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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 212th issue of the AGB Newsletter. Besides a lot of other interesting results, there is a fair bit of work on stars in globular clusters, as well as a re-appreciation of the term "Planetary Nebula"...

...which may explain the announcement of a conference on exoplanets in this newsletter; as well as one on planetary nebulæ, at the IA GA in Hawai'i.

And the Fizeau programme for collaboration on interferometry projects is still alive and kicking.

We congratulate Marcelo Leal-Ferreira on his Ph.D. thesis, and wish him all the best in his future career.

If you are looking for a Ph.D. position, or a postdoctoral research position, there are a couple of each on offer in Leuven!

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

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

Food for Thought

This month's thought-provoking statement is:

How do we recognise a bona-fide planetary nebula from planetary nebula impostors?

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

On the need of the Light Elements Primary Process (LEPP)

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Extant chemical evolution models underestimate the Galactic production of Sr, Y and Zr as well as the Solar System abundances of s-only isotopes with $90 < A < 130$. To solve this problem, an additional (unknown) process has been invoked, the so-called LEPP (Light Element Primary Process). In this paper we investigate possible alternative solutions. Basing on Full Network Stellar evolutionary calculations, we investigate the effects on the Solar System s-only distribution induced by the inclusion of some commonly ignored physical processes (e.g., rotation) or by the variation of the treatment of convective overshoot, mass-loss and the efficiency of nuclear processes. Our main findings are: 1) at the epoch of the formation of the Solar System, our reference model produces super-solar abundances for the whole s-only distribution, even in the range $90 < A < 130$; 2) within errors, the s-only distribution relative to ^{150}Sm is flat; 3) the s-process contribution of the less massive AGB stars ($M < 1.5$ M$_\odot$) as well as of the more massive ones ($M > 4.0$ M$_\odot$) are negligible; 4) the inclusion of rotation implies a downward shift of the whole distribution with an higher efficiency for the heavy s-only isotopes, leading to a flatter s-only distribution; 5) different prescriptions on convection or mass-loss produce nearly rigid shifts of the whole distribution. In summary, a variation of the standard paradigm of AGB nucleosynthesis would allow to reconcile models predictions with Solar System s-only abundances. Nonetheless, the LEPP cannot be definitely ruled out, because of the uncertainties still affecting stellar and Galactic chemical evolution models.

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Discovery of a shell of neutral atomic hydrogen surrounding the carbon star IRC +10°216

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We have used the Robert C. Byrd Green Bank Telescope to perform the most sensitive search to date for neutral atomic hydrogen (H I) in the circumstellar envelope (CSE) of the carbon star IRC +10°216. Our observations have uncovered a low surface brightness H I shell of diameter $\sim 1300''$ (~ 0.8 pc), centered on IRC +10°216. The H I shell has an angular extent comparable to the far ultraviolet-emitting astrosphere of IRC +10°216 previously detected with the GALEX satellite, and its kinematics are consistent with circumstellar matter that has been decelerated by the local interstellar medium. The shell appears to completely surround the star, but the highest H I column densities are measured along the leading edge of the shell, near the location of a previously identified bow shock. We estimate a total mass of atomic hydrogen associated with IRC +10°216 CSE of $M_{\rm HI} \sim 3 \times 10^{-3}$ M$_\odot$. This is only a small fraction of the expected total mass of the CSE ($< 1\%$) and is consistent with the bulk of the stellar wind originating in molecular rather than atomic form, as expected for a cool star with an effective temperature $T_{\rm eff} \lesssim 2200$ K. H I mapping of a $2^\circ \times 2^\circ$ region surrounding IRC +10°216 has also allowed us to characterize the line-of-sight interstellar emission in the region and has uncovered a link between diffuse FUV emission southwest of IRC +10°216 and the Local Leo Cold Cloud.

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Available from arXiv:1502.02050
and from http://www.haystack.mit.edu/hay/staff/lmatthew/Matthews_etal_IRC+10216.pdf

The progenitors and lifetimes of planetary nebulæ

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Planetary Nebulæ (PNe) are amongst the most spectacular objects produced by stellar evolution, but the exact identity of their progenitors has never been established for a large and homogeneous observational sample. We investigate the relationship between PNe and their stellar progenitors in the Large Magellanic Cloud (LMC) through the statistical comparison between a highly complete spectroscopic catalog of PNe and the spatially resolved age distribution of the underlying stellar populations. We find that most PN progenitors in the LMC have main-sequence lifetimes in a narrow range between 5 and 8 Gyr, which corresponds to masses between 1.2 and 1.0 $M_{\odot}$, and produce PNe that last 26^{+6}_{-7} kyr on average. We tentatively detect a second population of PN progenitors, with main-sequence lifetimes between 35 and 800 Myr, i.e. masses between 8.2 and 2.1 $M_{\odot}$, and average PN lifetimes of 11^{+6}_{-7} kyr. These two distinct and disjoint populations of progenitors strongly suggest the existence of at least two physically distinct formation channels for PNe. Our determination of PN lifetimes and progenitor masses has implications for the understanding of PNe in the context of stellar evolution models, and for the role that rotation, magnetic fields, and binarity can play in the shaping of PN morphologies.

