THE AGB NEWSLETTER

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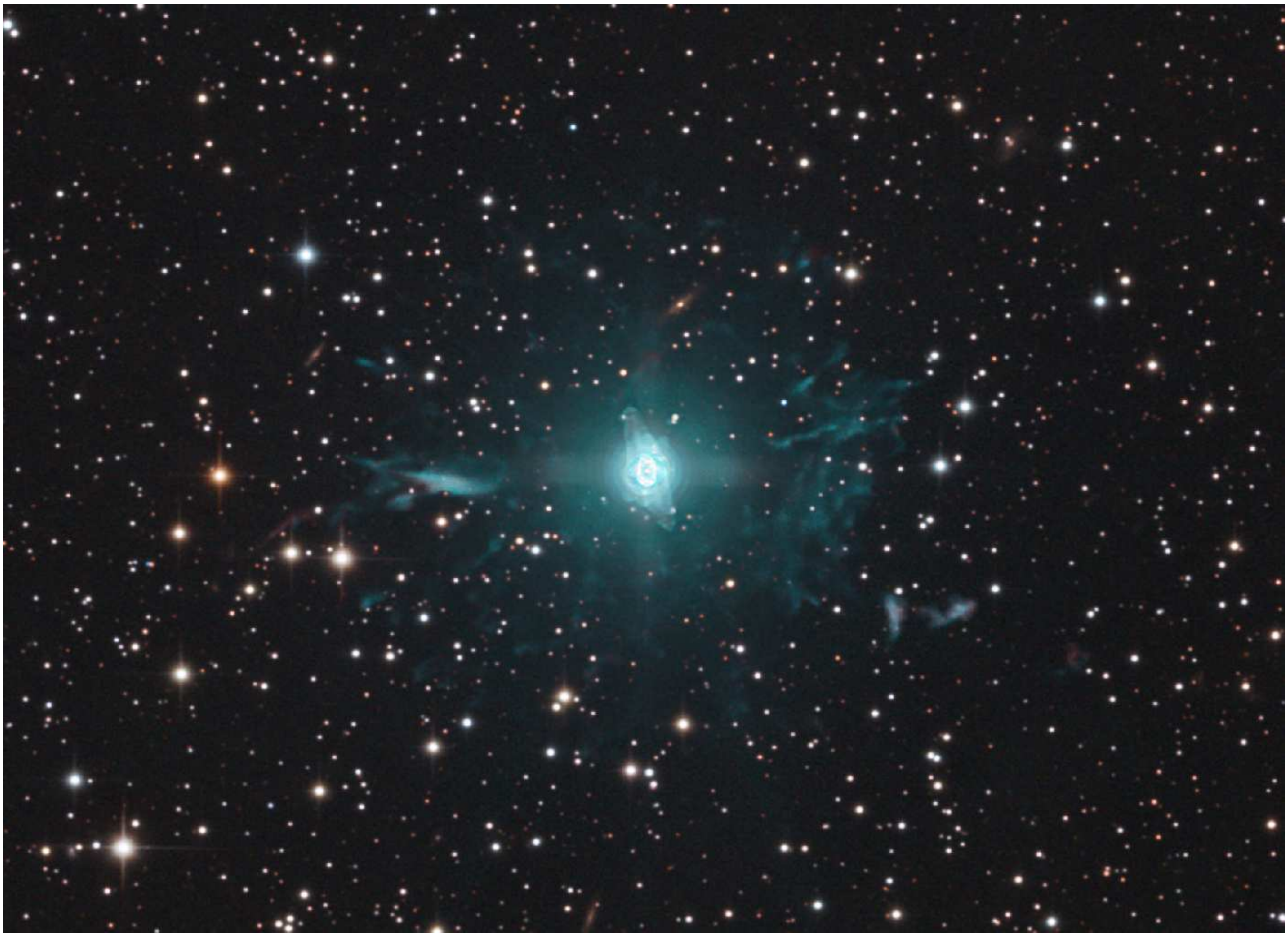

Figure 1: Hα, [O III] and RGB composite image of the planetary nebula NGC 5882; a total of 21 hour exposure (!) using an 80cm $f/7$ Cassegrain telescope situated at Cerro Tololo, Chile. Credit: CHART32.

Editorial

Dear Colleagues,

It is our pleasure to present you the 221st issue of the AGB Newsletter.

Sakib Rasool kindly pointed us at the website of the CHART32 team – http://www.chart32.de/ – which features some superb images of planetary nebulæ. We selected the picture of NGC 5882, showing especially very well the outer ejecta. Amateur telescopes with fast optics can capture low surface brightness features beyond the reach of large professional telescopes (e.g., they have discovered stellar tidal streams around galaxies invisible to 8-m class telescopes). Hopefully this encourages amateurs to push their equipment to the limits, at dark locations, to detect faint halos around planetary nebulæ – we look forward to seeing the results!

One reader responded to a response to an earlier *Food for Thought*: "In a recent response to a food-for-thought statement it was pointed out that, additional to pre-planetary nebulæ, there could be a second source of complex organic compounds, namely in shells of Li-rich K giant stars at the RGB luminosity bump. It must be said here that i) there is no evidence that there are *shells* around those objects, ii) there are indeed evolved AGB stars in the sample of de la Reza et al. (2015), iii) there is plenty of evidence that Li-rich RGB stars are by no means restricted to the luminosity bump, iv) there is no evidence for an abrupt enrichment in Li in these stars (it could well be that only a few stars go through this stage), and v) that signatures of these complex organic compounds are also found around young stellar objects. Hence, even if spaceborn complex organic compounds are a prerequisite for life on planets, we do not owe our lives to AGB stars, at least not in this respect." What about grains? We've needed them – can we do without AGB stars? And what about radio-active elements, to keep Earth's core liquid and the magnetic field strong?

