THE AGB NEWSLETTER

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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 206$^{\rm th}$ issue of the AGB Newsletter. You've been very active! Common themes include extra-galactic populations, interacting circumstellar envelopes, white dwarves and other stellar cores and their possible explosions, chemistry and nucleosynthesis, and what about water fountains...

The Fizeau exchange programme in the field of interferometry is still going strong, so here's your chance to get involved with the powerful yet still rather expert technique.

Likewise: never tried your hands on modelling diffuse clouds and their spectra? Why not attend a CLOUDY workshop! One of our own Ph.D. students has just returned from one and was extremely positive about it.

A kind reminder that our e-mail address has changed to astro.agbnews@keele.ac.uk

The next issue is planned to be distributed around the 1$^{\rm st}$ of October.

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

Food for Thought

This month's thought-provoking statement is:

One way or another, AGB stars are responsible for all type Ia supernovæ

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

Planetary nebulæ: the universal mass–metallicity relation for Local Group dwarf galaxies and the chemistry of NGC 205

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Here we study 16 planetary nebulæ (PNe) in the dwarf irregular galaxy NGC 205 by using GMOS@Gemini spectra to derive their physical and chemical parameters. The chemical patterns and evolutionary tracks for 14 of our PNe suggest that there are no type I PNe among them. These PNe have an average oxygen abundance of $12+\log(O/H) = 8.08\pm0.28$, progenitor masses of 2–2.5 $M_\odot$ and thus were born $\sim$ 1.0–1.7 Gyr ago. Our results are in good agreement with previous PN studies in NGC 205. The present $12 + \log(O/H)$ is combined with our previous works and with the literature to study the PN metallicity trends of the Local Group (LG) dwarf galaxies, in an effort to establish the PN luminosity– and mass–metallicity relations (LZR and MZR) for the LG dwarf irregulars (dIrrs) and dwarf spheroidals (dSphs). Previous attempts to obtain such relations failed to provide correct conclusions because were based on limited samples (Richer & McCall 1995; Gonçalves et al. 2007). As far as we are able to compare stellar with nebular metallicities, our MZR is in very good agreement with the slope of the MZR recently obtained for LG dwarf galaxies using spectroscopic stellar metallicities (Kirby et al. 2013). Actually, we found that both dIrr and dSph galaxies follow the same MZR, at variance with the differences claimed in the past. Moreover our MZR is also consistent with the global MZR of star-forming galaxies, which span a wider stellar mass range ($\sim 10^6$–10^{11} $M_\odot$).

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Detection of solar-like oscillations in the bright red giant stars γ Psc and θ^1 Tau from a 190-day high-precision spectroscopic multisite campaign

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Red giants are evolved stars which exhibit solar-like oscillations. Although a multitude of stars have been observed with

space telescopes, only a handful of red-giant stars were targets of spectroscopic asteroseismic observing projects.We search for solar-like oscillations in the two bright red-giant stars γ Psc and θ^1 Tau from time series of ground-based spectroscopy and determine the frequency of the excess of oscillation power $\nu_{\rm max}$ and the mean large frequency separation $\Delta\nu$ for both stars. Seismic constraints on the stellar mass and radius will provide robust input for stellar modelling. The radial velocities of γ Psc and θ^1 Tau were monitored for 120 and 190 days, respectively. Nearly 9000 spectra were obtained. To reach the accurate radial velocities, we used simultaneous thorium–argon and iodine-cell calibration of our optical spectra. In addition to the spectroscopy, we acquired VLTI observations of γ Psc for an independent estimate of the radius. Also 22 days of observations of θ^1 Tau with the MOST satellite were analysed. The frequency analysis of the radial velocity data of γ Psc revealed an excess of oscillation power around 32 μHz and a large frequency separation of 4.1 ± 0.1 μHz. θ^1 Tau exhibits oscillation power around 90 μHz, with a large frequency separation of 6.9 ± 0.2 μHz. Scaling relations indicate that γ Psc is a star of about ~ 1 $M_\odot$ and 10 $R_\odot$. θ^1 Tau appears to be a massive star of about 3 $M_\odot$ and 11 $R_\odot$. The radial velocities of both stars were found to be modulated on time scales much longer than the oscillation periods.The estimated radii from seismology are in agreement with interferometric observations and also with estimates based on photometric data. While the mass of θ^1 Tau is in agreement with results from dynamical parallaxes, we find a lower mass for γ Psc than what is given in the literature. The long periodic variability agrees with the expected time scales of rotational modulation.

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Spitzer SAGE-Spec: Near infrared spectroscopy, dust shells and cool envelopes in extreme Large Magellanic Cloud AGB stars

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K-band spectra are presented for a sample of 39 *Spitzer* IRS SAGE-Spec sources in the Large Magellanic Cloud. The spectra exhibit characteristics in very good agreement with their positions in the near-infrared–*Spitzer* color–magnitude diagrams and their properties as deduced from the *Spitzer* IRS spectra. Specifically, the near infrared spectra show strong atomic and molecular features representative of oxygen-rich and carbon-rich asymptotic giant branch stars, respectively. A small subset of stars were chosen from the luminous and red extreme "tip" of the color–magnitude diagram. These objects have properties consistent with dusty envelopes but also cool, carbon-rich "stellar" cores. Modest amounts of dust mass loss combine with the stellar spectral energy distribution to make these objects appear extreme in their near-infrared and mid-infrared colors. One object in our sample, HV 915, a known post asymptotic giant branch star of the RV Tau type exhibits CO 2.3-μm band head emission consistent with previous work that demonstrates the object has a circumstellar disk.

