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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 301st issue of the AGB Newsletter.

No one responded to last month's Food for Thought about changes to the newsletter. This could mean no changes are desired. Or... In any case, the future of the newsletter is uncertain, given further evolution of the IT infrastructure and regulations at the host institution. Sometimes change enables, often it disables.

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

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

Food for Thought

This month's thought-provoking statement is:

We have gained a lot over the past century of astronomical research. What have we lost?

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

VeSPA: The SuperWASP Variable Star Photometry Archive

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We present the first results from the SuperWASP Variable Stars (SVS) citizen science project. The photometry archive of the Wide Angle Search for Planets has previously been searched for periodic variations and the results of this search formed the basis of the SVS project on the Zooniverse. The SVS project asks volunteers to visually inspect light curve plots and categorize each one according to a broad classification scheme. Results from the first two years of SVS have now been published online as the SuperWASP Variable Star Photometry Archive (VeSPA). The archive can be browsed online, downloaded in full, or queried, filtered, and sorted to export a refined set of results. An interactive light curve viewer also allows any light curve to be folded at a user-defined period. Analysis of citizen science results and development of VeSPA features are both ongoing. Updated results will be published every six months.

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Hot white dwarf candidates from the IGAPS–GALEX cross-match

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White dwarf (WD) stars are often associated with the central stars of planetary nebulæ (CSPNe) on their way to the cooling track. A large number of WD star candidates have been identified; thanks to optical large-scale surveys such as Gaia DR2 and EDR3. However, hot-WD/CSPNe stars are quite elusive in optical bands due to their high temperatures and low-optical luminosities. The Galaxy Evolution Explorer (GALEX) matched with the INT Galactic Plane Survey (IGAPS) allowed us to identify hot-WD candidates by combining the GALEX far-UV (FUV)and near-UV (NUV)with optical photometric bands (g, r, i, and Hα). After accounting for source confusion and filtering bad photometric data, a total of 236 485 sources were found in the GALEX and IGAPS footprint (GaPHAS). A preliminary selection of hot stellar sources was made using the GALEX colour cut on FUV–NUV > -0.53 mag, yielding 74 hot-WD candidates. We analysed their spectral energy distribution (SED) by developing a fitting program for single- and two-body SED using an MCMC algorithm; 41 are probably binary systems (a binary fraction of ~ 55 per cent was estimated). Additionally, we classified the WD star candidates using different infrared (IR) colours available for our sample, obtaining similar results as in the SED analysis for the single and binary systems. This supports the strength of the fitting method and the advantages of the combination of GALEX UV with optical photometry. Ground-based time-series photometry and spectra are required in order to confirm the nature of the WD star candidates.

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Tracing a decade of activity towards a yellow hypergiant. The spectral and spatial morphology of IRC +10°420 at au scales

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The fate of a massive star during the latest stages of its evolution is highly dependent on its mass-loss history and geometry, with the yellow hypergiants being key objects. We present near-IR interferometric observations of the famous yellow hypergiant IRC +10°420 and blue spectra taken between 1994–2019. Our 2.2-μm GRAVITY/VLTI observations attain a spatial resolution of $\sim$ 5 stellar radii and spatially resolve the hot emission in the K-band tracing the gas via Na I doublet emission and the Brγ emission. Our geometric modelling reveals a compact neutral zone (Na I) which is slightly larger than the continuum but within an extended Brγ emitting region. Our study confirms an hour-glass geometry of the wind, but we find no signature of a companion at 7–800 au separations at the contrast limit of our observations (3.7 mag at 3σ) to explain this geometry. We report an evolution of the ejecta over 7 years, and constrain the opening angle of the hour-glass to be $< 10°$. Lastly, we present the first blue optical spectra of IRC +10°420 since 1994. The multi-epoch data indicate that the spectral type, and thus temperature, of the object has essentially remained constant during the intervening years. Therefore, the observed increase in temperature of 2000 K in less than two decades prior to 1994 is now halted. This suggests that this yellow hypergiant has "hit" the White Wall in the H–R diagram preventing it from evolving blue-wards, and will likely undergo a major mass-loss event in the near future.