The next issue is planned to be distributed around the 1st of January 2016.

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

Food for Thought

This month's thought-provoking statement is:

Understanding interstellar solid state physics helps to understand circumstellar solid state physics

Reactions to this statement or suggestions for next month's statement can be e-mailed to astro.agbnews@keele.ac.uk (please state whether you wish to remain anonymous)

Refereed Journal Papers

The red giant branch phase transition: Implications for the RGB luminosity function bump and detections of Li-rich red clump stars

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We performed a detailed study of the evolution of the luminosity of He-ignition stage and of the red giant branch bump luminosity during the red giant branch phase transition for various metallicities. To this purpose we calculated a grid of stellar models that sample the mass range of the transition with a fine mass step equal to 0.01 $M_{\odot}$. We find that for a stellar population with a given initial chemical composition, there is a critical age (of 1.1–1.2 Gyr) around which a decrease in age of just 20–30 million years causes a drastic drop in the red giant branch tip brightness. We also find a narrow age range (a few 10^7 yr) around the transition, characterized by the luminosity of the red giant branch bump being brighter than the luminosity of He ignition. We discuss a possible link between this occurrence and observations of Li-rich core He-burning stars.

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Hydrodynamic simulations of the interaction between an AGB star and a main sequence companion in eccentric orbits

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The Rotten Egg Nebula has at its core a binary composed of a Mira star and an A-type companion at a separation > 10 au. It has been hypothesized to have formed by strong binary interactions between the Mira and a companion in an eccentric orbit during periastron passage ~ 800 years ago. We have performed hydrodynamic simulations of an asymptotic giant branch star interacting with companions with a range of masses in orbits with a range of initial eccentricities and periastron separations. For reasonable values of the eccentricity, we find that Roche lobe overflow can take place only if the periods are $\ll 100$ years. Moreover, mass transfer causes the system to enter a common envelope phase within several orbits. Since the central star of the Rotten Egg nebula is an AGB star, we conclude that such a common envelope phase must have lead to a merger, so the observed companion must have been a tertiary companion of a binary that merged at the time of nebula ejection. Based on the mass and timescale of the simulated disc formed around the companion before the common envelope phase, we analytically estimate the properties of jets that could be launched. Allowing for super-Eddington accretion rates, we find that jets similar to those observed are plausible, provided that the putative lost companion was relatively massive.

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Low-ionization structures in planetary nebulæ – I. Physical, kinematic and excitation properties

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Though the low-ionization small-scale structures (LISs) such as knots, filaments and jets of planetary nebulæ (PNe) are known for ~ 30 yr, some of their observational properties are not well established. In consequence, our ability to include them in the wider context of the formation and evolution of PNe is directly affected. Why most structures have lower densities than the PN shells hosting them? Is their intense emission in low-ionization lines the key to their main excitation mechanism? Therefore, if considered altogether, can LISs line ratios, chemical abundances and kinematics enlighten the interplay between the different excitation and formation processes? Here we present a spectroscopic analysis of five PNe that possess LISs confirming that all nebular components have comparable electron temperatures, whereas the electron density is systematically lower in LISs than in the surrounding nebula. Chemical abundances of LISs versus other PN components do not show significant differences as well. By using diagnostic diagrams from shock models, we demonstrate that LISs' main excitation is due to shocks, whereas the other components are mainly photoionized. We also propose new diagnostic diagrams involving a few emission lines ([N II], [O III], [S II]) and $\log(f_{\rm shocks}/f_\star)$, where $f_{\rm shocks}$ and $f_\star$ are the ionization photon fluxes due to the shocks and the central star ionizing continuum, respectively. A robust relation differentiating the structures is found, with the shock-excited clearly having $\log(f_{\rm shocks}/f_\star) > -1$; while the photoionized structures have $\log(f_{\rm shocks}/f_\star) < -2$. A transition zone, with $-2 < \log(f_{\rm shocks}/f_\star) < -1$, where both mechanisms are equally important, is also defined.

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Evidence for a [WR] or WEL-type binary nucleus in the bipolar planetary nebula Vy 1-2

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We present high-dispersion spectroscopic data of the compact planetary nebula Vy 1-2, where high expansion velocities up to 100 km s^{-1} are found in the Hα, [N II] and [O III] emission lines. *Hubble* Space Telescope images reveal a bipolar structure. Vy 1-2 displays a bright ring-like structure with a size of $2.''4 \times 3.''2$ and two faint bipolar lobes in the east–west direction. A faint pair of knots is also found, located almost symmetrically on opposite sides of the nebula at position angle $= 305°$. Furthermore, deep low-dispersion spectra are also presented and several emission lines are detected for the first time in this nebula, such as the doublet [Cl III] 5517,5537, [K IV] 6101, C II 6461 and the doublet C IV 5801,5812 Å. By comparison with the solar abundances, we find enhanced N, depleted C and solar O. The central star must have experienced the hot-bottom burning (CN-cycle) during the second dredge-up phase, implying a progenitor star of $M \geq 3$ M$_\odot$. The very low C/O and N/O abundance ratios suggest a likely post-common envelope close binary system. A simple spherically symmetric geometry with either a blackbody or an H-deficient stellar atmosphere model is not able to reproduce the ionization structure of Vy 1-2. The effective temperature and luminosity of its central star indicate a young nebula located at a distance of ~ 9.7 kpc with an age of ~ 3500 yr. The detection of stellar emission lines, C II 6461, the doublet C IV $\lambda\lambda$ 5801,5812 and O III 5592 Å, emitted from an H-deficient star, indicates the presence of a late-type Wolf–Rayet or a WEL-type central star.