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Eyes in the sky: Interactions between AGB winds and the interstellar magnetic field

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The extended circumstellar envelopes (CSE) of evolved low-mass stars display a large variety of morphologies. Understanding the various mechanisms that give rise to these extended structures is important to trace their mass-loss history. Here we aim to examine the role of the interstellar magnetic field in shaping the extended morphologies of slow dusty winds of Asymptotic Giant-branch (AGB) stars in an effort to pin-point the origin of so-called eye shaped CSE of three carbon-rich AGB stars. In addition, we seek to understand if this pre-planetary nebula (PN) shaping can be responsible for asymmetries observed in PNe. Hydrodynamical simulations are used to study the effect of typical interstellar magnetic fields on the free-expanding spherical stellar winds as they sweep up the local interstellar medium (ISM). The simulations show that typical Galactic interstellar magnetic fields of 5 to 10 μG, are sufficient to alter the spherical expanding shells of AGB stars to appear as the characteristic eye shape revealed by far-infrared observations. The typical sizes of the simulated eyes are in accordance with the observed physical sizes. However, the eye shapes are of transient nature. Depending on the stellar and interstellar conditions they develop after 20,000 to 200,000 yr and last for about 50,000 to 500,000 yr, assuming that the star is at rest relative to the local interstellar medium. Once formed the eye shape will develop lateral outflows parallel to the magnetic field. The "explosion" of a PN in the center of the eye-shaped dust shell gives rise to an asymmetrical nebula with prominent inward pointing Rayleigh–Taylor instabilities.

Interstellar magnetic fields can clearly affect the shaping of wind-ISM interaction shells. The occurrence of the eyes is most strongly influenced by stellar space motion and ISM density. Observability of this transient phase is favoured for lines-of-sight perpendicular to the interstellar magnetic field direction. The simulations indicate that shaping of the pre-PN envelope can strongly affect the shape and size of PNe.

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Circumstellar envelope manifestations in the optical spectra of evolved stars

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We consider the peculiarities of the optical spectra of far evolved stars with circumstellar gaseous-dusty envelopes: the time variability of the absorption–emission profiles of the Hα line, the presence of stationary emission and absorption molecular bands, multicomponent complex profiles of the Na I D-doublet lines. We show that the peculiarities of the line profiles (the presence of an emission component in the Na I D-doublet lines, the specific type of the molecular features, the asymmetry or splitting of the profiles of strongest absorptions with low excitation potential of the low level) can be associated with the kinematic and chemical properties of the circumstellar envelope and its morphological type.

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Infrared Spectroscopy of Asymptotic Giant Branch Stars in the Galactic Bulge

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We have selected a homogeneous sample of asymptotic giant branch (AGB) stars in the Galactic bulge population from the ISOGAL survey. Our target stars cover a wide range of mass-loss rates (10^{-8}–10^{-4} $M_\odot$ yr^{-1}) and differ primarily by their age on the AGB. This homogeneous sample is thus ideally suited to study the dust formation process as a function of age on the AGB. We observed our sample with the *Spitzer* InfraRed Spectrograph, and studied the overall properties of the infrared spectra of these targets. The analysis is complicated by the presence of strong and variable background emission, and the extracted infrared AGB star spectra are affected by interstellar extinction. Several stars in our sample have no detectable dust emission, and we used these "naked stars" to characterize the stellar and molecular contributions to the infrared spectra of our target stars. The resulting dust spectra of our targets do indeed show significant variety in their spectral appearance, pointing to differing dust compositions for the targets. We classify the spectra based on the shape of their 10-μm emission following the scheme by Sloan & Price. We find that the early silicate emission classes associated with oxide dust are generally under-represented in our sample due to extinction effects. We also find a weak 13-μm dust feature in two of our otherwise naked star spectra, suggesting that the carrier of this feature could potentially be the first condensate in the sequence of dust condensation.

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Emission and recombination coefficients for hydrogen with κ-distributed electron energies

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We provide a data set of emission and recombination coefficients of hydrogen using a κ-distribution of electron energies rather than the more traditional Maxwell–Boltzmann (MB) distribution. The data are mainly relevant to thin and relatively cold plasma found in planetary nebulæ and H II regions. The data set extends the previous data sets provided by Storey and Hummer which were computed using a MB distribution. The data set, which is placed in the public domain, is structured as a function of electron number density, temperature and κ. An interactive FORTRAN data server is also provided as an accessory to probe the data and obtain Lagrange-interpolated values for any choice of all three variables between the explicitly computed values.

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Stellar origin of the ^{182}Hf cosmochronometer and the presolar history of solar system matter

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Among the short-lived radioactive nuclei inferred to be present in the early solar system via meteoritic analyses, there are several heavier than iron whose stellar origin has been poorly understood. In particular, the abundances inferred for ^{182}Hf (half-life = 8.9 million years) and ^{129}I (half-life = 15.7 million years) are in disagreement with each other if both nuclei are produced by the rapid neutron-capture process. Here, we demonstrate that contrary to previous assumption, the slow neutron-capture process in asymptotic giant branch stars produces ^{182}Hf. This has allowed us to date the last rapid and slow neutron-capture events that contaminated the solar system material at $\sim$ 100 million years and $\sim$ 30 million years, respectively, before the formation of the Sun.