Submitted to ApJ Letters
Available from arXiv:1502.01015

On the blue loops of intermediate-mass stars

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We consider the blue loops in the Hertzsprung–Russell diagram that occur when intermediate-mass stars begin core helium burning. It has long been known that the excess of helium above the burning shell, the result of the contraction of the convective core during core hydrogen burning, has the effect of making such stars redder and larger than they would be otherwise. The outward motion of the burning shell in mass removes this excess and triggers the loop. Hitherto nobody has attempted to demonstrate why the excess helium has this effect. We consider the effect of the local opacity, which is reduced by excess helium, the shell fuel supply, which is also reduced, and the local mean molecular weight, which is increased. We demonstrate that the mean molecular weight is the decisive reddening factor. The opacity has a much smaller effect and a reduced fuel supply actually favours blueward motion.

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Chemical abundances and dust in the Halo planetary nebula K 648 in M 15: Its origin and evolution based on an analysis of multiwavelength data

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We report an investigation of the extremely metal-poor and C-rich planetary nebula (PN) K 648 in the globular cluster M 15 using the UV to far-IR data obtained using the Subaru, HST, FUSE, *Spitzer*, and *Herschel*. We determined the nebular abundances of ten elements. The enhancement of F ([F/H] = +0.96) is comparable to that of the halo PN BoBn 1. The central stellar abundances of seven elements are determined. The stellar C/O ratio is similar to the nebular C/O ratios from recombination line and from collisionally excited line (CEL) within error, and the stellar Ne/O ratio is also close to the nebular CEL Ne/O ratio. We found evidence of carbonaceous dust grains and molecules including Class B 6–9-μm and 11.3-μm polycyclic aromatic hydrocarbons and the broad 11-μm feature. The profiles of these bands are similar to those of the C-rich halo PNe H 4-1 and BoBn 1. Based on the theoretical model, we determined the physical conditions of the gas and dust and their masses, i.e. 0.048 $M_\odot$ and 4.95×10^{-7} $M_\odot$, respectively. The observed chemical abundances and gas mass are in good agreement with an asymptotic giant branch nucleosynthesis model prediction for stars with an initial 1.25 $M_\odot$ plus a 2.0×10^{-3} $M_\odot$ partial mixing zone (PMZ) and stars with an initial mass of 1.5 $M_\odot$ without a PMZ. The core-mass of the central star is approximately 0.61–0.63 $M_\odot$. K 648 is therefore likely to have evolved from a progenitor that experienced coalescence or tidal disruption during the early stages of evolution, and became a $\sim$ 1.25–1.5 $M_\odot$ blue straggler.

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On the serendipitous discovery of a Li-rich giant in the globular cluster NGC 362

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We have serendipitously identified the first lithium-rich giant star located close to the red giant branch bump in a globular cluster. Through intermediate-resolution FLAMES spectra we derived a lithium abundance of $A(\text{Li}) = 2.55$ (assuming local thermodynamical equilibrium), which is extremely high considering the star's evolutionary stage. Kinematic and photometric analysis confirm the object as a member of the globular cluster NGC 362. This is the fourth Li-rich giant discovered in a globular cluster but the only one known to exist at a luminosity close to the bump magnitude. The three previous detections are clearly more evolved, located close to, or beyond the tip of their red giant branch. Our observations are able to discard the accretion of planets/brown dwarfs, as well as an enhanced mass-loss mechanism as a formation channel for this rare object. Whilst the star sits just above the cluster bump luminosity, its temperature places it towards the blue side of the giant branch in the colour–magnitude diagram. We require further dedicated observations to unambiguously identify the star as a red giant: we are currently unable to confirm whether Li production has occurred at the bump of the luminosity function or if the star is on the pre zero-age horizontal branch. The latter scenario provides the opportunity for the star to have synthesised Li rapidly during the core helium flash or gradually during its red giant branch ascent via some extra mixing process.