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An atlas of bright star spectra in the near infrared from Cassini–VIMS

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We present the *Cassini* Atlas Of Stellar Spectra (CAOSS), comprised of near-infrared low-resolution spectra of bright stars recovered from space-based observations by the *Cassini* spacecraft. The 65 stellar targets in the atlas are predominately M, K and S giants. However it also contains spectra of other bright nearby stars including carbon stars and main sequence stars from A to F. The spectra presented are free of all spectral contamination caused by the Earth's atmosphere, including the detrimental telluric molecular bands which put parts of the near-infrared spectrum out of reach of terrestrial observations. With a single instrument, a spectro-photometric dataset is recovered that spans the near-infrared from 0.8 to 5.1 μm with spectral resolution ranging from $R = 53.5$ to $R = 325$. Spectra have been calibrated into absolute flux units after careful characterisation of the instrumental spectral efficiency. Spectral energy distributions for most stars match closely with literature values. All final data products have been made available online.

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and from http://www.physics.usyd.edu.au/sifa/caoss/

The origin and evolution of r- and s-process elements in the Milky Way stellar disk

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Elements heavier than iron are produced through neutron-capture processes in the different phases of stellar evolution. Asymptotic giant branch (AGB) stars are believed to be mainly responsible for elements that form through the *slow* neutron-capture process, while the elements created in the *rapid* neutron-capture process have less understood production sites. Knowledge of abundance ratios as functions of metallicity can lead to insights on the origin and evolution of our Galaxy and its stellar populations.
We aim to trace the chemical evolution of the neutron-capture elements Sr, Zr, La, Ce, Nd, Sm, and Eu in the Milky Way stellar disk. This will allow us to constrain the formation sites of these elements as well as to probe the evolution of the Galactic thin and thick disks.
Using spectra of high resolution ($42\,000 \lesssim R \lesssim 65\,000$) and high signal-to-noise ($S/N \gtrsim 200$) obtained with the MIKE and the FEROS spectrographs, we determine Sr, Zr, La, Ce, Nd, Sm, and Eu abundances for a sample of 593 F and G dwarf stars in the Solar neighbourhood. The abundance analysis is based on spectral synthesis using one-dimensional, plane-parallel, local thermodynamic equilibrium (LTE) model stellar atmospheres calculated with the MARCS 2012 code.
We present abundance results for Sr (156 stars), Zr (311 stars), La (242 stars), Ce (365 stars), Nd (395 stars), Sm (280 stars) and Eu (378 stars). We find that Nd, Sm, and Eu show trends similar to what is observed for the α-elements in the [X/Fe]–[Fe/H] abundance plane. For [Sr/Fe] and [Zr/Fe] we find decreasing abundance ratios for increasing metallicity, reaching sub-solar values at super-solar metallicities. [La/Fe] and [Ce/Fe] do not show any clear trend with metallicity, being close to solar values at all [Fe/H]. The trends of abundance ratios [X/Fe] as a function of stellar ages present different slopes before and after 8 Gyr.
The rapid neutron-capture process is active early in the Galaxy, mainly in type II supernovæ from stars in the mass range 8–10 $M_\odot$. Europium is almost completely produced by r-process but Nd and Sm show similar trends to Eu even if their s-process component is higher. Strontium and Zr are thought to be mainly produced by s-process, but

show significant enrichment at low metallicity that requires extra r-process production, that probably is different from the classical r-process. Finally, La and Ce are mainly produced via s-process from AGB stars in mass range 2–4 $M_{\odot}$, which can be seen by the decrease in [La/Eu] and [Ce/Eu] at [Fe/H] ≈ -0.5. The trend of $[X/\mathrm{Fe}]$ with age could be explained by considering that the decrease in $[X/\mathrm{Fe}]$ for the thick disk stars can be due to the decrease of type II supernovæ with time meaning a reduced enrichment of r-process elements in the interstellar medium. In the thin disk the trends are flatter that probably is due to that the main production from s-process is balanced by Fe production from type Ia supernovæ.

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Chemical abundances of planetary nebulæ in the substructures of M 31

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We present deep spectroscopy of planetary nebulæ (PNe) that are associated with the substructures of the Andromeda Galaxy (M 31). The spectra were obtained with the OSIRIS spectrograph on the 10.4 m GTC. Seven targets were selected for the observations, three in the Northern Spur and four associated with the Giant Stream. The most distant target in our sample, with a rectified galactocentric distance > 100 kpc, was the first PN discovered in the outer streams of M 31. The [O III] 4363 auroral line was well detected in the spectra of all targets, enabling electron temperature determination. Ionic abundances are derived based on the [O III] temperatures, and elemental abundances of helium, nitrogen, oxygen, neon, sulfur, and argon are estimated. The relatively low N/O and He/H ratios as well as abundance ratios of α-elements indicate that our target PNe might belong to populations as old as ~ 2 Gyr. Our PN sample, including the current seven and the previous three observed by Fang et al., have rather homogeneous oxygen abundances. The study of abundances and the spatial and kinematical properties of our sample leads to the tempting conclusion that their progenitors might belong to the same stellar population, which hints at a possibility that the Northern Spur and the Giant Stream have the same origin. This may be explained by the stellar orbit proposed by Merrett et al. Judging from the position and kinematics, we emphasize that M 32 might be responsible for the two substructures. Deep spectroscopy of PNe in M 32 will help to assess this hypothesis.