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The astrosphere of the asymptotic giant branch star CIT 6

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We have discovered two extended half-ring structures in a far-ultraviolet image taken with the GALEX satellite of the well-known mass-losing carbon star CIT 6 (RW LMi). The northern (southern) ring is brighter (fainter) with a diameter of about 15′ (18′). These structures most likely represent the astrosphere resulting from the shock interaction of CIT 6's molecular wind with the Warm Interstellar Medium, as it moves through the latter. These data provide a direct estimate of the size of CIT 6's circumstellar envelope that is a factor $\sim$ 20 larger than previous estimates based on CO millimeter-wave line data. We find that CIT 6 has been undergoing heavy mass-loss for at least 93,000 yr and the total envelope mass is 0.29 $M_\odot$ or larger, assuming a constant mass-loss rate of 3.2×10^{-6} $M_\odot$ yr^{-1}. Assuming that the shock front has reached a steady-state and CIT 6's motion relative to the ISM is in the sky-plane, we measure the termination-shock standoff distance directly from the image and find that CIT 6 is moving at a speed of $\gtrsim$39 (0.17 cm$^{-3}/n_{\rm ISM})^{1/2}$ km s^{-1} through the interstellar medium around it. However, comparisons with published numerical simulations and analytical modelling shows that CIT 6's forward shock (the northern ring) departs from the parabolic shape expected in steady-state. We discuss several possible explanations for this departure.

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Large-scale environments of binary AGB stars probed by *Herschel*. II: Two companions interacting with the wind of π^1 Gruis

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Context: The Mass loss of Evolved StarS (MESS) sample observed with PACS on board the *Herschel* Space Observatory revealed that several asymptotic giant branch (AGB) stars are surrounded by an asymmetric circumstellar envelope (CSE) whose morphologyis most likely caused by the interaction with a stellar companion. The evolution of AGB stars in binary systems plays a crucial role in understanding the formation of asymmetries in planetary nebulæ (PNe), but at present, only a handful of cases are known where the interaction of a companion with the stellar AGB wind is observed.
Aims: We probe the environment of the very evolved AGB star π^1 Gruis on large and small scales to identify the triggers of the observed asymmetries.
Methods: Observations made with *Herschel*/PACS at 70 μm and 160 μm picture the large-scale environment of π^1 Gru. The close surroundings of the star are probed by interferometric observations from the VLTI/AMBER archive. An analysis of the proper motion data of *Hipparcos* and *Tycho*-2 together with the *Hipparcos* Intermediate Astrometric Data help identify the possible cause for the observed asymmetry.
Results: The *Herschel*/PACS images of π^1 Gru show an elliptical CSE whose properties agree with those derived from a CO map published in the literature. In addition, an arc east of the star is visible at a distance of 38″ from the primary. This arc is most likely part of an Archimedean spiral caused by an already known G0 V companion that is orbiting the primary at a projected distance of 460 au with a period of more than 6200 yr. However, the presence of the elliptical CSE, proper motion variations, and geometric modelling of the VLTI/AMBER observations point towards a third component in the system, with an orbital period shorter than 10 yr, orbiting much closer to the primary than the G0 V star.

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Kepler and the Long Period Variables

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High precision *Kepler* photometry is used to explore the details of AGB light curves. Since AGB variability has a typical time scale on order of a year we discuss at length the removal of long term trends and quarterly changes in *Kepler* data. Photometry for a small sample of nine SR AGB stars are examined using a 30 minute cadence over a period of 45 months. While undergoing long period variations of many magnitudes, the light curves are shown to be smooth at the millimagnitude level over much shorter time intervals. No flares or other rapid events were detected on the sub-day time scale. The shortest AGB period detected is on the order of 100 days. All the SR variables in our sample are shown to have multiple modes. This is always the first overtone typically combined with the fundamental. A second common characteristic of SR variables is shown to be the simultaneous excitation of multiple closely separated periods for the same overtone mode. Approximately half the sample had a much longer variation in the light curve, likely a long secondary period. The light curves were all well represented by a combination of sinusoids. However, the

properties of the sinusoids are time variable with irregular variations present at low level. No non-radial pulsations were detected. It is argued that the long secondary period variation seen in many SR variables is intrinsic to the star and linked to multiple mode pulsation.

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The gas-rich circumbinary disk of HR 4049. II: A detailed study of the near-infrared spectrum

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HR 4049 is a peculiar evolved binary which is surrounded by a circumbinary disk. Mid-infrared observations show that the disk is rich in molecular gas and radially extended. To study the properties of this disk, we re-analyzed a set of near-infrared observations at high spectral resolution obtained with Gemini-Phoenix. These data cover absorption lines originating from the first overtone of CO and from H_2O in the 2.3-μm region as well as more complex emission–absorption profiles from H_2O and the fundamental mode of CO near 4.6 μm. By using an excitation diagram and from modeling the spectrum, we find that most of the CO overtone and H_2O absorption originates from hot gas ($T_{\rm ex} \approx 1000$ K) with high column densities, consistent with the mid-infrared data. The strong emission in the wavelength range of the CO fundamental furthermore suggests that there is a significant quantity of gas in the inner cavity of the disk. In addition, there is a much colder component in the line of sight to the disk. A detailed analysis of the overtone line profiles reveals variations in the line widths which are consistent with a radially extended disk in Keplerian rotation with hotter gas closer to the central star. We estimate the mass of the primary to be ~ 0.34 $M_\odot$ and discuss the implications for its evolutionary status.

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On the H I hole and AGB stellar population of the Sagittarius dwarf irregular galaxy

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Using two HST/ACS data-sets that are separated by ~ 2 years has allowed us to derive the relative proper motion for the Sagittarius dwarf irregular (SagDIG) and reduce the heavy foreground Galactic contamination. The proper-motion decontaminated SagDIG catalog provides a much clearer view of the young red-supergiant and intermediate-age asymptotic giant branch populations. We report the identification of 3 Milky Way carbon-rich dwarf stars, probably belonging to the thin disk, and pointing to the high incidence of this class at low Galactic latitudes. A sub-group of 4 oxygen-rich candidate stars depicts a faint, red extension of the well-defined SagDIG carbon-rich sequence. The origin of these oxygen-rich candidate stars remains unclear, reflecting the uncertainty in the ratio of carbon/oxygen

rich stars. SagDIG is also a gas-rich galaxy characterized by a single large cavity in the gas disk (H I hole), which is offset by ~ 360 pc from the optical centre of the galaxy. We nonetheless investigate the stellar feedback hypothesis by comparing the proper-motion cleaned stellar populations within the H I hole with appropriately selected comparison regions, having higher H I densities external to the hole. The comparison shows no significant differences. In particular, the centre of the H I hole (and the comparison regions) lack stellar populations younger than ~ 400 Myr, which are otherwise abundant in the inner body of the galaxy. We conclude that there is no convincing evidence that the SagDIG H I hole is the result of stellar feedback, and that gravitational and thermal instabilities in the gas are the most likely mechanism for its formation.

