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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 205th issue of the AGB Newsletter. Phosphine, fluorine, maybe molybdenum or ruthenium, lithium, perhaps water, and what about fullerenes... there's something for everyone's taste.

Looking for a postdoctoral job? There's one in Teramo on offer!

Please note our e-mail address has changed to astro.agbnews@keele.ac.uk

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:

What is the most important nuclear reaction rate that needs to be determined more accurately?

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)

Confirmation of circumstellar phosphine

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Phosphine (PH_3) was tentatively identified a few years ago in the carbon star envelopes IRC +10°216 and CRL 2688 from observations of an emission line at 266.9 GHz attributable to the $J = 1$–0 rotational transition. We report the detection of the $J = 2$–1 rotational transition of PH_3 in IRC +10°216 using the HIFI instrument on board *Herschel*, which definitively confirms the identification of PH_3. Radiative transfer calculations indicate that infrared pumping to excited vibrational states plays an important role in the excitation of PH_3 in the envelope of IRC +10°216, and that the observed lines are consistent with phosphine being formed anywhere between the star and 100 $R_\star$ from the star, with an abundance of 10^{-8} relative to H_2. The detection of PH_3 challenges chemical models, none of which offers a satisfactory formation scenario. Although PH_3 locks just 2% of the total available phosphorus in IRC +10°216, it is together with HCP, one of the major gas phase carriers of phosphorus in the inner circumstellar layers, suggesting that it could be also an important phosphorus species in other astronomical environments. This is the first unambiguous detection of PH_3 outside the solar system, and a further step towards a better understanding of the chemistry of phosphorus in space.

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First release of the IPHAS Catalogue of new extended planetary nebulæ

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We present the first results of our search for new, extended planetary nebulæ (PNe) based on careful, systematic, visual scrutiny of the imaging data from the INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS). The newly uncovered PNe will help to improve the census of this important population of Galactic objects that serve as key windows into the late stage evolution of low to intermediate mass stars. They will also facilitate study of the faint end of the ensemble Galactic PN luminosity function. The sensitivity and coverage of IPHAS allows PNe to be found in regions of greater extinction in the Galactic Plane and/or those PNe in a more advanced evolutionary state and at larger distances compared to the general Galactic PN population. Using a set of newly revised optical diagnostic diagrams in combination with access to a powerful, new, multi-wavelength imaging database, we have identified 159 true, likely and possible PNe for this first catalogue release. The ability of IPHAS to unveil PNe at low Galactic latitudes and towards the Galactic Anticenter, compared to previous surveys, makes this survey an ideal tool to contribute to the improvement of our knowledge of the whole Galactic PN population.

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The YNEV stellar evolution and oscillation code

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We have developed a new stellar evolution and oscillation code YNEV, which calculates the structures and evolutions

of stars, taking into account hydrogen and helium burning. A nonlocal turbulent convection theory and an updated overshoot mixing model are optional in this code. The YNEV code can evolve low- and intermediate-mass stars from pre-main sequence (PMS) to thermal pulsing asymptotic branch giant (TP-AGB) or white dwarf. The YNEV oscillation code calculates the eigenfrequencies and eigenfunctions of the adiabatic oscillations of given stellar structure. The input physics and the numerical scheme adopted in the code are introduced in this paper. The examples of solar models, stellar evolutionary tracks of low- and intermediate-mass stars with different convection theory (i.e., mixing-length theory (MLT) and the nonlocal turbulent convection theory), and stellar oscillations are shown.

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Formation and X-ray emission from hot bubbles in planetary nebulæ. I. Hot bubble formation

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We carry out high resolution two-dimensional radiation-hydrodynamic numerical simulations to study the formation and evolution of hot bubbles inside planetary nebulæ (PNe). We take into account the evolution of the stellar parameters, wind velocity and mass-loss rate from the final thermal pulses during the asymptotic giant branch (AGB) through to the post-AGB stage for a range of initial stellar masses. The instabilities that form at the interface between the hot bubble and the swept-up AGB wind shell lead to hydrodynamical interactions, photoevaporation flows and opacity variations. We explore the effects of hydrodynamical mixing combined with thermal conduction at this interface on the dynamics, photoionization, and emissivity of our models. We find that even models without thermal conduction mix significant amounts of mass into the hot bubble. When thermal conduction is not included, hot gas can leak through the gaps between clumps and filaments in the broken swept-up AGB shell and this depressurises the bubble. The inclusion of thermal conduction evaporates and heats material from the clumpy shell, which expands to seal the gaps, preventing a loss in bubble pressure. The dynamics of bubbles without conduction is dominated by the thermal pressure of the thick photoionized shell, while for bubbles with thermal conduction it is dominated by the hot, shocked wind.

