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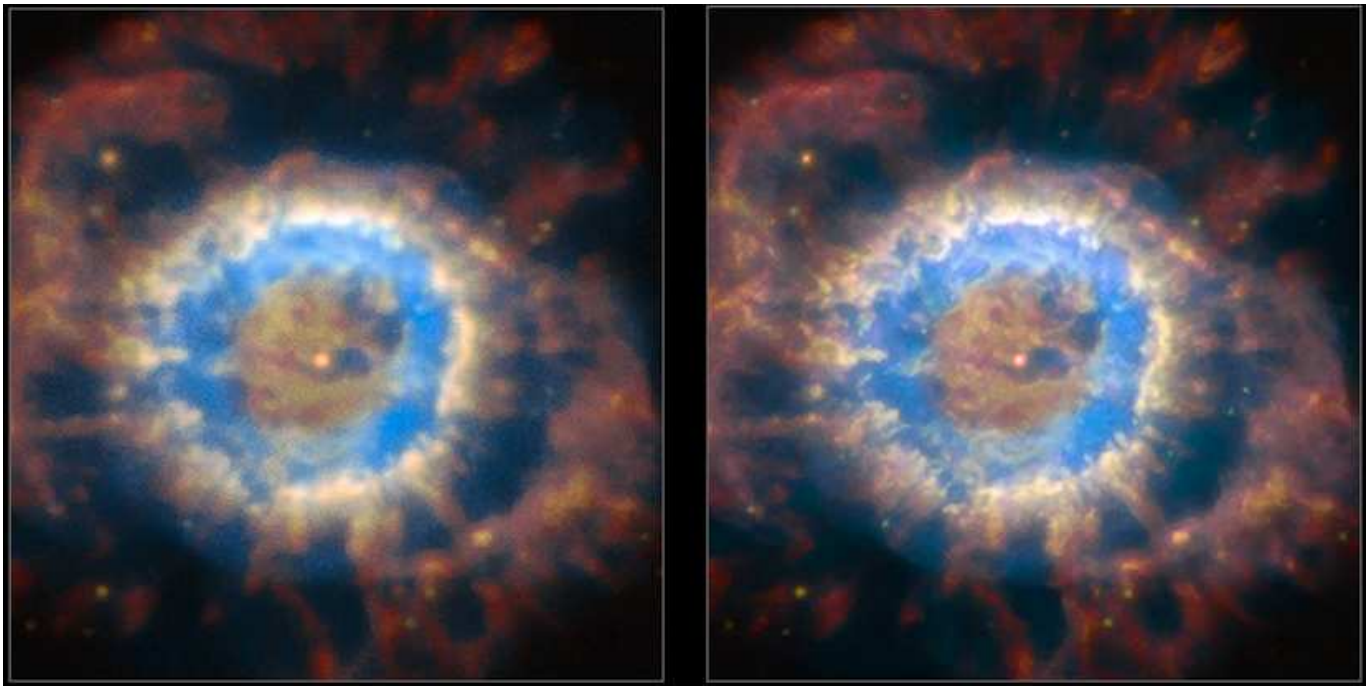

Figure 1: The planetary nebula NGC 6369 observed with the MUSE instrument at ESO's VLT before (*left*) and after (*right*) employing the adaptive optics module GALACSI. See http://www.eso.org/public/news/eso1724 for more.

Editorial

Dear Colleagues,

It is a pleasure to present you the 241st issue of the AGB Newsletter. It's not the most voluminous of editions, despite the slightly delayed issue – but no less interesting, in particular if you're studying dust.

Great news for some: a postdoctoral position is available in Belgium.

If you skipped the front page, please turn back a page and have a look. If you have a result you would like to see featured on the front page, be it an image, diagram, or spectrum, just send us the file.

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:

Planetary nebulæ are cool – or hot?