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Electron-capture supernovæ exploding within their progenitor wind

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The most massive stars on the asymptotic giant branch (AGB), or the so-called super-AGB stars, are thought to produce supernovæ triggered by electron captures in their degenerate O+Ne+Mg cores. Super-AGB stars are expected to have slow winds with high mass-loss rates, so their circumstellar density is high. The explosions of super-AGB stars are therefore presumed to occur in this dense circumstellar environment. We provide the first synthetic light curves for such events by exploding realistic electron-capture supernova progenitors within their super-AGB winds. We find that the early light curve – that is, before the recombination wave reaches the bottom of the hydrogen-rich envelope of supernova ejecta (the plateau phase) – is not affected by the dense wind. However, after the luminosity drop following the plateau phase, the luminosity remains much higher when the super-AGB wind is taken into account. We compare our results to the historical light curve of SN 1054, the progenitor of the Crab Nebula, and show that the explosion of an electron-capture supernova within an ordinary super-AGB wind can explain the observed light curve features. We conclude that SN 1054 could have been a Type IIn supernova without any extra extreme mass loss, which was previously suggested to be necessary to account for its early high luminosity. We also show that our light curves match Type IIn supernovæ with an early plateau phase or the so-called Type IIn-P supernovæ, and suggest that they are electron-capture supernovæ within super-AGB winds. Although some electron-capture supernovæ can be bright in the optical spectral range due to the large progenitor radius, their X-ray luminosity from the interaction does not necessarily get as bright as other Type IIn supernovæ whose optical luminosities are also powered by the interaction. Thus, we suggest that optically bright X-ray-faint Type IIn supernovæ can emerge from electron-capture supernovæ. Optically faint Type IIn supernovæ, such as SN 2008S, can also originate from electron-capture supernovæ if their hydrogen-rich envelope masses are small. We argue that some of them can be observed as Type IIn-b supernovæ due to the small hydrogen-rich envelope mass.

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From the ashes: JVLA observations of water fountain nebula candidates show the rebirth of IRAS 18455+0448

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Context: The class of water fountain nebulæ is thought to represent the stage of the earliest onset of collimated bipolar outflows during the post-Asymptotic Giant Branch phase. They thus play a crucial role in the study of the formation of bipolar Planetary Nebulæ (PNe). To date, 14 water fountain nebulæ have been identified. The identification of more sources in this unique stage of stellar evolution will enable us to study the origin of bipolar PNe morphologies in more detail.
Aims: Water fountain candidates can be identified based on the often double peaked 22 GHz H_2O maser spectrum with a large separation between the maser peaks (often > 100 km s^{-1}). However, even a fast bipolar outflow will only have a moderate velocity extent in its maser spectrum when located close to the plane of the sky. In this project we aim to enhance the water fountain sample by identifying objects whose jets are aligned close to the plane of the sky.
Methods: We present the results of seven sources observed with the *Jansky* Very Large Array (JVLA) that were identified as water fountain candidates in an Effelsberg 100-m telescope survey of 74 AGB and early post-AGB stars.
Results: We find that our sample of water fountain candidates displays strong variability in their 22 GHz H_2O maser spectra. The JVLA observations show an extended bipolar H_2O maser outflow for one source, the OH/IR star IRAS 18455+0448. This source was previously classified as a dying OH/IR star based on the exponential decrease of its 1612 MHz OH maser and the lack of H_2O masers. We therefore also re-observed the 1612, 1665, and 1667 MHz OH masers. We confirm that the 1612 MHz masers have not reappeared and find that the1665/1667 MHz masers have decreased in strength by several orders of magnitude during the last decade. The JVLA observations also reveal a striking asymmetry in the red-shifted maser emission of IRAS 19422+3506.
Conclusions: The OH/IR star IRAS 18455+0448 is confirmed to be a new addition to the class of water fountain nebulæ. Its kinematic age is ~ 70 yr, but could be lower, depending on the distance and inclination. Previous observations indicate, with significant uncertainty, that IRAS 18455+0448 has a surprisingly low mass compared to available estimates for other water fountain nebulæ. The available historical OH maser observations make IRAS 18455+0448 unique for the study of water fountain nebulæ and the launch of post-AGB bipolar outflows. The other candidate sources appear high mass-loss OH/IR stars with partly radially beamed H_2O masers.

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Modeling SNR G 1.9+0.3 as a supernova Inside a planetary nebula

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Using 3D numerical hydrodynamical simulations we show that a type Ia supernova (SN Ia) explosion inside a planetary nebula (PN) can explain the observed shape of the G 1.9+0.3 supernova remnant (SNR), and its X-ray morphology. The SNR G 1.9+0.3 morphology can be generally described as a sphere with two small and incomplete lobes protruding on opposite sides of the SNR, termed "ears", a structure resembling many elliptical PNe. Observations show the

synchrotron X-ray emission to be much stronger inside the two ears than in the rest of the SNR. We numerically show that a spherical SN Ia explosion into a circumstellar matter (CSM) with the structure of an elliptical PN with ears can explain the X-ray properties of SNR G 1.9+0.3. While the ejecta have already collided with the PN shell in most of the SNR and its forward shock has been slowed down, the ejecta is still advancing inside the ears. The fast forward shock inside the ears explains the stronger X-ray emission there. SN Ia inside PNe (SNIPs) seem to comprise a non-negligible fraction of resolved SN Ia remnants.