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Imaging the outward motions of clumpy dust clouds around the red supergiant Antares with VLT/VISIR

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Aim: We present a $0''.5$-resolution 17.7-μm image of the red supergiant Antares. Our aim is to study the structure of the circumstellar envelope in detail.
Methods: Antares was observed at 17.7-μm with the VLT mid-infrared instrument VISIR. Taking advantage of the BURST mode, in which a large number of short exposure frames are taken, we obtained a diffraction-limited image with a spatial resolution of $0''.5$.
Results: The VISIR image shows six clumpy dust clouds located at $0''.8$–$1''.8$ (43–96 $R_\star$ = 136–306 au) away from the star. We also detected compact emission within a radius of $0''.5$ from the star. Comparison of our VISIR image taken in 2010 and the 20.8-μm image taken in 1998 with the Keck telescope reveals the outward motions of four dust clumps. The proper motions of these dust clumps (with respect to the central star) amount to $0''.2$–$0''.6$ in 12 years.

This translates into expansion velocities (projected onto the plane of the sky) of 13–40 km s^{-1} with an uncertainty of $\pm$7 km s^{-1}. The inner compact emission seen in the 2010 VISIR image is presumably newly formed dust, because it is not detected in the image taken in 1998. If we assume that the dust is ejected in 1998, the expansion velocity is estimated to be 34 km s^{-1}, in agreement with the velocity of the outward motions of the clumpy dust clouds. The mass of the dust clouds is estimated to be (3–6)$\times 10^{-9}$ M$_\odot$. These values are lower by a factor of 3–7 than the amount of dust ejected in one year estimated from the (gas+dust) mass-loss rate of 2×10^{-6} M$_\odot$ yr^{-1}, suggesting that the continuous mass loss is superimposed on the clumpy dust cloud ejection.
Conclusions: The clumpy dust envelope detected in the 17.7-μm diffraction-limited image is similar to the clumpy or asymmetric circumstellar environment of other red supergiants. The velocities of the dust clumps cannot be explained by a simple accelerating outflow, implying the possible random nature of the dust cloud ejection mechanism.

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Some optical properties of graphite from IR to millimetric wavelengths

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Far infrared (FIR) data on the optical properties of graphite are presently lacking. An important step towards filling this gap was taken by Kuzmenko et al. (2008) who measured, on HOPG (Highly Oriented Pyrolitic Graphite) at normal incidence and from 10 to 300 K, the in-plane dielectric functions from 0.3 to 200 μm, and the reflectance between 0.3 and about 300 μm. We show here how, using recent developments of the electron theory of graphene, extended to graphite, it is possible to properly extrapolate the data farther even than 1000 μm, in effect all the way to Direct Current. The plasma frequency as well as the scattering rate of free electrons are shown to both decrease with T, but level off near 0 K, in agreement with theory. Along the way, we noticed significant discrepancies with the well-known and often used derivation of Philipp (1977) at room temperature, and also with previous data on temperature dependence and absorbance of graphitic material samples in different physical forms. Possible reasons for these discrepancies are discussed. Finally, the absorption efficiency of small graphitic spheres is deduced for the spectral range from 0.3 to 10000 μm. This may contribute to the discussion on model dust candidates for recently observed astronomical far infrared emissions.

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Multiperiodic semiregular variable stars in the ASAS data base: A pilot study

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Based on a search for multi-periodic variability among the semi-regular red variable stars in the database of the All Sky Automated Survey (ASAS), a sample of 72 typical examples is presented. Their period analysis was performed using Discrete Fourier Transform. In 41 stars we identified two significant periods each, simultaneously present, while the remaining 31 cases revealed even three such periods per star. They occur in a range roughly between 50 and 3000 days. Inter-relationships between these periods were analyzed using the "double period diagram" which compares adjacent periods, and the so-called "Petersen diagram", the period ratio vs. the shorter period. In both diagrams we could identify six sequences of accumulation of the period values. For five of these sequences (containing 97% of all data points) we found an almost perfect coincidence with those of previous studies which were based on very different samples of semi-regular red variables. Therefore, existence and locations of these sequences in the diagrams

seem to be universal features, which appear in any data set of semi-regularly variable red giants of the AGB; we conclude that they are caused by different pulsation modes as the typical and consistent properties of similar stellar AGB configurations. Stellar pulsations can be considered as the principal cause of the observed periodic variability of these stars, and not binary, rotation of a spotted surface or other possible reasons suggested in the literature.