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

Pushing the limits: detecting H_2 emission from faint bipolar planetary nebulæ in the IPHAS sample

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We have obtained deep narrowband images in the near-infrared H_2 (2.122 μm) emission line for a sample of 15 faint Isaac Newton Telescope Photometric Hα Survey (IPHAS) bipolar planetary nebulæ (PNe) to search for molecular material. H_2 emission is found in most of them (14 out of 15), mostly associated with rings at their equatorial regions and with their bipolar lobes. These detections add to the high occurrence of H_2 emission among bipolar PNe reported in previous works, resulting from the large reservoir of molecular material in these sources and the suitable excitation conditions for H_2 emission. The correlation between detailed bipolar morphology and H_2 luminosity is also confirmed: bipolar PNe with broad equatorial rings (R-BPNe) have almost no continuum emission, are H_2 brighter and have larger H_2/Brγ line ratio than bipolar PNe with pinched equatorial waists (W-BPNe). The origin of this dichotomy is unclear. The larger size and age of R-BPNe are consistent with shock excitation of H_2, whereas ultraviolet pumping is most likely the excitation mechanism in the smaller and younger W-BPNe, which would explain their lower H_2 luminosity. Although both types of bipolar PNe seem to proceed from the same progenitor population, this does not imply that R-BPNe descend from W-BPNe. Otherwise, we note that some of the H_2-weak bipolar PNe harbor post-common envelope binary systems and symbiotic stars. Finally, we suggest that the long-living H_2 emission from R-BPNe arises from a discrete distribution of compact knots embedded within the ionized gas at the equatorial region.

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Available from https://arxiv.org/abs/1707.00368

Determining the magnitudes and spectral types of the components of the binary Mira X Ophiuchi

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Several values for the magnitudes and spectral types of the components of the binary Mira X Ophiuchi have been published in the literature over the last century. Analysis of new photometry and spectroscopy of the star between 2016 May and 2016 December indicates that the V magnitude of the constant star is 9.0 and its spectral type K1 III. The spectral type of the Mira changed from M6 III at maximum to M7 III as it faded and passed through minimum. The Mira's V magnitude varied between 6.47 at maximum and 9.83 at minimum, a range of 3.36 magnitudes.

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Low-temperature MIR to submillimeter mass absorption coefficient of interstellar dust analogues II: Mg and Fe-rich amorphous silicates

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To model the cold dust emission observed in the diffuse interstellar medium, in dense molecular clouds or in cold clumps that could eventually form new stars, it is mandatory to know the physical and spectroscopic properties of this dust and to understand its emission. This work is a continuation of previous studies aiming at providing astronomers with spectroscopic data of realistic cosmic dust analogues for the interpretation of observations. The aim of the present work is to extend the range of studied analogues to iron-rich silicate dust analogues. Ferromagnesium amorphous silicate dust analogues were produced by a sol-gel method with a mean composition close to $Mg_{1-x}Fe_xSiO_3$ with $x = 0.1$, 0.2, 0.3, 0.4. Part of each sample was annealed at 500 °C for two hours in a reducing atmosphere to modify the oxidation state of iron. We have measured the mass absorption coefficient (MAC) of these eight ferromagnesium amorphous silicate dust analogues in the spectral domain 30–1000 μm for grain temperature in the range 10–300 K and at room temperature in the 5–40 μm range. The MAC of ferromagnesium samples behaves in the same way as the MAC of pure Mg-rich amorphous silicate samples. In the 30–300 K range, the MAC increases with increasing grain temperature whereas in the range 10–30 K, we do not see any change of the MAC. The MAC cannot be described by a single power law in $\lambda^{-\beta}$. The MAC of the samples does not show any clear trend with the iron content. However the annealing process has, on average, an effect on the MAC that we explain by the evolution of the structure of the samples induced by the processing. The MAC of all the samples is much higher than the MAC calculated by dust models. The complex behavior of the MAC of amorphous silicates with wavelength and temperature is observed whatever the exact silicate composition (Mg vs. Fe amount). It is a universal characteristic of amorphous materials, and therefore of amorphous cosmic silicates, that should be taken into account in astronomical modeling. The enhanced MAC of the measured samples compared to the MAC calculated for cosmic dust model implies that dust masses are overestimated by the models.