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CO line observations of OH/IR stars in the inner Galactic Bulge: characteristics of stars at the tip of the AGB

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Context: OH/IR stars are examples of late stellar evolution on the asymptotic giant branch (AGB), and they are, as such, important objects to study. They are also excellent probes of stellar populations, in particular in regions of high interstellar extinction such as the central regions of our Galaxy.
Aims: Our goal is to characterise the stellar and circumstellar properties of high-mass-loss-rate OH/IR stars in the inner Galactic Bulge using the Atacama Large Millimeter/submillimeter Interferometer (ALMA).
Methods: Rotational lines of ^{12}CO and ^{13}CO, as well as a millimetre-wave continuum, have been observed for a

sample of 22 OH/IR stars in directions within 2° of the Galactic Centre. Photometry data (≈ 1–30 μm) have been gathered from the literature to construct spectral energy distributions (SEDs) and to determine pulsational variability. Radiative transfer models have been used to interpret the line and photometry data.
Results: All stars in the sample were detected in at least one CO line, and eight objects were detected in 324-GHz continuum. Based on luminosity criteria, the sample is divided into 17 objects that most likely lie within the inner Galactic Bulge, and five objects that are most likely foreground objects. The median luminosity of the inner-Galactic-Bulge sub-sample, 5600 $L_\odot$, corresponds to an initial mass in the range 1.2–1.6 $M_\odot$, indicating that these inner-Galactic-Bulge OH/IR stars descend from solar-type stars. The objects in this sub-sample are further divided into two classes based on their SED characteristics: Eleven objects have SEDs that are well matched by models invoking dust envelopes extending from a few stellar radii and outwards, while six objects are better modelled as having detached dust envelopes with inner radii in the range 200–600 au and warmer central stars. The former objects have periodic variability, while the latter objects are predominantly non-periodic. The median gas-mass-loss rate, gas terminal expansion velocity, gas-to-dust mass ratio, and circumstellar $^{12}CO/^{13}CO$ abundance ratio have been estimated to be 2×10^{-5} $M_\odot$ yr^{-1}, 18 km s^{-1}, 200 (excluding the sources with detached dust envelopes, which show markedly lower gas-to-dust ratios), and 5, respectively, for the inner-Galactic-Bulge sub-sample. All line brightness distributions are resolved at an angular scale of ≈ 0.″15, but only two objects show a structure in their circumstellar envelopes at our resolution and sensitivity. In both cases, this structure takes the form of a cavity and a bipolar morphology.
Conclusions: The inner-Galactic-Bulge sub-sample consists of high mass-loss-rate stars that descend from solar-type progenitors and that lie near the tip of the AGB. Some of the sample stars may have recently ceased mass loss and, hence, have begun to evolve beyond the AGB, as evidenced by a change in circumstellar characteristics and indications of warmer central stars. The inferred very low stellar $^{12}C/^{13}C$ isotope ratios are indicative of CNO-cycle nuclear processing, and they are most likely established at the surfaces of the stars during the first dredge-up on the red giant branch since these stars are not expected to experience hot-bottom burning. The inner-Galactic-Bulge OH/IR stars studied here constitute an excellent sample of equidistant objects for the purpose of understanding the evolution of the mass-loss-rate characteristics at the tip of the AGB.

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Stringent limits on ^{28}SiO maser emission from the recurrent nova T Coronæ Borealis

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There are indications that the third known eruption of the recurrent nova T CrB is imminent, and multi-wavelength observations prior to the eruption are important to characterise the system before it erupts. T CrB is known to display the SiO fundamental vibrational feature at 8 μm. When the anticipated eruption occurs, it is possible that the shock produced when the ejected material runs into the wind of the red giant in the system may be traced using SiO maser emission. We have used the 100-m Effelsberg Radio Telescope to search for ^{28}SiO emission in the $\upsilon = 1$, $\upsilon = 2$, $J = 1 \rightarrow 0$ transitions, at 43.122 GHz and 42.820 GHz respectively, while the system is in quiescence. We find no evidence for such emission. We set stringent 3σ upper limits of 1.66 mJy on emission in the $\upsilon = 1$, $J = 1 \rightarrow 0$ transition, and 1.72 mJy in the $\upsilon = 2$, $J = 1 \rightarrow 0$ transition, respectively, for a noise bandwith of 250 kHz. The corresponding limits for a 31.25 kHz bandwidth are 4.69 mJy and 4.86 mJy respectively. These upper limits improve on previous upper limits for this system by more than two orders of magnitude.