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Spectroscopic study on the beryllium abundances of red giant stars

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An extensive spectroscopic study was carried out for the beryllium abundances of 200 red giants (mostly of late G and early K type), which were determined from the near-UV Be II 3131.066 line based on high-dispersion spectra obtained by *Subaru*/HDS, with an aim of investigating the nature of surface Be contents in these evolved giants; e.g., dependence upon stellar parameters, degree of peculiarity along with its origin and build-up timing. We found that Be is considerably deficient (to widely different degree from star to star) in the photosphere of these evolved giants by $\sim$ 1–3 dex (or more) compared to the initial abundance. While the resulting Be abundances (A(Be)) appear to weakly depend upon $T_{\rm eff}$, $\log g$, [Fe/H], M, age, and $v_{\rm e} \sin i$, this may be attributed to the metallicity dependence of A(Be) coupled with the mutual correlation between these stellar parameters, since such tendencies almost disappear in the metallicity-scaled Be abundance ([Be/Fe]). By comparing the Be abundances (as well as their correlations with Li and C) to the recent theoretical predictions based on sophisticated stellar evolution calculations, we concluded that such a considerable extent/diversity of Be deficit is difficult to explain only by the standard theory of first dredge-up in the envelope of red giants, and that some extra mixing process (such as rotational or thermohaline mixing) must be responsible, which presumably starts to operate already in the main-sequence phase. This view is supported by the fact that appreciable Be depletion is seen in less evolved intermediate-mass B–A type stars near to the main sequence.

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Photodissociation and chemistry of N_2 in the circumstellar envelopes of carbon-rich AGB stars

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Context: The envelopes of AGB stars are irradiated externally by ultraviolet photons; hence, the chemistry is sensitive to the photodissociation of N_2 and CO, which are major reservoirs of nitrogen and carbon, respectively. The photodissociation of N_2 has recently been quantified by laboratory and theoretical studies. Improvements have also been made for CO photodissociation.
Aims: For the first time, we use accurate N_2 and CO photodissociation rates and shielding functions in a model of the circumstellar envelope of the carbon-rich AGB star, IRC $+10°216$.
Methods: We use a state-of-the-art chemical model of an AGB envelope, the latest CO and N_2 photodissociation data, and a new method for implementing molecular shielding functions in full spherical geometry with isotropic incident radiation. We compare computed column densities and radial distributions of molecules with observations.
Results: The transition of $N_2 \rightarrow N$ (also, $CO \rightarrow C \rightarrow C^+$) is shifted towards the outer envelope relative to previous

models. This leads to different column densities and radial distributions of N-bearing species, especially those species whose formation/destruction processes largely depend on the availability of atomic or molecular nitrogen, for example, C_nN ($n = 1, 3, 5$), C_nN^- ($n = 1, 3, 5$), HC_nN ($n = 1, 3, 5, 7, 9$), H_2CN and CH_2CN.
Conclusions: The chemistry of many species is directly or indirectly affected by the photodissociation of N_2 and CO, especially in the outer shell of AGB stars where photodissociation is important. Thus, it is important to include N_2 and CO shielding in astrochemical models of AGB envelopes and other irradiated environments. In general, while differences remain between our model of IRC +10°216 and the observed molecular column densities, better agreement is found between the calculated and observed radii of peak abundance.

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Fluorine in the solar neighborhood: is it all produced in AGB stars?

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The origin of "cosmic" fluorine is uncertain, but there are three proposed production sites/mechanisms for the origin: asymptotic giant branch (AGB) stars, ν nucleosynthesis in Type II supernovæ, and/or the winds of Wolf–Rayet stars. The relative importance of these production sites has not been established even for the solar neighborhood, leading to uncertainties in stellar evolution models of these stars as well as uncertainties in the chemical evolution models of stellar populations. We determine the fluorine and oxygen abundances in seven bright, nearby giants with well determined stellar parameters. We use the 2.3-μm vibrational–rotational HF line and explore a pure rotational HF line at 12.2 μm. The latter has never been used before for an abundance analysis. To be able to do this, we have calculated a line list for pure rotational HF lines. We find that the abundances derived from the two diagnostics agree. Our derived abundances are well reproduced by chemical evolution models including only fluorine production in AGB stars and, therefore, we draw the conclusion that this might be the main production site of fluorine in the solar neighborhood. Furthermore, we highlight the advantages of using the 12-μm HF lines to determine the possible contribution of the ν process to the fluorine budget at low metallicities where the difference between models including and excluding this process is dramatic.