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Pulsation-induced atmospheric dynamics in M-type AGB stars. Effects on wind properties, photometric variations and near-IR CO line profiles

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Wind-driving in asymptotic giant branch (AGB) stars is commonly attributed to a two-step process. First, matter in the stellar atmosphere is levitated by shock waves, induced by stellar pulsation, and second, this matter is accelerated by radiation pressure on dust, resulting in a wind. In dynamical atmosphere and wind models the effects of the stellar pulsation are often simulated by a simplistic prescription at the inner boundary. We test a sample of dynamical models for M-type AGB stars, for which we kept the stellar parameters fixed to values characteristic of a typical Mira variable but varied the inner boundary condition. The aim was to evaluate the effect on the resulting atmosphere structure and wind properties. The results of the models are compared to observed mass-loss rates and wind velocities, photometry, and radial velocity curves, and to results from 1D radial pulsation models. Dynamical atmosphere models are calculated, using the DARWIN code for different combinations of photospheric velocities and luminosity variations. The inner boundary is changed by introducing an offset between maximum expansion of the stellar surface and the luminosity and/or by using an asymmetric shape for the luminosity variation. Models that resulted in realistic wind velocities and mass-loss rates, when compared to observations, also produced realistic photometric variations. For the

models to also reproduce the characteristic radial velocity curve present in Mira stars (derived from CO $\Delta v = 3$ lines), an overall phase shift of 0.2 between the maxima of the luminosity and radial variation had to be introduced. We find that a group of models with different boundary conditions (29 models, including the model with standard boundary conditions) results in realistic velocities and mass-loss rates, and in photometric variations.

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J-type carbon stars: A dominant source of ^{14}N-rich presolar SiC grains of type AB

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We report Mo isotopic data of 27 new presolar SiC grains, including 12 ^{14}N-rich AB (^{14}N/^{15}N > 440, AB2) and 15 mainstream (MS) grains, and their correlated Sr and Ba isotope ratios when available. Direct comparison of the data for the MS grains, which came from low-mass asymptotic giant branch (AGB) stars with large *s*-process isotope enhancements, with the AB2 grain data demonstrates that AB2 grains show near-solar isotopic compositions and lack *s*-process enhancements. The near-normal Sr, Mo, and Ba isotopic compositions of AB2 grains clearly exclude born-again AGB stars, where the intermediate neutron-capture process (*i*-process) takes place, as their stellar source. On the other hand, low-mass CO novæ, and early R- and J-type carbon stars show ^{13}C and ^{14}N excesses but no *s*-process enhancements and are thus potential stellar sources of AB2 grains. Since both early R-type carbon stars and CO novæ are rare objects, the abundant J-type carbon stars (10–15% of all carbon stars) are thus likely to be a dominant source of AB2 grains.

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Radial pulsations of red giant branch stars

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We performed hydrodynamic computations of nonlinear stellar pulsations of population I stars at the evolutionary stages of the ascending red giant branch and the following luminosity drop due to the core helium flash. Red giants populating this region of the Hertzsprung–Russell diagram were found to be the fundamental mode pulsators. The pulsation period is the largest at the tip of the red giant branch and for stars with initial masses from 1.1 $M_\odot$ to 1.9 $M_\odot$ ranges from $\Pi \approx 254$ days to $\Pi \approx 33$ days, respectively. The rate of period change during the core helium flash is comparable with rates of secular period change in Mira type variables during the thermal pulse in the helium shell source. The period change rate is largest ($\dot{\Pi}/\Pi \approx -10^{-2}$ yr^{-1}) in stars with initial mass $M_{\rm zams} = 1.1$ $M_\odot$ and decreases to $\dot{\Pi}/\Pi \sim -10^{-3}$ yr^{-1} for stars of the evolutionary sequence $M_{\rm zams} = 1.9$ $M_\odot$. Theoretical light curves of red giants pulsating with periods $\Pi > 200$ days show the presence of the secondary maximum similar to that observed in many Miras.