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Relating turbulent pressure and macroturbulence across the HR diagram with a possible link to γ Dor stars

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A significant fraction of the envelope of low- and intermediate-mass stars is unstable to convection, leading to sub-surface turbulent motion. Here, we consider and include the effects of turbulence pressure in our stellar evolution calculations. In search of an observational signature, we compare the fractional contribution of turbulent pressure to the observed macroturbulent velocities in stars at different evolutionary stages. We find a strong correlation between the two quantities, similar to what was previously found for massive OB stars. We therefore argue that turbulent pressure fluctuations of finite amplitude may excite high-order, high-angular degree stellar oscillations, which manifest themselves at the surface an additional broadening of the spectral lines, i.e. macroturbulence, across most of the HR diagram. When considering the locations in the HR diagram where we expect high-order oscillations to be excited by stochastic turbulent pressure fluctuations, we find a close match with the observational γ Doradus instability strip, which indeed contains high-order, non-radial pulsators. We suggest that turbulent pressure fluctuations on a percentual level may contribute to the γ Dor phenomenon, calling for more detailed theoretical modelling in this direction.

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KVN monitoring obsevations toward the recent outburst symbiotic star V407 Cygni

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Simultaneous time monitoring observations of H_2O and SiO maser lines were performed toward the D-type symbiotic binary system V407 Cyg with the Korean VLBI Network single dish radio telescope. These monitoring observations were carried out from March 2, 2010 (optical phase $\phi = 0.0$), 8 days before the nova outburst on March 10, 2010 to June 5, 2014 ($\phi = 2.13$). Eight days before the nova outburst, we detected the SiO $v = 1$, 2, $J = 1$–0 maser lines which exhibited values of 0.51 K ($\sim$ 6.70 Jy) and 0.71 K ($\sim$ 9.30 Jy), respectively, while after the outburst we could not detect them on April 2 ($\phi = 0.04$), May 5 ($\phi = 0.09$), May 8 ($\phi = 0.09$), or on June 5, 2010 ($\phi = 0.13$) within the upper limits of our KVN observations. After restarting our monitoring observations, we detected SiO $v = 2$, $J = 1$–0 masers starting on October 20, 2011 ($\phi = 0.83$) and detected SiO $v = 1$, $J = 1$–0 masers starting on December 22, 2011 ($\phi = 0.92$). These results provide clear evidence of the interaction between the shock from the nova outburst and the SiO maser regions of the Mira envelope. The peak emission of SiO $v = 1$, 2, $J = 1$–0 masers always occurred at blueshifted velocities with respect to the stellar velocity except for that of SiO $v = 1$ at one epoch. These phenomena may be related to the redistribution of SiO maser regions after the outburst. The peak velocity variations of SiO masers associated with stellar pulsation phases show an increasing blueshifted trend during our monitoring interval after the outburst.

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LX Cygni: A carbon star is born

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Context: The Mira variable LX Cygni (LX Cyg) has shown a dramatic increase of its pulsation period in the recent

decades and is appearing to undergo an important transition in its evolution.
Aims: We aim to investigate the spectral type evolution of this star over recent decades as well as during one pulsation cycle in more detail and discuss it in connection with the period evolution.
Methods: We present optical, near- and mid-infrared low-resolution as well as optical high-resolution spectra to determine the current spectral type. The optical spectrum of LX Cyg has been followed for more than one pulsation cycle. We compare recent spectra to archival spectra to trace the spectral type evolution, and we analyse a *Spitzer* mid-IR spectrum for the presence of molecular and dust features. Furthermore, the current pulsation period is derived from AAVSO data.
Results: We found that the spectral type of LX Cyg changed from S to C sometime between 1975 and 2008. Currently, the spectral type C is stable during a pulsation cycle. We show that spectral features typical of C-type stars are present in its spectrum from ~ 0.5 to 14 μm, and attribute an emission feature at 10.7 μm to SiC grains. Within only 20 years, the pulsation period of LX Cyg has increased from ~ 460 d to ~ 580 d and is stable now.
Conclusions: We conclude that the change in spectral type and increase in pulsation period happened simultaneously and are causally connected. Both a recent thermal pulse (TP) and a simple surface temperature decrease appear unlikely to explain the observations. We therefore suggest that the underlying mechanism is related to a recent third dredge-up mixing event that brought up carbon from the interior of the star, i.e. that a genuine abundance change happened. We propose that LX Cyg is a rare transition type object that is uniquely suited to study the transformation from oxygen- to carbon-rich stars in detail.

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Is the semi-regular variable RU Vulpeculæ undergoing a helium-shell flash?