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Carbon in red giants in globular clusters and dwarf spheroidal galaxies

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We present carbon abundances of red giants in Milky Way globular clusters and dwarf spheroidal galaxies (dSphs). Our sample includes measurements of carbon abundances for 154 giants in the clusters NGC 2419, M 68, and M 15 and 398 giants in the dSphs Sculptor, Fornax, Ursa Minor, and Draco. This sample doubles the number of dSph stars with measurements of [C/Fe]. The [C/Fe] ratio in the clusters decreases with increasing luminosity above $\log(L/L_\odot) \simeq 1.6$, which can be explained by deep mixing in evolved giants. The same decrease is observed in dSphs, but the initial [C/Fe] of the dSph giants is not uniform. Stars in dSphs at lower metallicities have larger [C/Fe] ratios. We hypothesize that [C/Fe] (corrected to the initial carbon abundance) declines with increasing [Fe/H] due to the metallicity dependence of the carbon yield of asymptotic giant branch stars and due to the increasing importance of Type Ia supernovæ at higher metallicities. We also identified 11 very carbon-rich giants (8 previously known) in three dSphs. However, our selection biases preclude a detailed comparison to the carbon-enhanced fraction of the Milky Way stellar halo. Nonetheless, the stars with [C/Fe] $< +1$ in dSphs follow a different [C/Fe] track with [Fe/H] than the halo stars. Specifically, [C/Fe] in dSphs begins to decline at lower [Fe/H] than in the halo. The difference in the metallicity of the [C/Fe] "knee" adds to the evidence from [α/Fe] distributions that the progenitors of the halo had a shorter timescale for chemical enrichment than the surviving dSphs.

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The circumstellar matter of supernova 2014J and the core-degenerate scenario

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I show that the circumstellar matter (CSM) of the type Ia supernova 2014J is too massive and its momentum too large to be accounted for by any but the core-degenerate (CD) scenario for type Ia supernovæ. Assuming the absorbing gas is of CSM origin, the several shells responsible of the absorption potassium lines are accounted for by a mass loss episode from a massive asymptotic giant branch star during a common envelope phase with a white dwarf companion. The time-varying potassium lines can be accounted for by ionization of neutral potassium and the Na-from-dust absorption (NaDA) model. Before explosion some of the potassium resides in the gas phase and some in dust. Weakening in absorption strength is caused by potassium-ionizing radiation of the supernova, while release of atomic potassium from dust increases the absorption. I conclude that if the absorbing gas originated from the progenitor of SN 2014J, then a common envelope phase took place about 15,000 years ago, leading to the merging of the core with the white dwarf companion, i.e. the core-degenerate scenario. Else, the absorbing material is of interstellar medium origin.

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Binarity and the abundance discrepancy problem in planetary nebulæ

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The discrepancy between abundances computed using optical recombination lines (ORLs) and collisionally excited lines (CELs) is a major unresolved problem in nebular astrophysics. We show here that the largest abundance discrepancies are reached in planetary nebulæ with close binary central stars. This is illustrated by deep spectroscopy of three nebulæ with a post common-envelope (CE) binary star. Abell 46 and Ou 5 have O^{2+}/H^+ abundance discrepancy factors larger than 50, and as high as 300 in the inner regions of Abell 46. Abell 63 has a smaller discrepancy factor around 10, but still above the typical values in ionized nebulæ. Our spectroscopic analysis supports previous conclusions that, in addition to "standard" hot ($T_e \sim 10^4$ K) gas, a colder ($T_e \sim 10^3$ K) ionized component that is highly enriched in heavy elements also exists. These nebulæ have low ionized masses, between 10^{-3} and 10^{-1} $M_\odot$ depending on the adopted electron densities and temperatures. Since the much more massive red-giant envelope is expected to be entirely ejected in the CE phase, the currently observed nebulæ would be produced much later, in post-CE mass loss episodes when the envelope has already dispersed. These observations add constraints to the abundance discrepancy problem. Possible explanations are revised. Some are naturally linked to binarity, such as for instance high-metallicity nova ejecta, but it is difficult at this stage to depict an evolutionary scenario consistent with all the observed properties. The hypothesis that these nebulæ are the result of tidal destruction, accretion and ejection of Jupiter-like planets is also introduced.

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White dwarf evolutionary sequences for low-metallicity progenitors: The impact of third dredge-up

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We present new white dwarf evolutionary sequences for low-metallicity progenitors. White dwarf sequences have been derived from full evolutionary calculations that take into account the entire history of progenitor stars, including the thermally-pulsing and the post-asymptotic giant branch phases. We show that for progenitor metallicities in the range 0.00003–0.001, and in the absence of carbon enrichment due to the occurrence of a third dredge-up episode, the resulting H envelope of the low-mass white dwarfs is thick enough to make stable H burning the most important energy source even at low luminosities. This has a significant impact on white dwarf cooling times. This result is independent of the adopted mass-loss rate during the thermally-pulsing and post-AGB phases, and the planetary nebulæ stage. We conclude that in the absence of third dredge-up episodes, a significant part of the evolution of low-mass white dwarfs resulting from low-metallicity progenitors is dominated by stable H burning. Our study opens the possibility of using the observed white dwarf luminosity function of low-metallicity globular clusters to constrain the efficiency of third dredge up episodes during the thermally-pulsing AGB phase of low-metallicity progenitors.