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Optical properties of non-stoichiometric amorphous silicates with application to circumstellar dust extinction

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Optical constants of non-stoichiometric amorphous magnesium–iron silicates are determined. It is demonstrated that these can well reproduce the observed mid-infrared emission spectra of evolved stars. Stoichiometric and non-stoichiometric amorphous magnesium–iron silicate films are fabricated by pulsed laser deposition. Transmittance and ellipsometry measurements are performed in the wavelength range between 2 and 200 μm and 1.7 and 33 μm, respectively. Optical constants are derived from transmittance and ellipsometric Ψ and Δ spectra by means of oscillator models. The optical constants are applied in radiative transfer models for examining reproducibility of the observed spectral features of circumstellar dust shells around supergiants. The spectra of four selected supergiants are dominated by amorphous silicate dust emission in the wavelength range of 9 and 25 μm. To obtain a good fit to the observed spectra, we take into account amorphous corundum and metallic iron particles as additional dust components to account for dust emission at $\lambda < 8$ μm and in between the two silicate features. For each of the objects, a set of model parameters (dust mass, condensation temperature) is derived by an automated optimization procedure which well reproduces the observation. Consequently, our model spectra using the new optical data find that the silicate bands at ~ 10 and ~ 18 μm depend on the magnesium and iron ratio in the silicate system, and that a good fit requires a significant iron content of the amorphous silicate dust component to reproduce the observed peak positions and shape of the silicate bands.

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The planetary nebula IC 4776 and its post-common-envelope binary central star

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We present a detailed analysis of IC 4776, a planetary nebula displaying a morphology believed to be typical of central star binarity. The nebula is shown to comprise a compact hourglass-shaped central region and a pair of precessing jet-like structures. Time-resolved spectroscopy of its central star reveals periodic radial velocity variability consistent with a binary system. While the data are insufficient to accurately determine the parameters of the binary, the most likely solutions indicate that the secondary is probably a low-mass main sequence star. An empirical analysis of the chemical abundances in IC 4776 indicates that the common-envelope phase may have cut short the AGB evolution of the progenitor. Abundances calculated from recombination lines are found to be discrepant by a factor of approximately two relative to those calculated using collisionally excited lines, suggesting a possible correlation between low abundance discrepancy factors and intermediate-period post-common-envelope central stars and/or Wolf–Rayet central stars. The detection of a radial velocity variability associated with binarity in the central star of IC 4776 may be indicative of a significant population of (intermediate-period) post-common-envelope binary central stars which would be undetected by classic photometric monitoring techniques.

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Resonant drag instability of grains streaming in fluids

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It is shown that grains streaming through a fluid are generically unstable if their velocity, projected along some direction, matches the phase velocity of a fluid wave. This can occur whenever grains stream faster than a fluid wave. The wave itself can be quite general – sound waves, magnetosonic waves, epicyclic oscillations, and Brunt–Väisälä oscillations each generate instabilities, for example. A simple expression for this "resonant drag instability" (RDI) growth rate is derived. This expression (i) illustrates why such instabilities are so virulent and generic, and (ii) allows for simple analytic computation of RDI growth rates and properties for different fluid systems. As examples, we introduce several new instabilities, which could see application across a variety of astrophysical systems from protoplanetary disks to galactic outflows.

