show superb agreement with the evolutionary tracks of the Geneva evolutionary group. Our census includes 6400 RSGs in M 31 and 2850 RSGs in M 33 within their Holmberg radii; by contrast, only a few hundred RSGs are known so far in the Milky Way. Our catalog serves as the basis for a study of the RSG binary frequency being published separately, as well as future studies relating to the evolution of massive stars. Here we use the matches between the NIR-selected RSGs and their optical counterparts to show that the apparent similarity in the reddening of OB stars in M 31 and M 33 is the result of Malmquist bias; the average extinction in M 31 is likely higher than that of M 33. As expected, the distribution of RSGs follows that of the spiral arms, while the much older AGB population is more uniformly spread across each galaxy's disk.

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Conference Paper

Betelgeuse's two minima and the following faint phase in 2020

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The great minimum of Betelgeuse in February 2020 around visual magnitude 1.5 was among the deepest ones documented in the last century of observations. Many authors have presented explanations on this rare phenomenon, without achieving a satisfactory and definitive view, also because a secondary minimum of magnitude 1.0 occurred six months later, well before the next pulsational minimum expected for April 2021. A dust cloud ejected exactly in phase with the minimum of the 1.2 years main pulsational period, and right on our line-of-sight, seemed to be the explanation for the February 2020 great minimum. Another ejection should be invocated for August 2020 minimum (detected with STEREO satellite, IR ground-based observations and twilight observations), while the actual "faint phase" (beginning of December 2020) is still below the 0.4 magnitudes, typical of intermediate phases, which actually are broad maxima. The velocity to reach both minima in the light curve has been similar, as well as the restoring phase, that's why this "faint phase" is another feature which requires further explanation.

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Available from https://www.uai.it/sito/eventi-nazionali-correnti/
28-convegno-del-gad-e-meeting-uai-stelle-variabili-e-pianeti-extrasolari-online-il-10-e-11-ottobre/

Review Paper

Evolution and mass loss of cool ageing stars: a Dædalean story

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The chemical enrichment of the Universe; the mass spectrum of planetary nebulæ, white dwarfs and gravitational wave progenitors; the frequency distribution of Type I and II supernovæ; the fate of exoplanets ... a multitude of phenomena which is highly regulated by the amounts of mass that stars expel through a powerful wind. For more than half a century, these winds of cool ageing stars have been interpreted within the common interpretive framework of 1-dimensional (1D) models. I here discuss how that framework now appears to be highly problematic.

- Current 1D mass-loss rate formulæ differ by orders of magnitude, rendering contemporary stellar evolution predictions highly uncertain.

These stellar winds harbour 3D complexities which bridge 23 orders of magnitude in scale, ranging from the nanometer up to thousands of astronomical units. We need to embrace and understand these 3D spatial realities if we aim to quantify mass loss and assess its effect on stellar evolution. We therefore need to gauge

- the 3D life of molecules and solid-state aggregates: the gas-phase clusters that form the first dust seeds are not yet identified. This limits our ability to predict mass-loss rates using a self-consistent approach.
- the emergence of 3D clumps: they contribute in a non-negligible way to the mass loss, although they seem of limited importance for the wind-driving mechanism.
- the 3D lasting impact of a (hidden) companion: unrecognised binary interaction has biased previous mass-loss rate estimates towards values that are too large.

Only then will it be possible to drastically improve our predictive power of the evolutionary path in 4D (classical) spacetime of any star.

Published in Annual Review of Astronomy and Astrophysics (2021)
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Job Adverts

Postdoc positions with the ISM* group at STScI

Applications are invited for one or more postdoctoral research positions at the Space Telescope Science Institute. The successful applicant(s) will work in collaboration with the ISM*@ST researchers, to study dust properties in a diverse range of conditions, constrain the multi-dimensional structure of gas and dust, and/or study stellar populations and measure star formation histories of nearby galaxies. For a full list of the ISM*@ST research areas, see https://sites.google.com/view/ism-stsci. These positions are expected to start as soon as early 2021. In particular this year, we are looking for applicants interested in the following projects (dependent on funding).

1) Working with Dr. Karl Gordon, use JWST Integral Field Unit spectroscopic observations from 1–28 μm to study the detailed physics of gas and dust in Orion, NGC 7023, and the Horsehead photo-dissociation regions as part of JWST Early Release Science and MIRI Guaranteed Time Observation programs.

2) Working with Drs. Martha Boyer and Karoline Gilbert, use optical to infrared *Hubble* imaging to constrain the evolution of metal-poor giants and supergiants, including their contribution to the ISM of nearby galaxies as part of the Local Ultraviolet and Infrared Treasury (LUVIT) program.

3) Working with Dr. Karl Gordon, use an extensive set of ultraviolet through submm archival observations and a dust grain fitting code to investigate the dust grains present in the diffuse interstellar medium in galaxies in the Local Group.