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ALMA and *Herschel* observations of the prototype dusty and polluted white dwarf G 29-38

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ALMA Cycle 0 and *Herschel* PACS observations are reported for the prototype, nearest, and brightest example of a dusty and polluted white dwarf, G 29-38. These long wavelength programs attempted to detect an outlying, parent population of bodies at 1–100 au, from which originates the disrupted planetesimal debris that is observed within 0.01 au and which exhibits $L_{\rm IR}/L = 0.039$. No associated emission sources were detected in any of the data down to $L_{\rm IR}/L \sim 10^{-4}$, generally ruling out cold dust masses greater than 10^{24}–10^{25} g for reasonable grain sizes and properties in orbital regions corresponding to evolved versions of both asteroid and Kuiper belt analogs. Overall, these null detections are consistent with models of long-term collisional evolution in planetesimal disks, and the source regions for the disrupted parent bodies at stars like G 29-38 may only be salient in exceptional circumstances, such as a recent instability. A larger sample of polluted white dwarfs, targeted with the full ALMA array, has the potential to unambiguously identify the parent source(s) of their planetary debris.

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The *Chandra* Planetary Nebula Survey (ChanPlaNS). II. X-ray emission from compact planetary nebulæ

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We present results from the most recent set of observations obtained as part of the *Chandra* X-ray observatory Planetary Nebula Survey (ChanPlaNS), the first comprehensive X-ray survey of planetary nebulæ (PNe) in the solar neighborhood (i.e. within ~ 1.5 kpc of the Sun). The survey is designed to place constraints on the frequency of appearance and range of X-ray spectral characteristics of X-ray-emitting PN central stars and the evolutionary timescales of wind-shock-heated bubbles within PNe. ChanPlaNS began with a combined Cycle 12 and archive *Chandra* survey of 35 PNe. ChanPlaNS continued via a *Chandra* Cycle 14 Large Program which targeted all (24) remaining known compact ($R_{\rm neb}\lesssim 0.4$ pc), young PNe that lie within ~ 1.5 kpc. Results from these Cycle 14 observations include first-time X-ray detections of hot bubbles within NGC 1501, 3918, 6153, and 6369, and point sources in HbDs 1, NGC 6337, and Sp 1. The addition of the Cycle 14 results brings the overall ChanPlaNS diffuse X-ray detection rate to $\sim 27\%$ and the point source detection rate to $\sim 36\%$. It has become clearer that diffuse X-ray emission is associated with young ($\lesssim 5\times 10^3$ yr), and likewise compact ($R_{\rm neb}\lesssim 0.15$ pc), PNe with closed structures and high central electron densities ($n_{\rm e}\gtrsim 1000$ cm^{-3}), and rarely associated with PNe that show H_2 emission and/or pronounced butterfly structures. Hb 5 is one such exception of a PN with a butterfly structure that hosts diffuse X-ray emission. Additionally, of the five new diffuse X-ray detections, two host [WR]-type CSPNe, NGC 1501 and NGC 6369, supporting the hypothesis that PNe with central stars of [WR]-type are likely to display diffuse X-ray emission.

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Evidence of a Mira-like tail and bow shock about the semi-regular variable V CVn from four decades of polarization measurements

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Polarization is a powerful tool for understanding stellar atmospheres and circumstellar environments. Mira and semi-regular variable stars have been observed for decades and some are known to be polarimetrically variable, however, the semi-regular variable V Canum Venaticorum displays an unusually large, unexplained amount of polarization. We present ten years of optical polarization observations obtained with the HPOL instrument, supplemented by published observations spanning a total interval of about forty years for V CVn. We find that V CVn shows large polarization variations ranging from 1–6%. We also find that for the past forty years the position angle measured for V CVn has been virtually constant suggesting a long-term, stable, asymmetric structure about the star. We suggest that this asymmetry is caused by the presence of a stellar wind bow shock and tail, consistent with the star's large space velocity.

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V838 Monocerotis: the central star and its environment a decade after outburst

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Aims: V838 Monocerotis erupted in 2002, brightened in a series of outbursts, and eventually developed a spectacular light echo. A very red star emerged a few months after the outburst. The whole event has been interpreted as the result of a merger.
Methods: We obtained near- and mid-IR interferometric observations of V838 Mon with the AMBER and MIDI recombiners located at the Very Large Telescope Interferometer (VLTI) array. The MIDI two-beam observations were obtained with the 8-m unit telescopes between October 2011 and February 2012. The AMBER three-beam observations were obtained with the compact array ($B \leq 35$ m) in April 2013 and the long array ($B \leq 140$ m) in May 2014, using the 1.8-m auxiliary telescopes.
Results: A significant new result is the detection of a compact structure around V838 Mon, as seen from MIDI data. The extension of the structure increases from a FWHM of 25 mas at 8 μm to 70 mas at 13 μm. At the adopted distance of $D = 6.1 \pm 0.6$ kpc, the dust is distributed from about 150 to 400 au around V838 Mon. The MIDI visibilities reveal a flattened structure whose aspect ratio increases with wavelength. The major axis is roughly oriented around a position angle of $-10°$, which aligns with previous polarimetric studies reported in the literature. This flattening can be interpreted as a relic of the 2002 eruption or as caused by the influence of the currently embedded B3 V companion. The AMBER data provide a new diameter for the pseudo-photosphere, which shows that its diameter has decreased by about 40% in 10 yr, reaching a radius $R_\star = 750 \pm 200$ R$_\odot$ (3.5 ± 1.0 au).
Conclusions: After the 2002 eruption, which was interpreted as the merging of two stars, it seems that the resulting source is relaxing to a normal state. The nearby environment exhibits an equatorial overdensity of dust up to several hundred au.