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Stellar abundances and presolar grains trace the nucleosynthetic origin of molybdenum and ruthenium

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This work presents a large consistent study of molybdenum (Mo) and ruthenium (Ru) abundances in the Milky Way. These two elements are important nucleosynthetic diagnostics. In our sample of 71 Galactic metal-poor field stars, we detect Ru and/or Mo in 51 of these (59 including upper limits). The sample consists of high-resolution, high signal-to-noise spectra covering both dwarfs and giants from [Fe/H] = −0.63 down to −3.16. Thus we provide information on the behaviour of Mo I and Ru I at higher and lower metallicity than is currently known. In this sample we find a wide spread in the Mo and Ru abundances, which is typical of heavy elements. We confirm earlier findings of Mo enhanced stars around [Fe/H] = -1.5 and add ~ 15 stars both dwarfs and giants with normal (< 0.3 dex) Mo and Ru abundances, as well as more than 15 Mo and Ru enhanced (> 0.5 dex) stars to the currently known stellar sample. This indicates that several formation processes, in addition to high entropy winds, can be responsible for the formation of elements like Mo and Ru. We trace the formation processes by comparing Mo and Ru to elements (Sr, Zr, Pd, Ag, Ba, and Eu) with known formation processes. Based on how tight the two elements correlate with each other, we are able to distinguish if they share a common formation process and how important this contribution is to the element abundance. We find clear indications of contributions from several different formation processes, namely the p-process, and the slow (s-), and rapid (r-) neutron-capture processes. From these correlations we find that Mo is a highly convolved element that receives contributions from both the s-process and the p-process and less from the main and weak r-processes, whereas Ru is mainly formed by the weak r-process as is silver. We also compare our absolute elemental stellar abundances to relative isotopic abundances of presolar grains extracted from meteorites. Their isotopic abundances can be directly linked to the formation process (e.g., r-only isotopes) providing a unique comparison between observationally derived abundances and the nuclear formation process. The comparison to abundances in presolar grains shows that the r-/s-process ratios from the presolar grains match the total elemental chemical composition derived from metal-poor halo stars with [Fe/H] around -1.5 to -1.1 dex. This indicates that both grains and stars around and above [Fe/H] = -1.5 are equally (well) mixed and therefore do not support a heterogeneous presolar nebula. An inhomogeneous interstellar medium (ISM) should only be expected at lower metallicities. Our data, combined with the abundance ratios of presolar grains, could indicate that the AGB yields are less efficiently mixed into stars than into presolar grains. Finally, we detect traces of s-process material at [Fe/H] = -1.5, indicating that this process is at work at this and probably at even lower metallicity.

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Radio frequency Models of novæ in eruption. I. The free–free process in bipolar morphologies

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Observations of novæ at radio frequencies provide us with a measure of the total ejected mass, density profile and kinetic energy of a nova eruption. The radio emission is typically well characterized by the free–free emission process. Most models to date have assumed spherical symmetry for the eruption, although it has been known for as long as there have been radio observations of these systems, that spherical eruptions are to simplistic a geometry. In this paper, we build bipolar models of the nova eruption, assuming the free–free process, and show the effects of varying different parameters on the radio light curves. The parameters considered include the ratio of the minor- to major-axis, the inclination angle and shell thickness (further parameters are provided in the appendix). We also show the uncertainty introduced when fitting spherical model synthetic light curves to bipolar model synthetic light curves. We find that the optically thick phase rises with the same power law ($S_\nu \propto t^2$) for both the spherical and bipolar models. In the bipolar case there is a "plateau" phase – depending on the thickness of the shell as well as the ratio of the minor- to major-axis – before the final decline, that follows the same power law ($S_\nu \propto t^{-3}$) as in the spherical case. Finally, fitting spherical models to the bipolar model synthetic light curves requires, in the worst case scenario, doubling the

ejected mass, more than halving the electron temperature and reducing the shell thickness by nearly a factor of 10. This implies that in some systems we have been over predicting the ejected masses and under predicting the electron temperature of the ejecta.