Submitted to Physical Review Letters
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The Resonant Drag Instability (RDI): acoustic modes

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Recently, Squire & Hopkins (2017) showed any coupled dust–gas mixture is subject to a class of linear "resonant drag instabilities" (RDI). These can drive large dust-to-gas ratio fluctuations even at arbitrarily small dust-to-gas mass ratios μ. Here, we explore the RDI in the simple case where the gas satisfies neutral hydrodynamics and supports acoustic waves ($\omega^2 = k^2 c_s^2$). The gas and dust are coupled via an arbitrary drag law and subject to external accelerations (e.g., gravity, radiation pressure). If there is any dust drift velocity, the system is unstable. The instabilities exist for all dust-to-gas ratios μ and their growth rates depend only weakly on μ, as $\sim \mu^{1/3}$. The behavior changes depending on whether the drift velocity is larger or smaller than the sound speed c_s. In the supersonic limit a "resonant" instability appears with growth rate increasing without limit with wavenumber, even for vanishingly small μ and values of the coupling strength ("stopping time"). In the subsonic limit instabilities always exist, but their growth rates no longer increase indefinitely towards small wavelengths. The results are robust to the drag law and equation-of-state of the gas. The instabilities directly drive exponentially growing dust-to-gas-ratio fluctuations, which can be large even when the modes are otherwise weak. We discuss physical implications for cool-star winds, AGN-driven winds and torii, and starburst winds: the instabilities alter the character of these outflows and will drive clumping and turbulence in both gas and dust.

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Atypical Mg-poor Milky Way field stars with globular cluster second-generation like chemical patterns

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We report the peculiar chemical abundance patterns of eleven atypical Milky Way (MW) field red giant stars observed by the Apache Point Observatory Galactic Evolution Experiment (APOGEE). These atypical giants exhibit strong Al and N enhancements accompanied by C and Mg depletions, strikingly similar to those observed in the so-called second-generation (SG) stars of globular clusters (GCs). Remarkably, we find low-Mg abundances ([Mg/Fe] < 0.0) together with strong Al and N overabundances in the majority (5/7) of the metal-rich ([Fe/H] $\gtrsim -1.0$) sample stars, which is at odds with actual observations of SG stars in Galactic CGs of similar metallicities. This chemical pattern is unique and unprecedented among MW stars, posing urgent questions about its origin. These atypical stars could be former SG stars of dissolved GCs formed with intrinsically lower abundances of Mg and enriched Al (subsequently self-polluted by massive AGB stars) or the result of exotic binary systems. We speculate that the stars Mg-deficiency as well as the orbital properties suggest that they could have an extragalactic origin. This discovery should guide future dedicated spectroscopic searches of atypical stellar chemical patterns in our Galaxy; a fundamental step forward to understand the Galactic formation and evolution.

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Monitor variability of millimeter lines in IRC +10°216

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A single dish monitoring of millimeter maser lines SiS $J = 14$–13 and HCN $\nu_2 = 1^f$ $J = 3$–2 and several other rotation lines is reported for the archetypal carbon star IRC +10°216. Relative line strength variations of ~ 5–30% are found for eight molecular line features with respect to selected reference lines. Definite line-shape variation is found in limited velocity intervals of the SiS and HCN line profiles. The asymmetrical line profiles of the two lines are mainly due to the varying components. The dominant varying components of the line profiles have similar periods and phases as the IR light variation, although both quantities show some degree of velocity dependence; there is also variability asymmetry between the blue and red line wings of both lines. Combining the velocities and amplitudes with a wind velocity model, we suggest that the line profile variations are due to SiS and HCN masing lines emanating from the wind acceleration zone. The possible link of the variabilities to thermal, dynamical and/or chemical processes within or under this region is also discussed.