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The RCB star V854 Cen is surrounded by a hot dusty shell

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Aims: The hydrogen-deficient supergiants known as R Coronæ Borealis (RCB) stars might be the result of a double-degenerate merger of two white dwarfs (WDs), or a final helium shell flash in a planetary nebula central star. In this context, any information on the geometry of their circumstellar environment and, in particular, the potential detection of elongated structures, is of great importance.
Methods: We obtained near-IR observations of V854 Cen with the AMBER recombiner located at the Very Large Telescope Interferometer (VLTI) array with the compact array ($B \leq 35$ m) in 2013 and the long array ($B \leq 140$ m) in 2014. At each time, V854 Cen was at maximum light. The H- and K-band continua were investigated by means of spectrally dependant geometric models. These data were supplemented with mid-IR VISIR/VLT images.
Results: A dusty slightly elongated over density is discovered both in the H- and K-band images. With the compact array, the central star is unresolved ($\Theta \leq 2.5$ mas), but a flattened dusty environment of 8×11 mas is discovered whose flux increases from $\sim 20\%$ in the H band to reach $\sim 50\%$ at 2.3 μm, which indicates hot ($T \sim 1500$ K) dust in the close vicinity of the star. The major axis is oriented at a position angle (P.A.) of $126 \pm 29°$. Adding the long-array configuration dataset provides tighter constraints on the star diameter ($\Theta \leq 1.0$ mas), a slight increase of the overdensity to 12×15 mas and a consistent P.A. of $133 \pm 49°$. The closure phases, sensitive to asymmetries, are null and compatible with a centro-symmetric, unperturbed environment excluding point sources at the level of 3% of the total flux in 2013 and 2014. The VISIR images exhibit a flattened aspect ratio at the 15–20% level at larger distances ($\sim 1''$) with a position angle of $92 \pm 19°$, marginally consistent with the interferometric observations.
Conclusions: This is the first time that a moderately elongated structure has been observed around an RCB star. These observations confirm the numerous suggestions for a bipolar structure proposed for this star in the literature, which were mainly based on polarimetric and spectroscopic observations.

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Panchromatic *Hubble* Andromeda Treasury IX: A photometric survey of planetary nebulæ in M 31

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We search the *Hubble* Space Telescope (HST) Advanced Camera for Surveys and Wide Field Camera 3 broadband imaging data from the Panchromatic *Hubble* Andromeda Treasury (PHAT) survey to identify detections of cataloged planetary nebulæ (PNs). Of the 711 PNs currently in the literature within the PHAT footprint, we find 467 detected in the broadband. For these 467, we are able to refine their astrometric accuracy from $\sim 0\farcs3$ to $0\farcs05$. Using the resolution of the HST, we are able to show that 152 objects currently in the catalogs are definitively not PNs, and we show that 32 objects thought to be extended in ground-based images are actually point-like and therefore good

PN candidates. We also find one PN candidate that is marginally resolved. If this is a PN, it is up to 0.7 pc in diameter. With our new photometric data, we develop a method of measuring the level of excitation in individual PNs by comparing broadband and narrowband imaging and describe the effects of excitation on a PN's photometric signature. Using the photometric properties of the known PNs in the PHAT catalogs, we search for more PNs, but do not find any new candidates, suggesting that ground-based emission-line surveys are complete in the PHAT footprint to $F475W \simeq 24$ mag.

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Magnetic braking of stellar cores in red giants and supergiants

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Magnetic configurations, stable on the long term, appear to exist in various evolutionary phases, from main-sequence stars to white dwarfs and neutron stars. The large scale ordered nature of these fields, often approximately dipolar, and their scaling according to the flux conservation scenario favor the model of a fossil field (Duez et al. 2010). We make some first estimates of the magnetic coupling between the stellar cores and the outer layers in red giants and supergiants. Analytical expressions of the truncation radius of the field coupling are established for a convective envelope and for a rotating radiative zone with horizontal turbulence. The timescales of the internal exchanges of angular momentum are considered.
Numerical estimates are made on the basis of recent model grids.The direct magnetic coupling of the core to the extended convective envelope of red giants and supergiants appears unlikely. However, we find that the intermediate radiative zone is fully coupled to the core during the He-burning and later phases. This coupling is able to produce a strong spin down of the core of red giants and supergiants, also leading to relatively slowly rotating stellar remnants, like white dwarfs and pulsars. Some angular momentum is also transferred to the outer convective envelope of red giants and supergiants during the He-burning phase and later.

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The drop during less than 300 days of a dusty white dwarf's infrared luminosity

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We report *Spitzer*/IRAC photometry of WD J 0959−0200, a white dwarf that displays excess infrared radiation from a disk, likely produced by a tidally disrupted planetesimal. We find that in 2010, the fluxes in both 3.6 μm and 4.5 μm decreased $\sim 35\%$ in less than 300 days. The drop in the infrared luminosity is likely due to an increase of the inner disk radius from one of two scenarios: (i) a recent planetesimal impact; (ii) instability in the circumstellar disk. The current situation is tantalizing; high sensitivity, high cadence infrared studies will be a new tool to study the interplay between a disk and its host white dwarf star.

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Gas physical conditions and kinematic of the giant outflow Ou 4

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Ou 4 is a recently discovered bipolar outflow with a projected size of more than one degree in the plane of the sky. It is apparently centred on the young stellar cluster – whose most massive representative is the triple system HR 8119– inside the H II region Sh 2-129. The driving source, the nature, and the distance of Ou 4 are not known.