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The semi-regular variable star RU Vulpeculæ (RU Vul) is being observed visually since 1935. Its pulsation period and amplitude are declining since ~ 1954. A leading hypothesis to explain the period decrease in asymptotic giant branch (AGB) stars such as RU Vul is an ongoing flash of the He-burning shell, also called a thermal pulse (TP), inside the star. In this paper, we present a CCD photometric light curve of RU Vul, derive its fundamental parameters, and test if the TP hypothesis can describe the observed period decline. We use CCD photometry to determine the present-day pulsation period and amplitude in three photometric bands, and high-resolution optical spectroscopy to derive the fundamental parameters. The period evolution of RU Vul is compared to predictions by evolutionary models of the AGB phase. We find that RU Vul is a metal-poor star with a metallicity $[\mathrm{M/H}] = -1.59 \pm 0.05$ and an effective surface temperature of $T_{\mathrm{eff}} = 3634 \pm 20$ K. The low metallicity of RU Vul and its kinematics indicate that it is an old, low-mass member of the thick disc or the halo population. The present day pulsation period determined from our photometry is ~ 108 d, the semi-amplitude in the V-band is 0.39 ± 0.03 mag. The observed period decline is found to be well matched by an evolutionary AGB model with stellar parameters comparable to those of RU Vul. We conclude that the TP hypothesis is in good agreement with the observed period evolution of RU Vul.

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Discovery of an eclipsing dwarf nova in the ancient nova shell Te 11

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We report on the discovery of an eclipsing dwarf nova (DN) inside the peculiar, bilobed nebula Te 11. Modelling of high-speed photometry of the eclipse finds the accreting white dwarf to have a mass 1.18 $M_{\odot}$ and temperature 13 kK. The donor spectral type of M2.5 results in a distance of 330 pc, colocated with Barnard's loop at the edge of the Orion–Eridanus superbubble. The perplexing morphology and observed bow shock of the slowly-expanding nebula may be explained by strong interactions with the dense interstellar medium in this region. We match the DN to the historic nova of 483 CE in Orion and postulate that the nebula is the remnant of this eruption. This connection supports the millennia time scale of the post-nova transition from high to low mass-transfer rates. Te 11 constitutes an important benchmark system for CV and nova studies as the only eclipsing binary out of just three DNe with nova shells.

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Spectroscopic variability of IRAS22272+5435

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A time series of high-resolution spectra was observed in the optical wavelength region for the bright proto-planetary nebula IRAS 22272+5435 (HD 235858), along with a simultaneous monitoring of its radial velocity and BVR_C magnitudes. The object is known to vary in light, color, and velocity due to pulsation with a period of 132 days. The light and color variations are accompanied by significant changes in spectral features, most of which are identified as lines of carbon-bearing molecules. According to the observations, the C_2 Swan system and CN Red system lines are stronger near the light minimum. A photospheric spectrum of the central star was calculated using new self-consistent atmospheric models. The observed intensity variations in the C_2 Swan system and CN Red system lines were found to be much larger than expected if due solely to the temperature variation in the atmosphere of the pulsating star. In addition, the molecular lines are blueshifted relative to the photospheric velocity. The site of formation of the strong molecular features appears to be a cool outflow triggered by the pulsation. The variability in atomic lines seems to be mostly due variations of the effective temperature during the pulsation cycle. The profiles of strong atomic lines are split, and some of them are variable in a time scale of a week or so, probably because of shock waves in the outer atmosphere.

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Modelling the spectral energy distribution of the red giant in RS Ophiuchi: evidence for irradiation

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We present an analysis of optical and infrared spectra of the recurrent nova RS Oph obtained during between 2006 and 2009. The best fit to the optical spectrum for 2006 September 28 gives effective temperature $T_{\rm eff} = 3900$ K for $\log g = 2.0$, while for $\log g = 0.0$ we find $T_{\rm eff} = 4700$ K, and a comparison with template stellar spectra provides $T_{\rm eff} \sim 4500$ K. The observed spectral energy distribution (SED), and the intensities of the emission lines, vary on short (~ 1 day) time-scales, due to disc variability. We invoke a simple one-component model for the accretion disc, and a model with a hot boundary layer, with high ($\sim 3.9 \times 10^{-6}$ M$_\odot$ yr^{-1}) and low ($\sim 2 \times 10^{-8}$ M$_\odot$ yr^{-1}) accretion rates, respectively. Fits to the accretion disc-extracted infrared spectrum (2008 July 15) yield effective temperatures for the red giant of $T_{\rm eff} = 3800 \pm 100$ K ($\log g = 2.0$) and $T_{\rm eff} = 3700 \pm 100$ K ($\log g = 0.0$). Furthermore, using a more sophisticated approach, we reproduced the optical and infrared SEDs of the red giant in the RS Oph system with a two-component model atmosphere, in which 90% of the surface has $T_{\rm eff} = 3600$ K and 10% has $T_{\rm eff} = 5000$ K. Such structure could be due to irradiation of the red giant by the white dwarf.

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The characterisation of irregularly-shaped particles. A re-consideration of finite-sized, "porous" and "fractal" grains

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Context: A porous and/or fractal description can generally be applied where particles have undergone coagulation into aggregates.
Aims: To characterise finite-sized, "porous" and "fractal" particles and to understand the possible limitations of these descriptions.
Methods: We use simple structure, lattice and network considerations to determine the structural properties of irregular particles.
Results: We find that, for finite-sized aggregates, the terms porosity and fractal dimension may be of limited usefulness and show with some critical and limiting assumptions, that "highly-porous" aggregates (porosity $\gtrsim$80%) may not be "constructable". We also investigate their effective cross-sections using a simple "cubic" model.
Conclusions: In place of the terms porosity and fractal dimension, for finite-sized aggregates, we propose the readily-determinable quantities of inflation, I (a measure of the solid filling factor and size), and dimensionality, D (a measure of the shape). These terms can be applied to characterise any form of particle, be it an irregular, homogeneous solid or a highly-extended aggregate.