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New R Coronæ Borealis and DY Persei star candidates and other related objects found in photometric surveys

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We have carried out a search for new R Coronæ Borealis (RCB) variables using the publicly accessible data from various photometric sky surveys and – whenever available – AAVSO visual data. Candidates were selected from Tisserand's "Catalogue enriched with R CrB stars" and by a visual inspection of light curves from the ASAS-3, MACHO, NSVS and OGLE surveys. We have identified two new RCB stars, four RCB candidates, and one DY Persei (DYPer) star candidate. Our identification was based mainly on photometric variability, color–color diagrams, and further information drawn from various catalogue sources; spectroscopic classifications were also reported in our analysis whenever available. Additionally, we present a sample of interesting stars which – although showing similar photometric variability – can be ruled out as RCB and DYPer stars or have been rejected as such on spectroscopic grounds in recent studies. Although not useful in the investigation of the aforementioned groups of variables, these objects defy an easy classification and might be interesting targets for follow-up studies which we encourage for all stars presented in this paper.

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The Penn State – Toruń Centre for Astronomy Planet Search stars. II. Lithium abundance analysis of the red giant clump sample

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Standard stellar evolution theory does not predict existence of Li-rich giant stars. Several mechanisms for Li-enrichment have been proposed to operate at certain locations inside some stars. The actual mechanism operating in real stars is still unknown. Using the sample of 348 stars from the Penn State – Toruń Centre for Astronomy Planet Search, for which uniformly determined atmospheric parameters are available, with chemical abundances and rotational velocities presented here, we investigate various channels of Li enrichment in giants. We also study Li-overabundant giants in more detail in search for origin of their peculiarities. Our work is based on the Hobby–Eberly Telescope spectra obtained with the High Resolution Spectrograph, which we use for determination of abundances and rotational velocities. The Li abundance was determined from the ^{7}Li λ670.8-nm line, while we use a more extended set of lines for α-elements abundances. In a series of Kolmogorov–Smirnov tests, we compare Li-overabundant giants with other stars in the

sample. We also use available IR photometric and kinematical data in search for evidence of mass-loss. We investigate properties of the most Li-abundant giants in more detail by using multi-epoch precise radial velocities. We present Li and α-elements abundances, as well as rotational velocities for 348 stars. We detected Li in 92 stars, of which 82 are giants. Eleven of them show significant Li abundance $A(\mathrm{Li_{NLTE}}) > 1.4$ and seven of them are Li-overabundant objects, according to common criterion of $A\mathrm{Li}) > 1.5$ and their location on HR diagram, including TYC 0684-00553-1 and TYC 3105-00152-1, which are two giants with Li abundances close to meteoritic level. For another 271 stars, upper limits of Li abundance are presented. We confirmed three objects with increased stellar rotation. We show that Li-overabundant giants are among the most massive stars from our sample and show larger than average effective temperatures. They are indistinguishable from the complete sample in terms of their distribution of luminosity, metallicity, rotational velocities, and α-elements abundances. Our results do not point out to one specific Li-enrichment mechanism operating in our sample of giants. On the contrary, in some cases, we cannot identify fingerprints of any of known scenarios. We show, however, that the four most Li-rich giants in our sample either have low-mass companions or have radial velocity variations at the level of ~ 100 m s^{-1}, which strongly suggests that the presence of companions is an important factor in the Li-enrichment processes in giants.

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First detection and characterization of symbiotic stars in M 31

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Symbiotic binaries are putative progenitors of type Ia supernovæ. The census of Galactic symbiotic binaries is so incomplete that we cannot reliably estimate the total population of these stars, and use it to check whether that number is consistent with the observed type Ia supernova rate in spiral galaxies. We have thus begun a survey of the nearest counterpart of our own Galaxy, namely M 31, where a relatively complete census of symbiotic stars is achievable. We report the first detections and spectrographic characterizations of 35 symbiotic binaries in M 31, and compare these stars with the symbiotic population in the Milky Way. These newly detected M 31 symbiotic binaries are remarkably similar to Galactic symbiotics, though we are clearly only sampling (in this feasibility study) the most luminous symbiotics in M 31. We have also found, in M 31, the symbiotic star (M 31 SyS J004233.17+412720.7) with the highest ionization level known amongst all symbiotics. An optical outburst of the M 31 symbiotic star M 31 SyS J004322.50+413940.9 was probably a nova-like outburst, the first symbiotic outburst detected outside the Milky Way and Magellanic Clouds.