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The double-degenerate, super-Chandrasekhar nucleus of the planetary nebula Henize 2-428

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The planetary nebula (PN) stage is the ultimate fate of stars with mass 1 to 8 $M_\odot$. The origin of their complex morphologies is poorly understood, although several mechanisms involving binary interaction have been proposed. In close binary systems, the orbital separation is short enough for the primary star to overfill its Roche lobe as it expands during the Asymptotic Giant Branch (AGB) phase. The excess material ends up forming a common-envelope (CE) surrounding both stars. Drag forces would then result in the envelope being ejected into a bipolar PN whose equator is coincident with the orbital plane of the system. Systems in which both stars have ejected their envelopes and evolve towards the white dwarf (WD) stage are called double-degenerates. Here we report that Henize 2-428 has a double-degenerate core with a combined mass unambiguously above the Chandrasekhar limit of 1.4 $M_\odot$. According to its short orbital period (4.2 hours) and total mass (1.76 $M_\odot$), the system should merge in 700 million years, triggering a Type Ia supernova (SN Ia) event. This finding supports the double-degenerate, super-Chandrasekhar evolutionary channel for the formation of SNe Ia.

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and from http://www.nature.com/nature/journal/vaop/ncurrent/full/nature14124.html

When do stars in 47 Tucanæ lose their mass?

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By examining the diffusion of young white dwarfs through the core of the globular cluster 47 Tucanæ, we estimate the time when the progenitor star lost the bulk of its mass to become a white dwarf. We find this to be not earlier than 40 Myr before the star reaches the tip of the asymptotic giant branch. According to stellar evolution models of the white-dwarf progenitors in 47 Tucanæ, we find this epoch to coincide approximately with the star ascending the asymptotic-giant branch and well after the helium flash. With the current data and analysis we cannot exclude some mass loss on the red-giant branch, but we argue that the bulk of the mass loss must occur very late in the star's history on the asymptotic-giant branch. We also confront the observed magnitudes of stars on the horizontal branch in 47 Tucanæ and find that they are consistent with the latest theoretical models of the horizontal branch stars of 0.8–0.9 $M_\odot$, further supporting the conclusion that the stars in 47 Tucanæ and likewise in other clusters lose the bulk of their mass on the asymptotic-giant branch.

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Micron-sized forsterite grains in the pre-planetary nebula of IRAS 17150−3224 – Searching for clues on the mysterious evolution of massive AGB stars

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Aims: We study the grain properties and location of the forsterite crystals in the circumstellar environment of the pre-planetary nebula (PPN) IRAS 17150−3224 in order to learn more about the as yet poorly understood evolutionary phase prior to the PPN.
Methods: We use the best-fit model for IRAS 17150−3224 of Meixner et al. (2002) and add forsterite to this model. We investigate different spatial distributions and grain sizes of the forsterite crystals in the circumstellar environment. We compare the spectral bands of forsterite in the mid-infrared and at 69 μm in radiative transport models to those in ISO/SWS and *Herschel*/PACS observations.
Results: We can reproduce the non-detection of the mid-infrared bands and the detection of the 69-μm feature with models where the forsterite is distributed in the whole outflow, in the superwind region, or in the AGB-wind region emitted previous to the superwind, but we cannot discriminate between these three models. To reproduce the observed spectral bands with these three models, the forsterite crystals need to be dominated by a grain size population of 2 μm up to 6 μm. We also tested models where the forsterite is located in a torus region or where it is concentrated in the equatorial plane, in a disk-like fashion. These models show either absorption features that are too strong or a 69-μm band that is too weak, respectively, so we exclude these cases. We observe a blue shoulder on the 69-μm band that cannot be explained by forsterite and we suggest a possible population of μm-sized ortho-enstatite grains. We hypothesise that the large forsterite crystals were formed after the superwind phase of IRAS 17150−3224, where the star developed an as yet unknown hyperwind with an extremely high mass-loss rate ($\gtrsim 10^{-3}$ M$_\odot$ yr^{-1}). The high densities of such a hyperwind could be responsible for the efficient grain growth of both amorphous and crystalline dust in the outflow. Several mechanisms are discussed that might explain the lower-limit of ~ 2 μm found for the forsterite grains, but none are satisfactory. Among the mechanisms explored is a possible selection effect due to radiation pressure based on photon scattering on micron-sized grains.