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Variations on a theme – the evolution of hydrocarbon solids: I. Compositional and spectral modelling – the eRCN and DG models

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Context: The compositional properties of hydrogenated amorphous carbons are known to evolve in response to the local conditions.
Aims: To present a model for low-temperature, amorphous hydrocarbon solids, based on the microphysical properties of random and defected networks of carbon and hydrogen atoms, that can be used to study and predict the evolution of their properties in the interstellar medium.
Methods: We adopt an adaptable and prescriptive approach to model these materials, which is based on a random covalent network (RCN) model, extended here to a full compositional derivation (the eRCN model), and a defective graphite (DG) model for the hydrogen poorer materials where the eRCN model is no longer valid.
Results: We provide simple expressions that enable the determination of the structural, infrared and spectral properties of amorphous hydrocarbon grains as a function of the hydrogen atomic fraction, $X_{\rm H}$. Structural annealing, resulting from hydrogen atom loss, results in a transition from H-rich, aliphatic-rich to H-poor, aromatic-rich materials.
Conclusions: The model predicts changes in the optical properties of hydrogenated amorphous carbon dust in response to the likely UV photon-driven and/or thermal annealing processes resulting, principally, from the radiation field in the environment. We show how this dust component will evolve, compositionally and structurally in the interstellar medium in response to the local conditions.

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Variations on a theme – the evolution of hydrocarbon solids: II. Optical property modelling – the optEC(s) model

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Context: The properties of hydrogenated amorphous carbon (a-C:H) dust are known to evolve in response to the local conditions.
Aims: We present an adaptable model for the determination of the optical properties of low-temperature, interstellar a-C:H grains that is based on the fundamental physics of their composition.
Methods: The imaginary part of the refractive index, k, for a-C:H materials, from 50 eV to cm wavelengths, is derived and the real part, n, of the refractive index is then calculated using the Kramers–Kronig relations.
Results: The formulated optEC(s) model allows a determination of the complex dielectric function, ϵ, and refractive index, $m(n,k)$, for a-C:H materials as a continuous function the band gap, $E_{\rm g}$, which is shown to lie in the range $\simeq -0.1$ to 2.7 eV. We provide expressions that enable a determination of their optical constants and tabulate $m(n,k,E_{\rm g})$ for 14 different values of $E_{\rm g}$. We explore the evolution of the likely extinction and emission behaviours of a-C:H grains and estimate the relevant transformation time-scales.
Conclusions: With the optEC(s) model we are able to predict how the optical properties of an a-C:H dust component in the interstellar medium will evolve in response to, principally, the local interstellar radiation field. The evolution of a-C:H materials appears to be consistent with many dust extinction, absorption, scattering and emission properties, and also with H_2 molecule, daughter "PAH" and hydrocarbon molecule formation resulting from its photo-driven decomposition.

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Variations on a theme – the evolution of hydrocarbon solids: III. Size-dependent properties – the optEC(s)(a) model

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Context: The properties of hydrogenated amorphous carbon (a-C:H) dust evolve in response to the local radiation field in the inter- stellar medium and the evolution of these properties is particularly dependent upon the particle size.
Aims: A model for finite-sized, low-temperature amorphous hydrocarbon particles, based on the microphysical properties of random and defected networks of carbon and hydrogen atoms, with surfaces passivated by hydrogen atoms, has been developed. Methods. The eRCN/DG and the optEC(s) models have been combined, adapted and extended into a new optEC(s)(a) model that is used to calculate the optical properties of hydrocarbon grain materials down into the sub-nanometre size regime, where the particles contain only a few tens of carbon atoms.
Results: The optEC(s)(a) model predicts a continuity in properties from large to small (sub-nm) carbonaceous grains. Tabulated data of the size-dependent optical constants (from EUV to cm wavelengths) for a-C:H (nano-)particles as a function of the bulk material band gap [$E_{\rm g}$(bulk)], or equivalently the hydrogen content, are provided. The effective band gap [$E_{\rm g}$(eff.)] is found to be significantly larger than $E_{\rm g}$(bulk) for hydrogen-poor a-C(:H) nano-particles and their predicted long-wavelength ($\lambda > 30$ μm) optical properties differ from those derived for interstellar polycyclic aromatic hydrocarbons (PAHs).
Conclusions: The optEC(s)(a) model is used to investigate the size-dependent structural and spectral evolution of a-C(:H) materials under ISM conditions, including: the IR–FUV extinction, the 217 nm bump and the infrared emission bands. The model makes several predictions that can be tested against observations.