The basic properties of Ou 4 and its environment are investigated in order to shed light on the origin of this remarkable outflow. Deep narrow-band imagery of the whole nebula at arcsecond resolution was obtained to study its detailed morphology. Long-slit spectroscopy of the tips of the bipolar lobes was secured to determine the gas ionization mechanism, physical conditions, and line-of-sight velocities. An estimate of the proper motions at the tip of the south lobe using archival plate images is attempted. The existing multi-wavelength data for Sh 2-129 and HR 8119 are also comprehensively reviewed.

The observed morphology of Ou 4, its emission-line spatial distribution, line flux ratios, and the kinematic modelling developed adopting a bow-shock parabolic geometry, illustrate the expansion of a *shock-excited* fast collimated outflow. The observed radial velocities of Ou 4 and its reddening are consistent with those of Sh 2-129 and HR 8119. The improved determination of the distance to HR 8119 (composed of two B0 V stars and one B0.5 V) and Sh 2-129 is 712 pc. We identify in WISE images a 5′-radius (1 pc at the distance above) bubble of emission at 22 μm emitted by hot (107 K) dust grains, located inside the central part of Ou 4 and corresponding to several [O III] emission features of Ou 4.

The apparent position of Ou 4 and the properties studied in this work are consistent with the hypothesis that Ou 4 is located inside the Sh 2-129 H II region, suggesting that it was launched some 90,000 yr ago by HR 8119. The outflow total kinetic energy is estimated to be $\approx 4\times10^{47}$ erg. However, the alternate possibility that Ou 4 is a bipolar planetary nebula, or the result of an eruptive event on a massive AGB or post–AGB star not yet identified, cannot be ruled out.

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Signs of a faint disc population at polluted white dwarfs

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Observations of atmospheric metals and dust discs around white dwarfs provide important clues to the fate of terrestrial planetary systems around intermediate mass stars. We present *Spitzer* IRAC observations of 15 metal polluted white dwarfs to investigate the occurrence and physical properties of circumstellar dust created by the disruption of planetary bodies. We find subtle infrared excess emission consistent with warm dust around KUV 15519+1730 and HS 2132+0941, and weaker excess around the DZ white dwarf G 245-58, which, if real, makes it the coolest white dwarf known to exhibit a 3.6-μm excess and the first DZ star with a bright disc. All together our data corroborate a picture where 1) discs at metal-enriched white dwarfs are commonplace and most escape detection in the infrared (possibly as narrow rings), 2) the discs are long lived, having lifetimes on the order of 10^6 yr or longer, and 3) the frequency of bright, infrared detectable discs decreases with age, on a timescale of roughly 500 Myr, suggesting large planetesimal disruptions decline on this same timescale.

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Maser and infrared studies of oxygen-rich late/post-AGB stars and water fountains: Development of a new identification method

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We explored an efficient method to identify evolved stars with oxygen-rich envelopes in the late AGB or post-AGB phase of stellar evolution, which include a rare class of objects – the "water fountains". Our method considers the OH and H_2O maser spectra, the near infrared Q-parameters (these are colour indices accounting for the effect of extinction), and far-infrared AKARI colours. Here we first present the results of a new survey on OH and H_2O masers. There were 108 colour-selected objects: 53 of them were observed in the three OH maser lines (1612, 1665, and 1667 MHz), with 24 detections (16 new for 1612 MHz); and 106 of them were observed in the H_2O maser line (22 GHz) with 24 detections (12 new). We identify a new potential water fountain source, IRAS 19356+0754, with large velocity coverages of both OH and H_2O maser emission. In addition, several objects with high velocity OH maser emission are reported for the first time. The Q-parameters as well as the infrared [09]–[18] and [18]–[65] AKARI colours of the surveyed objects are then calculated. We suggest that these infrared properties are effective in isolating aspherical from spherical objects, but the morphology may not necessarily be related to the evolutionary status. Nonetheless, by considering altogether the maser and infrared properties, the efficiency of identifying oxygen-rich late/post-AGB stars could be improved.

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Post-merger evolution of carbon-oxygen + helium white dwarf binaries and the origin of R Coronæ Borealis and extreme helium stars

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Orbital decay by gravitational-wave radiation will cause some close-binary white dwarfs (WDs) to merge within a Hubble time. The results from previous hydrodynamical WD-merger simulations have been used to guide calculations of the post-merger evolution of carbon-oxygen + helium (CO+He) WD binaries. Our models include the formation of a hot corona in addition to a Keplerian disk. We introduce a "destroyed-disk" model to simulate the effect of direct disk ingestion into the expanding envelope. These calculations indicate significant lifetimes in the domain of the rare R Coronæ Borealis (RCB) stars, before a fast evolution through the domain of the hotter extreme helium (EHe) stars. Surface chemistries of the resulting giants are in partial agreement with the observed abundances of RCB and EHe stars. The production of ^{3}He, ^{18}O and ^{19}F are discussed. Evolutionary timescales combined with binary white-dwarf merger rates from binary-star population synthesis are consistent with present-day numbers of RCBs and EHes, provided that the majority come from relatively recent (< 2 Gyr) star formation. However, most RCBs should be produced by CO-WD + low-mass HeWD mergers, with the He–WD having a mass in the range 0.20–0.35 $M_\odot$. Whilst, previously, a high He-WD mass (> 0.40 $M_\odot$) was required to match the carbon-rich abundances of RCB stars, the *destroyed − disk* model yields a high-carbon product with He-WD mass > 0.30 $M_\odot$, in better agreement with population synthesis results.