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and from http://www.stjerke.com

Oxygen enrichment in carbon-rich planetary nebulæ

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We study the relation between the chemical composition and the type of dust present in a group of 20 Galactic planetary nebulæ (PNe) that have high quality optical and infrared spectra. The optical spectra are used, together with the best available ionization correction factors, to calculate the abundances of Ar, C, Cl, He, N, Ne, and O relative to H. The infrared spectra are used to classify the PNe in two groups depending on whether the observed dust features are representative of oxygen-rich or carbon-rich environments. The sample contains one object from the halo, eight from the bulge, and eleven from the local disc. We compare their chemical abundances with nucleosynthesis model predictions and with the ones obtained in seven Galactic H II regions of the solar neighbourhood. We find evidence of O enrichment (by ~ 0.3 dex) in all but one of the PNe with carbon-rich dust (CRD). Our analysis shows that Ar, and especially Cl, are the best metallicity indicators of the progenitors of PNe. There is a tight correlation between the abundances of Ar and Cl in all the objects, in agreement with a lockstep evolution of both elements. The range of metallicities implied by the Cl abundances covers one order of magnitude and we find significant differences in the initial masses and metallicities of the PNe with CRD and oxygen-rich dust (ORD). The PNe with CRD tend to have intermediate masses and low metallicities, whereas most of the PNe with ORD show higher enrichments in N and He, suggesting that they had high-mass progenitors.

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Iron and s-elements abundance variations in NGC 5286: comparison with "anomalous" globular clusters and Milky Way satellites

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We present a high resolution spectroscopic analysis of 62 red giants in the Milky Way globular cluster NGC 5286. We have determined abundances of representative light proton-capture, α, Fe-peak and neutron-capture element groups, and combined them with photometry of multiple sequences observed along the colour–magnitude diagram. Our principal results are: (i) a broad, bimodal distribution in s-process element abundance ratios, with two main groups, the s-poor and s-rich groups; (ii) substantial star-to-star Fe variations, with the s-rich stars having higher Fe, e.g., $\langle[\mathrm{Fe/H}]\rangle_{s-\mathrm{rich}} - \langle[\mathrm{Fe/H}]\rangle_{s-\mathrm{poor}} \sim 0.2$ dex; and (iii) the presence of O–Na–Al (anti-)correlations in both stellar groups. We have defined a new photometric index, $c_{BVI} = (B-V) - (V-I)$, to maximise the separation in the colour–magnitude diagram between the two stellar groups with different Fe and s-element content, and this index is not significantly affected by variations in light elements (such as the O–Na anticorrelation). The variations in the overall metallicity present in NGC5286 add this object to the class of "anomalous" GCs. Furthermore, the chemical abundance pattern of NGC 5286 resembles that observed in some of the anomalous GCs, e.g., M 22, NGC 1851, M 2, and the more extreme ω Centauri, that also show internal variations in s-elements, and in light elements within stars with different Fe and s-elements content. In view of the common variations in s-elements, we propose the term s-Fe-anomalous GCs to describe this sub-class of objects. The similarities in chemical abundance ratios between these objects strongly suggest similar formation and evolution histories, possibly associated with an origin in tidally disrupted dwarf satellites.

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Planetary systems and real planetary nebulæ from planets destruction near white dwarfs

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We suggest that tidal destruction of Earth-like and icy planets near a white dwarf (WD) might lead to the formation of one or more low-mass planets in tight orbits around the WD. More massive planets contain hydrogen which will start burning on the surface of the WD and inflate an envelope, part of which be ejected to form a nebula. This nebula

will be ionized and be observed as a planetary nebula. The formation of the WD planetary system starts with a tidal break-up of icy or lower mass planets to planetesimals near their tidal radius of about 1 $R_\odot$. Internal stress forces keep the planetesimal from tidal break-up when their radius is less than about 100 km. We suggest that the planetesimals then bind together to form new sub-Earth-like planets around the WD at a few solar radii. More massive planets that contain hydrogen will supply the WD with fresh nuclear fuel to reincarnate its stellar-giant phase. Some of the hydrogen will be inflated in a large envelope that will cause the planetesimal formed from the core of the giant planets to be evaporated. In the post-giant phase the hot WD ionizes the gas that was blown in the wind of the stellar-giant envelope, and form a nebula that originated from a planet – a real planetary nebula (RPN).

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The pulsation modes, masses and evolution of luminous red giants

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The period–luminosity sequences and the multiple periods of luminous red giant stars are examined using the OGLE III catalogue of long-period variables in the Large Magellanic Cloud. It is shown that the period ratios in individual multimode stars are systematically different from the ratios of the periods at a given luminosity of different period–luminosity sequences. This leads to the conclusion that the masses of stars at the same luminosity on the different period–luminosity sequences are different. An evolutionary scenario is used to show that the masses of stars on adjacent sequences differ by about 16–26% at a given luminosity, with the shorter period sequence being more massive. The mass is also shown to vary across each sequence by a similar percentage, with the mass increasing to shorter periods. On one sequence, sequence B, the mass distribution is shown to be bimodal. It is shown that the small amplitude variables on sequences A′, A and B pulsate in radial and nonradial modes of angular degree $l = 0$, 1 and 2, with the $l = 1$ mode being the most common. The stars on sequences C′ and C are predominantly radial pulsators ($l = 0$). Matching period ratios to pulsation models shows that the radial pulsation modes associated with sequences A′, A, B, C′ and C are the 4$^{\rm th}$, 3$^{\rm rd}$, 2$^{\rm nd}$ and 1$^{\rm st}$ overtones and the fundamental mode, respectively.