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The evolution of amorphous hydrocarbons in the ISM: dust modelling from a new vantage point

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Context: The evolution of amorphous hydrocarbon materials, a-C(:H), principally resulting from ultraviolet (UV) photon absorption-induced processing, are likely at the heart of the variations in the observed properties of dust in the interstellar medium.
Aims: The consequences of the size-dependent and compositional variations in a-C(:H), from aliphatic-rich a-C:H to aromatic-rich a-C, are studied within the context of the interstellar dust extinction and emission.
Methods: Newly-derived optical property data for a-C(:H) materials, combined with that for an amorphous forsterite-type silicate with iron nano-particle inclusions, a-SilFe, are used to explore dust evolution in the interstellar medium.
Results: We present a new dust model that consists of a power-law distribution of small a-C grains and log-normal distributions of large a-SilFe and a-C(:H) grains. The model, which is firmly anchored by laboratory-data, is shown to quite naturally explain the variations in the infrared (IR) to far-ultraviolet (FUV) extinction, the 217 nm UV bump, the IR absorption and emission bands and the IR-mm dust emission.
Conclusions: The major strengths of the new model are its inherent simplicity and built-in capacity to follow dust evolution in interstellar media. We show that mantle accretion in molecular clouds and UV photo-processing in photo-dominated regions are likely the major drivers of dust evolution.

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H_2 formation via the UV photo-processing of a-C:H nano-particles

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Context: The photolysis of hydrogenated amorphous carbon, a-C(:H), dust by UV photon-irradiation in the laboratory leads to the release of H_2 as well as other molecules and radicals. This same process is also likely to be important in the interstellar medium.
Aims: We investigate molecule formation arising from the photo-dissociatively-driven, regenerative processing of a-C(:H) dust.
Methods: We explore the mechanism of a-C(:H) grain photolysis leading to the formation of H_2 and other molecules / radicals.
Results: The rate constant for the photon-driven formation of H_2 from a-C(:H) grains is estimated to be 2×10^{-17} cm^3 s^{-1}. In intense radiation fields photon-driven grain decomposition will lead to fragmentation into daughter species rather than H_2 formation.
Conclusions: The cyclic re-structuring of arophatic a-C(:H) nano-particles appears to be a viable route to formation of H_2 for low to moderate radiation field intensities ($1 \lesssim G_0 \lesssim 10^2$), even when the dust is warm ($T \sim$ 50–100 K).

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Clear evidence for the presence of second-generation asymptotic giant branch stars in metal-poor Galactic globular clusters

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Galactic globular clusters (GCs) are known to host multiple stellar populations: a first generation with a chemical pattern typical of halo field stars and a second generation (SG) enriched in Na and Al and depleted in O and Mg. Both stellar generations are found at different evolutionary stages (e.g., the main-sequence turnoff, the subgiant branch, and the red giant branch). The non detection of SG asymptotic giant branch (AGB) stars in several metal-poor ([Fe/H] < -1) GCs suggests that not all SG stars ascend the AGB phase, and that failed AGB stars may be very common in metal-poor GCs. This observation represents a serious problem for stellar evolution and GC formation/evolution theories. We report fourteen SG-AGB stars in four metal-poor GCs (M 13, M 5, M 3, and M 2) with different observational properties: horizontal branch (HB) morphology, metallicity, and age. By combining the H-band Al abundances obtained by the APOGEE survey with ground-based optical photometry, we identify SG Al-rich AGB stars in these four GCs and show that Al-rich RGB/AGB GC stars should be Na-rich. Our observations provide strong support for present, standard stellar models, i.e. without including a strong mass-loss efficiency, for low-mass HB stars. In fact, current empirical evidence is in agreement with the predicted distribution of FG and and SG stars during the He-burning stages based on these standard stellar models.

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The peculiar distribution of CH_3CN in IRC +10°216 seen by ALMA

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IRC +10°216 is a circumstellar envelope around a carbon-rich evolved star which contains a large variety of molecules. According to interferometric observations, molecules are distributed either concentrated around the central star or as a hollow shell with a radius of 15 arcsec. We present ALMA Cycle 0 band 6 observations of the $J = 14$–13 rotational transition of CH_3CN in IRC +10°216, obtained with an angular resolution of $0''.76 \times 0''.61$. The bulk of the emission is distributed as a hollow shell located at just 2 arcsec from the star, with a void of emission in the central region up to a radius of 1 arcsec. This spatial distribution is markedly different from those found to date in this source for other molecules. Our analysis indicates that methyl cyanide is not formed in either the stellar photosphere or far in the outer envelope, but at radial distances as short as 1–2 arcsec, reaching a maximum abundance of 0.02 molecules cm^{-3} at 2 arcsec from the star. Standard chemical models of IRC +10°216 predict that the bulk of CH_3CN molecules should be present at a radius of 15 arcsec where other species such as polyyne radicals and cyanopolyynes are observed, with an additional inner component within 1 arcsec from the star. The non-uniform structure of the circumstellar envelope and grain surface processes are discussed as possible causes of the peculiar distribution of methyl cyanide in IRC +10°216.

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Spectroscopically identified intermediate age stars at 0.5–3 pc distance from Sgr A*

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Context: Nuclear star clusters (NSCs) at the dynamical center of galaxies appear to have a complex star formation history. This suggests repeated star formation even in the influence of the strong tidal field from supermassive black holes.
Aim: In our previous study, we have detected 31 so far unknown early-type star candidates throughout the Galactic NSC (at 0.5–3 pc from Sgr A*; Nishiyama & Schödel 2013). The aim of this study is a confirmation of the spectral type for the candidates.
Method: We have carried out NIR spectroscopic observations of the candidates using Subaru/IRCS/AO188/LGS. K-band spectra for 20 out of the 31 candidates were obtained. By determining an equivalent width, EW(CO), of the ^{12}CO absorption feature at 2.294 μm, we have derived an effective temperature and a bolometric magnitude for each candidate, and then constructed an HR diagram.
Results: No young ($\sim$ Myr), massive stars are included in the 20 candidates we observed; however, 13 candidates are most likely intermediate-age giants (50–500 Myr). Two other sources have ages of $\sim$ 1 Gyr, and the remaining five sources are old ($>$ 1 Gyr), late-type giants.
Conclusions: Although none of the early-type star candidates from our previous narrow-band imaging observations can be confirmed as a young star, we find that the photometric technique is sensitive to distinguish old, late-type giants from young and intermediate-age populations. The intermediate-age stars could be so far unknown members