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Sulphur-bearing molecules in AGB stars I: The occurrence of hydrogen sulfide

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Through a survey of (sub-)millimetre emission lines of various sulphur-bearing molecules, we aim to determine which molecules are the primary carriers of sulphur in different types of AGB stars. In this paper, the first in a series, we investigate the occurrence of H_2S in AGB circumstellar envelopes and determine its abundance, where possible. We have surveyed 20 AGB stars with a range of mass-loss rates and of different chemical types using the APEX telescope to search for rotational transition lines of five key sulphur-bearing molecules: CS, SiS, SO, SO_2 and H_2S. Here we present our results for H_2S, including detections, non-detections and detailed radiative transfer modelling of the detected lines. We compare results based on different descriptions of the molecular excitation of H_2S and different abundance distributions, including those derived from chemical modelling results. We detected H_2S towards five AGB stars, all of which have high mass-loss rates of $\dot{M} \geq 5 \times 10^{-6}$ $M_\odot$ yr^{-1} and are oxygen-rich. H_2S was not detected towards the carbon or S-type stars that fall in a similar mass-loss range. For the stars in our sample with detections, we find peak o-H_2S abundances relative to H_2 between 4×10^{-7} and 2.5×10^{-5}. Overall, we conclude that H_2S can play a significant role in oxygen-rich AGB stars with higher mass-loss rates, but is unlikely to play a key role in stars of other chemical types or the lower mass-loss rate oxygen-rich stars. For two sources, V1300 Aql and GX Mon, H_2S is most likely the dominant sulphur-bearing molecule in the circumstellar envelope.

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Abundances in Galactic Bulge planetary nebulæ from optical, ultraviolet and infrared observations

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Iron suffers from high levels of depletion in the highly ionized environments of planetary nebulæ, making the direct determination of undepleted elemental iron abundances difficult. Zinc, which does not suffer from the same depletion effects as iron, may be used as a surrogate element to measure iron abundances as there is an approximately constant zinc-to-iron ratio across a wide range of metallicities. In this paper, we report zinc abundances of six Galactic Bulge planetary nebulæ determined from new observations taken with ISAAC on the Very Large Telescope, Chile, prior to the instrument's decommissioning as well as a further three based upon literature observations. UVES data of the sample planetary nebulae are presented and have been used to derive abundances, temperatures and densities of a variety of elements and ions. The abundances derived from the UVES data agree well with results from the literature. [Zn/H], determined from the ISAAC observations, is found to be generally sub-solar and [O/Zn] is found to be either consistent or enriched with respect to Solar.

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The *Herschel* Planetary Nebula Survey (HerPlaNS) – A Comprehensive dusty photoionization model of NGC 6781

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We perform a comprehensive analysis of the planetary nebula (PN) NGC 6781 to investigate the physical conditions of each of its ionized, atomic, and molecular gas and dust components and the object's evolution, based on panchromatic observational data ranging from UV to radio. Empirical nebular elemental abundances, compared with theoretical predictions via nucleosynthesis models of asymptotic giant branch (AGB) stars, indicate that the progenitor is a solar-metallicity, 2.25–3.0 $M_\odot$ initial mass star. We derive the best-fit distance of 0.46 kpc by fitting the stellar luminosity (as a function of the distance and effective temperature of the central star) with the adopted post-AGB evolutionary tracks. Our excitation energy diagram analysis indicate high excitation temperatures in the photodissociation region (PDR) beyond the ionized part of the nebula, suggesting extra heating by shock interactions between the slow AGB wind and the fast PN wind. Through iterative fitting using the Cloudy code with empirically-derived constraints, we find the best-fit dusty photoionization model of the object that would inclusively reproduce all of the adopted panchromatic observational data. The estimated total gas mass (0.41 $M_\odot$) corresponds to the mass ejected during the last AGB thermal pulse event predicted for a 2.5 $M_\odot$ initial-mass star. A significant fraction of the total mass (about 70%) is found to exist in the PDR, demonstrating the critical importance of the PDR in PNe that are generally recognized as the hallmark of ionized/H^+ regions.