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Conference Papers

The AGB bump: a calibrator for core mixing

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The efficiency of convection in stars affects many aspects of their evolution and remains one of the key-open questions in stellar modelling. In particular, the size of the mixed core in core-He-burning low-mass stars is still uncertain and impacts the lifetime of this evolutionary phase and, e.g., the C/O profile in white dwarfs. One of the known observables related to the Horizontal Branch (HB) and Asymptotic Giant Branch (AGB) evolution is the AGB bump. Its luminosity depends on the position in mass of the helium-burning shell at its first ignition, that is affected by the extension of the central mixed region. In this preliminary work we show how various assumptions on near-core mixing and on the thermal stratification in the overshooting region affect the luminosity of the AGB bump, as well as the period spacing of gravity modes in core-He-burning models.

Poster contribution, published in "3^rd^ CoRoT Symposium, Kepler KASC7 joint meeting"
Available from arXiv:1502.03318

OH masers in the Milky Way and Local Group galaxies in the SKA era

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The intense line emission of OH masers is a perfect tracer of regions where new stars are born as well as of evolved stars, shedding large amounts of processed matter into the interstellar medium. From SKA deep surveys at 18 cm, where the maser lines from the ground-state of the OH molecule arise, we predict the discovery of more than 20 000 sources of stellar and interstellar origin throughout the Galaxy. The study of this maser emission has many applications, including the determination of magnetic field strengths from polarisation measurements, studies of stellar kinematics using the precisely determined radial velocities, and distance determinations from VLBI astrometry. A new opportunity to study shocked gas in different galactic environments is expected to arise with the detection of lower luminosity masers. For the first time, larger numbers of OH masers will be detected in Local Group galaxies. New insights are expected in structure formation in galaxies by comparing maser populations in galaxies of different metallicity, as both their properties as well as their numbers depend on it. With the full capabilities of SKA, further maser transitions such as from excited OH and from methanol will be accessible, providing new tools to study the evolution of star-forming regions in particular.

Oral contribution, published in "Advancing Astrophysics with the Square Kilometre Array" for the SKA science book, Giardini–Naxos, Sicily, June 2014, Proceedings of Science
Available from arXiv:1501.06153

From the atmosphere to the circumstellar environment in cool evolved stars

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We discuss and illustrate contributions that optical interferometry has made on our current understanding of cool evolved stars. We include red giant branch (RGB) stars, asymptotic giant branch (AGB) stars, and red supergiants (RSGs). Studies using optical interferometry from visual to mid-infrared wavelengths have greatly increased our knowledge of their atmospheres, extended molecular shells, dust formation, and winds. These processes and the morphology

of the circumstellar environment are important for the further evolution of these stars toward planetary nebulæ (PNe) and core-collapse supernovæ (SNe), and for the return of material to the interstellar medium.

Oral contribution, published in "What the highest angular resolution can bring to stellar astrophysics?", VLTI School 2013, 9–21 September 2013, Barcelonnette (France), eds. Millour, Chiavassa, Bigot, Chesneau, Meilland & Stee, EAS Publications Series (2015)
Available from arXiv:1501.05825

Thesis

Magnetic fields and the formation of aspherical planetary nebulæ

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The general evolution of stars with initial mass between 0.8 and 8 solar masses is believed to be well understood until the last stages, when significant mass loss starts. However, an initially spherical star may evolve into an asymmetrical planetary nebula (PN), whereas the underlying mechanism to this process remains as a puzzle. Until about a decade ago, it was believed that stars in the asymptotic giant branch (AGB) phase were still spherically symmetric. Nevertheless, observations performed in the last years show that, for some sources, elongated and asymmetrical envelopes can already be detected during the AGB phase. In the following pre-PN and planetary nebula phases, a variety of morphologies is observed, and the sources are classified into round, elliptical/elongated, bipolar, quadrupolar, multipolar, spiral, collimated lobes and irregular. It is unknown which mechanism or set of mechanisms is responsible for this change of morphology, making this topic to be one of the most discussed by the evolved stars community.

To shed some light on this problem, three AGB stars (IK Tau, R Scl, and V644 Sco) and one red supergiant (VY CMa) were observed at optical wavelengths. We analyzed their dust scattered emission and searched for signs of upcoming asymmetries in their circumstellar envelope. The observations in R band reveal that the dust envelope of the AGB star IK Tau has a global elliptical morphology, and the presence of a central waist is discussed. The observation of VY CMa shows a complex morphology in the very extended nebula that surrounds the source. Furthermore, for the first time the detached shell around the AGB star V644 Sco was imaged, allowing a better investigation of the mass-loss episodes of the source. The detached shell around R Scl was also imaged and analyzed. The results reported in this thesis add together with previous works, confirming that the loss of spherical symmetry in the circumstellar envelope of evolved stars can already start during the AGB phase.