of a population formed in a starburst ~ 100 Myr ago. Finding no young ($\sim$ a few Myr) stars at $R = 0.5$–3 pc favors the in-situ formation scenario for the presence of the young stars at $R < 0.5$ pc. Furthermore, the different spatial distributions of the young and the intermediate-age stars imply that the Galactic NSC is an aggregate of stars born in different places and under different physical conditions.

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Conference Paper

CO and H I emission from the circumstellar envelopes of some evolved stars

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Studies of the CO and H I radio emission of some evolved stars are presented using data collected by the IRAM Plateau de Bure interferometer and Pico Veleta telescope, the Nançay Radio Telescope and the JVLA and ALMA arrays. Approximate axial symmetry of the physical and kinematic properties of the circumstellar envelope (CSE) are observed in CO emission, in particular, from RS Cnc, EP Aqr and the Red Rectangle. A common feature is the presence of a bipolar outflow causing an enhanced wind velocity in the polar directions. H I emission extends to larger radial distances than probed by CO emission and displays features related to the interaction between the stellar outflow and interstellar matter. With its unprecedented sensitivity, FAST will open a new window on such studies. Its potential in this domain is briefly illustrated.

Oral contribution, published in "Frontiers in Radio Astronomy and FAST Early Sciences Symposium", 2015
Available from arXiv:1510.08964

Announcements

The XII Torino workshop and IV CSFK Astromineralogy workshop

We are pleased to announce that registration is now open at the workshop website: https://indico.cern.ch/event/456759/ for

The XII Torino workshop on asymptotic giant branch stars: evolution, nucleosynthesis, observations, and the impact on cosmochemistry and The IV CSFK Astromineralogy workshop

to be held in Budapest from 31$^{\text{th}}$ July to 5$^{\text{th}}$ August 2016.
Abstract submission and financial support deadline: 30$^{\text{th}}$ April 2016
Registration and hotel booking deadline: 31$^{\text{th}}$ May 2016

There is no registration fee and participation is limited to 60 people so register early if you want to be there!

The Torino Workshops series started in Torino in 1995 and 11 workshops have been held so far in different parts of the world. The 12th workshop will be held jointly with the biannual CSFK Astromineralogy Workshop IV, which started in Budapest in 2010. Traditionally, the Torino workshops focus on the physics of asymptotic giant branch (AGB) stars and the production of nuclei therein. Many related topics are discussed in depth: nuclear astrophysics, galactic chemical evolution, stellar winds and dust formation, meteoritic stardust, cosmochemistry, and radioactive isotopes. These themes overlap with those of the Astromineralogy meetings, which traditionally cover topics from dust in forming planetary systems, meteorites, next ESA missions and space telescopes. The workshop will bring together astrophysicists, astronomers, nuclear physicists, and cosmochemists to discuss research topics in an interdisciplinary fashion. We want to identify current key scientific questions and methodologies to tackle them by combining different expertise, for example, combining laboratory analysis of cosmic materials and nuclear physics experiments to track the origin of cosmic dust and of nuclei in the Solar System, and interpreting recent observations of the chemical composition of stars using intermediate neutron-capture processes.

We acknowledge support from the Hungarian Academy of Sciences (MTA), the MTA Research Centre for Astronomy and Earth Sciences (CSFK), the MTA–CSFK Konkoly Observatory, the JINA Center for the Evolution of the Elements, and the INFN Section of Perugia.

We look forward to welcome you in Budapest in August 2016!

The Organizing Committee

Maria Lugaro (chair), Ákos Kereszturi, Marco Pignatari, Róbert Szabó, Christopher Tout, Maurizio Busso, and Eleonóra Hernold

Scientific Organizing Committee:

Oscar Straniero (chair), Carlos Abia, Sachiko Amari, Iris Dillmann, Marco Pignatari

See also https://indico.cern.ch/event/456759/

Conference 'Blowing in the wind'
7–13 august 2016, ICISE Quy nhon, Vietnam

The objective of this conference is to bridge the gap between researchers working on the inside and on the outside of stars. To build this bridge, we consider a range of fields all revolving around stellar winds: stellar structure evolution and abundances, winds launching mechanisms in luminous stars (such as OB, LVB, WR or AGB stars), pulsations and dust formation, meteoritic stardust, mass transfer in binaries, winds impact on circumstellar environments, bow shocks and planetary nebulæ, mass loss and its feedback onto host galaxies and stellar clusters. Summer 2016 is timely to examine what clues ALMA's fantastic resolution provides on stellar neighbourhoods, and how the big radio telescope FAST might be put to a good use for the next advances. Most Vietnamese astronomers work on stellar environments with the tools of radioastronomy and ICISE in Quy Nhon (Vietnam) is a perfect meeting point between Eastern and Western countries. Given the diversity of the participants, emphasis will be given to introductory and review talks, and room will be kept for discussions between participants coming from different horizons.

The answer, my friend, is blowing in the wind !

See also http://vietnam.in2p3.fr/2016/wind/