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ASYAGO visual magnitudes for Antares in July 2022

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The supergiant star Antares is the red gem among the evening stars of the Northern hemisphere summer time. It transits at the local meridian at sunset in the last decade of August, being in the most favourable observing conditions for a potential vaste public of astronomy enthousiasts and variable stars observers. Nevertheless the observing coverage of Antares in the citizen science context of AAVSO is rather limited and scattered as well as the data available in the literature, starting from the GCVS catalogue where the max 0.88 and min 1.16 visual luminosity are indicated without any periodical term. The present value of Antares' visual magnitude (13–31 July 2022) is 0.73, publicly measured at the summer ASYAGO "Asiago School for Young Astronomers with Galileo (reflector telescope 122 cm) Observations", held at the largest astrophysical observatory in Italy. The method of naked eye measures is rather simple and rigorous. The airmass correction is necessary because the comparison stars for Antares are all angularly far from it. 1. Equal altitude with Spica (α Vir): waiting the time when the two stars reach the same altitude, a quick look to both stars allows to evaluate the brigther one and to avoid the Purkinje effect (staring at the red one it appears brigther because our eye physiology). 2. Sandwich with airmass correction: is an extension of the Argelander's method to reference stars several degrees far from each other. Their apparent magnitude, extinct by the atmosphere, are compared to obtain the Antares' apparent magnitude, which is correct by its airmass, normally larger than the comparison stars Deneb (α Cyg) and Altair ($alpha$ Aql). Both methods yielded Antares visual magnitude 0.73, brighter than the General Catalogue of Variable Stars maximum value of 0.88 (http://www.sai.msu.su/gcvs/cgi-bin/search2.cgi?search=alf+Sco). In the ASYAGO school we examined and discussed also the use of the SIMBAD electronic catalogue, where the stars can present GAIA measures, not always available as well as literature's recent data. The accurate study of Antares can reserve very interesting results on the physics of the closest red supergiants, and the contribution of citizen scientists along the years can be very helpful.

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The recurrent nova V3890 Sgr: a near-infrared and optical study of the red giant component and its environment

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We present an analysis of the red giant component of the recurrent nova V3890 Sgr, using data obtained before and after its 2019 eruption. Its effective temperature is $T_{\rm eff} = 3050 \pm 200$ K for $\log g = 0.7$, although there are modest changes in $T_{\rm eff}$. There is an overabundance of both carbon (0.20 ± 0.05 dex) and sodium (1.0 ± 0.3 dex) relative to their solar values, possibly the result of ejecta from the 1990 nova eruption being entrained into the red giant photosphere. We find $^{12}{\rm C}/^{13}{\rm C} = 25 \pm 2$, a value similar to that found in red giants in other recurrent novae. The interpretation of the quiescent spectrum in the 5–38-μm region requires the presence of photospheric SiO absorption and cool (~ 400 K) dust in the red giant environment. The spectrum in the region of the Na I D lines is complex, and includes at least six interstellar components, together with likely evidence for interaction between ejecta from the 2019 eruption and material accumulated in the plane of the binary. Three recurrent novæ with giant secondaries have been shown to have environments with different dust content, but photospheres with similar $^{12}{\rm C}/^{13}{\rm C}$ ratios. The SiO fundamental bands most likely have a photospheric origin in the all three stars.

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Can we reveal the core-chemical composition of ultra-massive white dwarfs through their magnetic fields?

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Ultra-massive white dwarfs ($1.05\ {\rm M}_\odot \lesssim M_{\rm WD}$) are particularly interesting objects that allow us to study extreme astrophysical phenomena such as type Ia supernovae explosions and merger events. Traditionally, ultra-massive white dwarfs are thought to harbour oxygen–neon (ONe) cores. However, recent theoretical studies and new observations suggest that some ultra-massive white dwarfs could harbour carbon–oxygen (CO) cores. Although several studies have attempted to elucidate the core composition of ultra-massive white dwarfs, to date, it has not been possible to distinguish them through their observed properties. Here, we present a new method for revealing the core-chemical composition in ultra-massive white dwarfs that is based on the study of magnetic fields generated by convective mixing induced by the crystallization process. ONe white dwarfs crystallize at higher luminosities than their CO counterparts. Therefore, the study of magnetic ultra-massive white dwarfs in the particular domain where ONe cores have reached the crystallization conditions but CO cores have not, may provide valuable support to their ONe core-chemical composition, since ONe white dwarfs would display signs of magnetic fields and CO would not. We apply our method to eight white dwarfs with magnetic field measurements and we suggest that these stars are candidate ONe white dwarfs.