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H_2O maser emission associated with the planetary nebula IRAS 16333$-$4807

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We present simultaneous observations of H_2O maser emission and radio continuum at 1.3 cm carried out with the

Australia Telescope Compact Array towards two sources, IRAS 16333−4807 and IRAS 12405−6219, catalogued as planetary nebula (PN) candidates, and where single-dish detections of H_2O masers have been previously reported. Our goal was to unambiguously confirm the spatial association of the H_2O masers with these two PN candidates. We detected and mapped H_2O maser emission in both fields, but only in IRAS 16333−4807 the maser emission is spatially associated with the radio continuum emission. The properties of IRAS 16333−4807 provide strong support for the PN nature of the object, hereby confirming it as the fifth known case of a H_2O maser-emitting PN. This source is bipolar, like the other four known H_2O maser-emitting PNe, indicating that these sources might pertain to a usual, but short phase in the evolution of bipolar PNe. In IRAS 12405−6219, the H_2O maser and radio continuum emission are not associated with each other and, in addition, the available data indicate that this source is an H II region rather than a PN.

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High resolution spectroscopic observations of binary stars and yellow stragglers in three open clusters: NGC 2360, NGC 3680 and NGC 5822

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Binary stars in open clusters are very useful targets to constrain nucleosynthesis process. Since the luminosities of the stars are known because the distances of the clusters are also known, chemical peculiarities can be linked directly to the evolutionary status of a star. In addition, binary stars offer the opportunity to verify a relationship between them and the straggler population in both globular and open clusters. We carried out a detailed spectroscopic analysis to derive the atmospheric parameters for 16 red giants in binary systems and chemical composition for 11 of them of the open clusters NGC 2360, NGC 3680 and NGC 5822. We obtained abundances of C, N, O, Na, Mg, Al, Ca, Si, Ti, Ni, Cr, Y, Zr, La, Ce, and Nd. The atmospheric parameters of the studied stars and their chemical abundances were determined using high-resolution optical spectroscopy. We employ the local-thermodynamic-equilibrium model atmospheres of Kurucz and the spectral analysis code MOOG. The abundances of the light elements were derived using spectral synthesis technique. We found that the stars NGC 2360-92 and 96, NGC 3680-34 and NGC 5822-4 and 312 are yellow straggler stars. We show that the spectra of NGC 5822-4 and 312 present evidence of contamination by an A-type star as a secondary star. For the other yellow stragglers, the evidence of a contamination is given by the broad wings of the Hα. The detection of yellow straggler stars is important because the observed number can be compared with the number predicted by simulations of binary stellar evolution in open clusters. We also found that the other binary stars are not s-process enriched of which it may be suggest that in these binaries the secondary star is probably a faint main-sequence object. The lack of any s-process enrichment is very useful to set constraints for the number of white dwarfs in the open cluster, a subject that is related to the birthrate of these kind of stars in open clusters and also to the age of a cluster. Finally, rotational velocities were also determined and their values were compared with those already determined for field giant stars.

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Conference Paper

Interstellar and circumstellar fullerenes

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Fullerenes are a particularly stable class of carbon molecules in the shape of a hollow sphere or ellipsoid that might be formed in the outflows of carbon stars. Once injected into the inter- stellar medium (ISM), these stable species survive and are thus likely to be widespread in the Galaxy where they contribute to interstellar extinction, heating processes, and complex chemical reactions. In recent years, the fullerene species C_{60} (and to a lesser extent C_{70}) have been detected in a wide variety of circumstellar and interstellar environments showing that when conditions are favourable, fullerenes are formed efficiently. Fullerenes are the first and only large aromatics firmly identified in space. The detection of fullerenes is thus crucial to provide clues as to the key chemical pathways leading to the formation of large complex organic molecules in space, and offers a great diagnostic tool to describe the environment in which they reside. Since fullerenes share many physical properties with PAHs, understanding how fullerenes form, evolve and respond to their physical environment will yield important insights into one of the largest reservoirs of organic material in space. In spite of all these detections, many questions remain about precisely which members of the fullerene family are present in space, how they form and evolve, and what their excitation mechanism is. We present here an overview of what we know from astronomical observations of fullerenes in these different environments, and discuss current thinking about the excitation process. We highlight the various formation mechanisms that have been proposed, discuss the physical conditions conducive to the formation and/or detection of fullerenes in carbon stars, and their possible connection to PAHs, HACs and other dust features.

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and from http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=207

Job Advert

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The fellow will carry out the research at INAF–Osservatorio Astronomico di Teramo. Abroad periods for scientific collaborations are allowed upon authorization.

Details can be requested by e-mail to Sergio cristallo (sergio.cristallo[at]inaf.it).

See also http://193.204.1.1/agb_fellowship_position