Moreover, we studied one of the mechanisms that can play a role in the shaping process of the circumstellar envelope of these sources: magnetic fields. For this purpose, we investigated 22 GHz H_2O maser observations around five sources: four AGB stars (IK Tau, RT Vir, IRC +60°370, and AP Lyn) and one pre-PN (OH 231.8+4.2). By analyzing the linear and circular polarization in the masers, we detected the presence of magnetic field in four of these five sources. We measured the field strengths to be from a few tens up to a few hundreds of milligauss in the H_2O maser region (at a few tens of astronomical units from the star). Comparing our results with magnetic field measurements from the literature, obtained at different distances with respect to the stars, we tried to determine the most plausible geometry of the magnetic fields for the observed sources. However, it is not yet definitive if the observed fields are toroidal, poloidal, or dipole.

The influence of magnetic fields on the shaping process of the circumstellar envelope of evolved stars is still unclear, but their detection around AGB stars, pre-PNe and PNe supports that they might play a role in the process. More measurements of the strength of the fields, also at different distances to the stars, and the investigation of the geometry of the fields are fundamental for providing better constraints to models, and for the better understanding of this subject.

Defended on November 21, 2014
Available from http://hss.ulb.uni-bonn.de/2015/3903/3903.htm

Job Advert

Institute of Astronomy, Leuven University, Belgium
2 Ph.D. positions and 2 post-docs in the field of evolved stars and laboratory experiments

Interdisciplinary project on the stellar winds around evolved stars at the Leuven University in Belgium funded by the ERC-CoG 2014 grant AEROSOL (PI. L. Decin).

The project

At the Leuven University (Belgium), we seek candidates for two post-doctoral and two Ph.D. research positions, ready to play a key role in a new interdisciplinary project focusing on stellar winds around evolved (low-mass) stars. The candidates will interact closely with a team consisting of astrophysicists, chemists, and computational mathematicians, as the goal of the project is to boost our understanding of the physics and chemistry characterizing these stellar winds. The project builds upon novel data (including ALMA, *Herschel*, etc.), detailed theoretical wind models, and targeted laboratory experiments (see http://fys.kuleuven.be/ster/Projects/aerosol/aerosol).

Institute of Astronomy

The Institute of Astronomy of the Leuven University is a young and active research group of some 50 scientists, engineers and administrative staff (http://www.ster.kuleuven.be). The institute is involved in several international networks and research projects, involving telescopes at international observatories and space missions. The institute is also responsible for the organisation of the Master in Astronomy & Astrophysics of the Faculty of Science at the Leuven University. The institute has a long tradition in the observational and theoretical studies of the late stages of evolution of low and intermediate mass stars.

For the ERC-CoG AEROSOL project of Prof. L. Decin, we seek one post-doc and one Ph.D. candidate to work on the reduction, analysis and (radiative transfer) modeling of a whole suit of observations ranging from the UV to mm wavelength regime with the aim to retrieve the geometrical, thermodynamical and chemical structures of stellar winds. The post-doc preferentially has experience with infrared and (sub)millimeter observations and has in any case sufficient experience in implementing and exploiting radiative transfer models. The post-doc will also be allowed to carry out (part-time) his/her own research in collaboration with affiliated group members. The successful candidates will have access to recently obtained and granted observational data, advanced radiative transfer and forward chemistry modeling tools and will have the possibility to develop their own (hydro)simulations.

Physical Chemistry

As part of this project, one post-doc and one Ph.D. position is open in the research group of Prof. S. Carl in the field of experimental gas-phase reaction kinetics in the Department of Chemistry, division of Quantum and Physical chemistry, beginning preferably on 1st October 2015. The experimental work will be carried out in the modern and fully-equipped new research laboratories of the Department of Chemistry, opening in mid 2015. The experimental research concerns the determination of rate coefficients and product distributions of elementary gas-phase reactions involving key reactive species (Si- and S-bearing species and HCCO radicals) in stellar winds for which data is currently lacking. Specifically, several advanced laser-spectroscopic and chemiluminescence techniques will be employed by the Ph.D. student to follow photolytically-generated reactive species in real time in a novel temperature-graded reaction vessel (200–900 K) coupled with cavity- ringdown/Fourier-transform infrared spectroscopy to elucidate reaction product channels. The post-doc will concentrate on the construction and exploitation of a novel low-temperature Laval-nozzle apparatus with the aim to obtain the rates of the same gas-phase reactions at temperatures below 200 K.

Candidates should have an interest in physical chemistry, high-resolution laser spectroscopy, and technical experimentation. The group currently enjoys and encourages further close collaboration with researches in the department employing high-level quantum chemical calculations on species related to this project.