4) Working with Drs. Karl Gordon and Josh Peek, use Galex archival data to make the first 3D models of the interstellar medium structure of the high-latitude Galactic sky using dust scattering models.

The postdoc(s) would work closely as part of the dynamic, welcoming, and inclusive ISM*@ST group (https://sites.google.com/view/ism-stsci) that includes Drs. Martha Boyer, Karoline Gilbert, Karl Gordon, Joshua Peek, Julia Roman-Duval, Erik Tollerud, and a number of postdocs and graduate students. The ISM*@ST group has broad scientific interests centered on the interstellar medium, from dust producing stars to the gas and dust in the interstellar and circumgalactic medium, and studies of resolved stellar populations. This research will involve working with and, if possible, proposing for observations with *Hubble*, JWST, and ground-based facilities. Independent research in related areas will be encouraged and supported up to the 50% level pending satisfactory progress on the funding projects.

The successful applicants will benefit from the career mentoring program at STScI, interactions with the STScI and Johns Hopkins University research staff, and a stimulating work environment rich in colloquia, journal clubs, symposia, and learning opportunities related to the missions supported by STScI (HST, JWST, *Roman*). STScI is a member of SDSS-V, and the successful applicant will have full data rights to this project.

Applicants must hold a Ph.D. degree in Astronomy, Physics, Planetary Science, or related fields at the start of the post-doctoral researcher position. Research experience in the areas of interstellar dust, stellar populations, photodissociation regions, evolved stars, molecular clouds, or ISM structure is desirable. Expertise in UV–optical–MIR photometry or spectroscopy, numerical methods, or statistics, is a plus.

The positions are for two years, with a possible renewal for a third year subject to performance and availability of funds. The nominal start date is spring/summer/fall 2021 but earlier/later start dates are possible. STScI, located on Johns Hopkins University Campus in Baltimore, Maryland, offers an excellent benefit package (including comprehensive healthcare and paid parental leave), competitive salaries, and a stimulating work environment. STScI's pay for postdoctoral researchers is commensurate to the year of Ph.D. We especially welcome applications from women, underrepresented minorities, veterans, LBGTQ+ people, and other members of underrepresented groups.

ONLY use the below link to apply:

Applicants are requested to complete an on-line application through:
https://stsci.slideroom.com/#/permalink/program/58690

Do NOT use the green "Apply Now" button.

The following materials are requested in a single PDF file: a brief cover letter detailing your research interests and relevant expertise, a curriculum vitæ, a list of publications, and a summary of previous and current research (limited to 3 pages). Complete applications received by December 18, 2020, will receive full consideration. Also, applicants should arrange for three confidential letters of reference. Reference letters should be submitted by December 23, 2020 via the on-line application system. Questions regarding the application process can be sent directly to href-mailto:careers@stsci.educareers@stsci.edu.

STScI sees the diversity of our staff as a strategic priority in our desire to create a first-rate scientific community. We reflect that deep commitment in strongly encouraging women, minorities, veterans and disabled individuals to apply for these opportunities. As an Equal Opportunity and Affirmative Action Employer, STScI does not discriminate because of race, sex, color, age, religion, national origin, sexual orientation, lawful political affiliations, veteran status, or mental or physical handicap. Veterans, disabled or wounded warriors needing assistance with the employment process can contact us at careers@stsci.edu.

See also https://jobregister.aas.org/ad/f8fe81bb

ESO's Science Internship Projects

Dear colleagues,

we would like to advertise ESO's Science Internship Programme in Chile. The program funds undergraduate and postgraduate students to work with ESO researchers on astronomical research projects. You can find a selection of projects at https://www.eso.org/sci/activities/santiago/projects/InternshipProjects.html covering aspects of the field of evolved stars.

Candidates interested for one of the evolved stars topics are encouraged to contact Claudia Paladini (cpaladin@eso.org) and Peter Scicluna (peter.scicluna@eso.org) by December 10 providing their CV, project selected and a short email with the motivation.

See also https://recruitment.eso.org

See also https://www.eso.org/sci/activities/santiago/projects/InternshipProjects.html

Announcement

Cool Stars 20.5: Virtually Cool !!

The next Cool Stars, Stellar Systems, and the Sun Workshop will be a virtual one on 2–4 March 2021. We plan 3 daily sessions via a Zoom webinar that will be live-streamed, recorded, and uploaded to Youtube.

Sessions will consist of invited review talks, poster Haiku sessions, live contributed talks. Posters can be uploaded to Zenodo and will be linked to ADS. Topics will include: the Sun and the Heliosphere; Low mass stars and open clusters; Evolved luminous stars.

Mark your calendars and check out the deadlines and registrations at http://www.coolstars20half.com

We still hope to see you in Toulouse in 2022 for Cool Stars 21.

See also http://www.coolstars20half.com