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The evolution of ultra-massive carbon-oxygen white dwarfs

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Ultra-massive white dwarfs ($M_{\rm WD} \gtrsim 1.05\ {\rm M}_\odot$) are considered powerful tools to study type Ia supernovæ explosions, merger events, the occurrence of physical processes in the Super Asymptotic Giant Branch (SAGB) phase, and the existence of high magnetic fields. Traditionally, ultra-massive white dwarfs are expected to harbour oxygen–neon (ONe) cores. However, new observations and recent theoretical studies suggest that the progenitors of some ultra-massive white dwarfs can avoid carbon burning, leading to the formation of ultra-massive white dwarfs harbouring carbon–oxygen (CO) cores. Here we present a set of ultra-massive white dwarf evolutionary sequences with CO cores for a wide range of metallicity and masses. We take into account the energy released by latent heat and phase separation during the crystallization process and by ^{22}Ne sedimentation. Realistic chemical profiles resulting from the full computation of progenitor evolution are considered. We compare our CO ultra-massive white dwarf models with ONe models. We conclude that CO ultra-massive white dwarfs evolve significantly slower than their ONe counterparts mainly for three reasons: their larger thermal content, the effect of crystallization, and the effect of ^{22}Ne sedimentation. We also provide colors in several photometric bands on the basis of new model atmospheres. These CO ultra-massive white dwarf models, together with the ONe ultra-massive white dwarf models, provide an appropriate theoretical framework to study the ultra-massive white dwarf population in our Galaxy.

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Rotating and expanding gas in binary post-AGB stars

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There is a class of binary post-AGB stars (binary system including a post-AGB star) that are surrounded by Keplerian disks and outflows resulting from gas escaping from the disk. To date, there are seven sources that have been studied in detail through interferometric millimeter-wave maps of CO lines ALMA/NOEMA). For the cases of the Red Rectangle, IW Carinæ, IRAS 08544−4431, and AC Herculis, it is found that around $\geq 85\%$ of the total nebular mass is located in the disk with Keplerian dynamics. The remainder of the nebular mass is located in an expanding component. This outflow is probably a disk wind consisting of material escaping from the rotating disk. These sources are the disk-dominated nebulæ. On the contrary, our maps and modeling of 89 Herculis, IRAS 19125+0343, and R Scuti, which allowed us to study their morphology, kinematics, and mass distribution, suggest that, in these sources, the outflow clearly is the dominant component of the nebula ($\sim 75\%$ of the total nebular mass), resulting in a new subclass of nebulæ around binary post-AGB stars: the outflow-dominated sources. Besides CO, the chemistry of this type of source has been practically unknown thus far. We also present a very deep single-dish radio molecular survey in the 1.3, 2, 3, 7, and 13 mm bands (~ 600 hours of telescope time). Our results and detections allow us to classify our sources as O- or /C-rich. We also conclude that the calculated abundances of the detected molecular species other than CO are particularly low, compared with AGB stars. This fact is very significant in those sources where the rotating disk is the dominant component of the nebula.

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Conference Paper

Commotion in their motions: proper motion anomalies of nearby AGB stars

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Proper motion anomalies (PMa) are often useful for identifying companions, but using this technique for large and luminous stars like Asymptotic Giant Branch (AGB) stars is problematic. We studied nearby AGB stars and their potential companions in a PMa catalog derived from Hipparcos and Gaia DR2 proper motion measurements. We found that companion configurations based on PMa for AGB stars are often implausible, such that the radius of the primary star is larger than the orbit of the putative companion. This may suggest an alternative origin of PMa in AGB stars, possibly surface brightness fluctuations due to their large convective surfaces.

Poster contribution, published in 240^{th} **meeting of the American Astronomical Society**
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