The positions

At the Leuven University, the candidates will join the Institute for Astronomy (Prof. L. Decin) or the Physical Chemistry section (Prof. S. Carl). The interdisciplinary project is carried out in collaboration with Prof. T. Millar (Belfast University) and Prof. J. Nuth (NASA, Greenbelt). The four candidates will interact closely with the other team members at the Institute of Astronomy and Department of Chemistry. At the Leuven University, we have access to parallel computing facilities, to be exploited extensively in this project.

Contract

The Ph.D. candidates will be employed for a 2+2 (after positive evaluation) period at the Institute of Astronomy or a 2+1 period at the Department of Chemistry. The initial contract for the post-doc positions runs over 2 years and could be prolonged with another year after positive evaluation. The salary will be commensurate to the standard scale for Ph.D. and post-doctoral researchers at the Leuven University. The preferred starting date is between 1 October 2015 and 1 December 2015, but will be adapted to the selected candidate's availability. Candidates are thus requested to indicate their preferred starting date in the application.

Interested?

The successful post-doc candidates must have a Ph.D. degree in astrophysics or chemistry, while the Ph.D. candidates must have obtained a master degree in (astro)physics, mathematics or chemistry. The application must include

- A Curriculum Vitæ (including publication list).
- A statement of research interests and future plans (maximum 3 pages).
- A letter detailing your specific qualifications for the position and your career/educational goals (maximum 1 page).
- Two letters of recommendation from professors well acquainted with your academic achievements. The letters are to be submitted separately to the address mentioned below.

DEADLINE for the application: 1 May 2015

More information can be obtained by contacting:

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See also http://fys.kuleuven.be/ster/vacancies

Fizeau exchange visitors program call for applications

Dear colleagues!

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

The deadline for applications is March 15.
Fellowships can be awarded for missions starting in May.

NOTE: a special Fizeau call will be issued in late April for financial support requests for the VLTI school 2015 in Cologne: http://www.astro.uni-koeln.de/vltischool2015

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

The program is funded by OPTICON/FP7.

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

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

See also www.european-interferometry.eu

IAU GA focus meeting: Planetary nebulæ as probes of galactic structure and evolution

The IAU General Assembly will be held in Honolulu, August 5–6, 2015. Focus Meeting 4, 5–6 Aug, is on planetary nebulæ. Topics covered include

- The evolutionary paths to planetary nebulæ (PNe), and the binary connection.
- The PN luminosity function as extragalactic distance scale.
- Abundances of PNe in our Galaxy and in nearby spirals, and galactic evolution.
- PNe as dynamical probes in elliptical and spiral galaxies.
- PNe in intracluster populations.

Abstract submission, either for talks or for posters, is now open. If you like to participate you should submit your science abstract by March 18, 2015. Please note that this is a hard deadline, as requested by the IAU, and that we will not be able to accommodate late talks or posters.

The meeting is chaired by Letizia Stanghellini (NOAO), Roberto Mendez (University of Hawaii), and Miriam Peña (UNAM, DF)

See also http://www.iau.org/science/events/1131/

Spectroscopy of Exoplanets: 2nd Announcement of the ExoMol conference at Cumberland Lodge near to London, UK

After four years of the ExoMol project we will be holding a conference 'Spectroscopy of Exoplanets' at Cumberland Lodge near to London. The conference will begin in the morning on 24 July and running through to the evening of 26 July 2015 (departing after breakfast the following day).

Cumberland Lodge is a 17th Century house located in Great Windsor Park. It offers easy access to Heathrow and is close to Windsor Castle, which is the oldest and largest occupied castle in the world and the official residence of Her Majesty the Queen. We would aim to visit the castle during the course of the conference. You may like to look at the Cumberland Lodge website: http://www.cumberlandlodge.ac.uk/

The provisional programme includes sessions on:

- Spectroscopy of atmospheres of exoplanets
- Molecules in stellar and Galactic context
- Sources of opacity data (theoretical and laboratory)
- Characterising exoplanetary atmospheres
- Observational issues
- Chemistry and structure of exoplanets
- as well as Quiz, Windsor Castle Visit, and Karaoke

Invited speakers are:

- Peter Bernath (ODU, USA)
- Vincent Boudon (Dijon, France)
- Adam Burrows (Princeton, USA)
- Iouli Gordon (Harvard, USA)
- Nikku Madhusudhan (Cambridge, UK)
- Thomas Masseron (Cambridge, UK)
- Amanda Ross (Lyon, France)
- Ingo Walman (UCL, UK)

Organizers:

- Jonathan Tennyson (UCL)

- Laura McKemmish (UCL)
- Sergey Yurchenko (UCL)
- Emma Barton (UCL)
- Giovanna Tinetti (UCL)
- France Allard (ENS-Lyon)
- Attila Csaszar (Eötvös-Budapest)

See also http://www.exomol.com/conference/2015/