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High-resolution spectroscopic observations of the new CEMP-s star CD -50^circ**776**

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Carbon enhanced metal poor (CEMP) stars are a particular class of low metalicity halo stars whose chemical analysis may provide important contrains to the chemestry evolution of the Galaxy and to the models of mass transfer and evolution of components in binary systems. Here, we present a detailed analysis of the CEMP star CD $-50°776$, using high resolution optical spectroscopy. We found that CD $-50°776$ has a metalicity [Fe/H] = -2.31 and a carbon abundance [C/Fe] = $+1.21$. Analyzing the s-process elements and the europium abundances, we show that this star is actually a CEMP-s star, based on the criteria set in the literature to classify these chemically peculiar objects. We

also show that CD $-50°776$ is a lead star, since it has a ratio [Pb/Ce] = +0.97. In addition, we show that CD $-50°776$ develops radial velocity variations that may be attributed to the orbital motion in a binary system. The abundance pattern of CD $-50°776$ is discussed and compared to other CEMP-*s* stars already reported in the literature to show that this star is a quite exceptional object among the CEMP stars, particularly due to its low nitrogen abundance. Explaining this pattern may require to improve the nucleosynthesis models, and the evolutionary models of mass transfer and binary interaction.

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Study of the aluminium content in AGB winds using ALMA – Indications for the presence of gas-phase $(Al_2O_3)_n$ clusters

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Context: The condensation of inorganic dust grains in the winds of evolved stars is poorly understood. As of today, it is not yet known which molecular clusters form the first dust grains in oxygen-rich (C/O < 1) Asymptotic Giant Branch (AGB) winds. Aluminium oxides and iron-free silicates are often put forward as promising candidates for the first dust seeds.
Aims: We aim to constrain the dust formation histories in the winds of oxygen-rich AGB stars.
Methods: We have obtained ALMA observations with a spatial resolution of 120×150 mas^2 tracing the dust formation region of a low mass-loss rate and a high mass-loss rate AGB star, respectively being R Dor and IK Tau. Emission line profiles of AlO, AlOH and AlCl are detected in the ALMA data and are used to derive a lower limit of atomic aluminium incorporated in molecules. This constrains the aluminium budget that can condense into grains.
Results: Radiative transfer models constrain the fractional abundances of AlO, AlOH, and AlCl in IK Tau and R Dor. We show that the gas-phase aluminium chemistry is completely different in both stars, with a remarkable difference in the AlO and AlOH abundance stratification. The amount of aluminium locked up in these 3 molecules is small, $\leq 1.1 \times 10^{-7}$ w.r.t. H_2, for both stars, i.e. only $\leq 2\%$ of the total aluminium budget. An important result is that AlO and AlOH, being the direct precursors of alumina (Al_2O_3) grains, are detected well beyond the onset of the dust condensation proving that the aluminium oxide condensation cycle is not fully efficient. The ALMA observations allow us to quantitatively assess the current generation of theoretical dynamical–chemical models for AGB winds. We discuss how the current proposed scenario of aluminium dust condensation for low mass-loss rate AGB stars within a few stellar radii from the star, in particular for R Dor and W Hya, poses a challenge if one wishes to explain both the dust spectral features in the spectral energy distribution (SED), in interferometric data, and in polarized light signal. In particular, the estimated grain temperature of Al_2O_3 is too high for the grains to retain their amorphous structure. We advocate that large gas-phase $(Al_2O_3)_n$-clusters ($n > 34$) can be the potential agents of the broad 11-μm feature in the SED and in the interferometric data and we propose potential formation mechanisms for these large clusters.

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Job Advert

Postdoctoral position

This position is situated within the framework of the STARLAB BRAINbe network
– http://www.astro.ulb.ac.be/pmwiki/BRAIN/HomePage –
financed by BELSPO. The network is a collaboration between the Royal Observatory of Belgium (R.O.B. – M. Groenewegen), the astronomy department of the U.L.B. (Prof. A. Jorissen, the principal investigator of STARLAB), and the astronomy department of the K.U. Leuven (Prof. C. Wælkens). One of the three work packages within STARLAB aims at a better understanding of the mass-loss process in late-type stars, analysing data from the *Herschel* satellite, and the ALMA interferometer. This workpackage is a collaboration between R.O.B. and K.U. Leuven (Prof. L. Decin).

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