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Detailed microscopic calculation of stellar electron and positron capture rates on ^{24}Mg for O+Ne+Mg core simulations

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Few white dwarfs, located in binary systems, may acquire sufficiently high mass accretion rates resulting in the burning of carbon and oxygen under non-degenerate conditions forming a O+Ne+Mg core. These O+Ne+Mg cores are gravitationally less bound than more massive progenitor stars and can release more energy due to the nuclear burning. They are also amongst the probable candidates for low entropy r-process sites. Recent observations of subluminous Type II-P supernovæ (e.g., 2005cs, 2003gd, 1999br, 1997D) were able to rekindle the interest in 8–10 $M_{\odot}$ which develop O+Ne+Mg cores. Microscopic calculations of capture rates on ^{24}Mg, which may contribute significantly to the collapse of O+Ne+Mg cores, using shell model and proton–neutron quasi-particle random phase approximation (pn-QRPA) theory, were performed earlier and comparisons made. Simulators, however, may require these capture rates on a fine scale. For the first time a detailed microscopic calculation of the electron and positron capture rates on ^{24}Mg on an extensive temperature–density scale is presented here. This type of scale is more appropriate for interpolation purposes and of greater utility for simulation codes. The calculations are done using the pn-QRPA theory using a separable interaction. The deformation parameter, believed to be a key parameter in QRPA calculations, is adopted from experimental data to further increase the reliability of the QRPA results. The resulting calculated rates are up to a factor of 14 or more enhanced as compared to shell model rates and may lead to some interesting scenario for core collapse simulators.

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New molecules in IRC +10°216: confirmation of C_5S and tentative identification of MgCCH, NCCP, and SiH_3CN

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The C-star envelope IRC +10°216 harbors a rich variety of molecules, with more than 80 detected to date. During the course of a λ 3 mm survey of IRC +10°216 carried out with the IRAM 30-m telescope we have detected various weak lines, with antenna temperatures of a few mK, that we assign to rotational transitions of four new molecules. The observation of three lines of C_5S confirms a previous tentative identification of this molecule by Bell et al. (1993) based on a line at 24.0 GHz. We also report the tentative identification of three molecules not yet observed in space: MgCCH, the first metal acetylide detected in space, and NCCP and SiH_3CN, the phosphorus and silicon analogs of cyanogen (NCCN) and methyl cyanide (CH_3CN). We derive the following column densities: $N(C_5S) = (2–14) \times 10^{12}$ cm^{-2} (depending on the rotational temperature adopted), $N(MgCCH) = 2 \times 10^{12}$ cm^{-2}, $N(NCCP) = 7 \times 10^{11}$ cm^{-2}, and $N(SiH_3CN) = 10^{12}$ cm^{-2}. The S-bearing carbon chain C_5S is less abundant than C_3S, while MgCCH has an abundance in between that of MgNC and those of MgCN and HMgNC. On the other hand, NCCP and SiH_3CN are the least abundant P- and Si-bearing molecules observed to date in IRC +10°216. Based on the behaviour of similar molecules it is likely that these four species are formed in the outer circumstellar layers of IRC +10°216. We discuss possible gas-phase formation routes.

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Helium enrichment and carbon-star production in metal-rich populations

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We present new theoretical stellar evolutionary models of metal-rich asymptotic giant branch (AGB) stars. Stellar models are evolved with initial masses between 1 $M_\odot$ and 7 $M_\odot$ at $Z = 0.007$, and 1 $M_\odot$ and 8 $M_\odot$ at $Z = 0.014$ (solar) and at $Z = 0.03$. We evolve models with a canonical helium abundance and with helium enriched compositions ($Y = 0.30, 0.35, 0.40$) at $Z = 0.014$ and $Z = 0.03$. The efficiency of third dredge-up and the mass range of carbon stars decreases with an increase in metallicity. We predict carbon stars form from initial masses between 1.75–7 $M_\odot$ at $Z = 0.007$ and between 2–4.5 $M_\odot$ at solar metallicity. At $Z = 0.03$ the mass range for C-star production is narrowed to 3.25–4 $M_\odot$. The third dredge-up is reduced when the helium content of the model increases owing to the reduced number of thermal pulses on the AGB. A small increase of $\Delta Y = 0.05$ is enough to prevent the formation of C stars at $Z = 0.03$, depending on the mass-loss rate, whereas at $Z = 0.014$, an increase of $\Delta Y \gtrsim 0.1$ is required to prevent the formation of C stars. We speculate that the probability of finding C stars in a stellar population depends as much on the helium abundance as on the metallicity. To explain the paucity of C stars in the inner region of M 31 we conclude that the observed stars have $Y \gtrsim 0.35$ or that the stellar metallicity is higher than [Fe/H] ≈ 0.1.

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Conference Paper

Evolved stars with complex atmospheres – the high spectral resolution, mid-IR view

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The physical structures of the outer atmospheres of red giants are not known. They are certainly complex and a range of recent observations are showing that we need to embrace to non-classical atmosphere models to interpret these regions. This region's properties is of importance, not the least, for the understanding of the mass-loss mechanism for these stars, which is not still understood. Here, we present observational constraints of the outer regions of red giants, based on mid-IR, high spectral resolution spectra. We also discuss possible non-LTE effects and highlight a new non-LTE code that will be used to analyse the spectra of these atmospheric layers. We conclude by mentioning our new SOFIA/EXES observations of red giants at 6 μm, where the vibration–rotation lines of water vapour can be detected and spectrally resolved for the first time.

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Announcements

Cloudy workshop
2015 Jan 12–16
Queen's University Belfast

Registration is now open for the 2015 January Cloudy workshop. It will be held Jan 12–16 at Queen's University Belfast, Northern Ireland.

Cloudy is a code that simulates diffuse gaseous environments. It calculates the plasma, chemistry, radiation transport, and dynamics problems simultaneously and self consistently, building from the foundation of individual atomic and molecular processes. The result is a prediction of the conditions in the material and its observed spectrum.

This workshop will cover observation, theory, and application of Cloudy to a wide variety of astronomical environments. This includes the theory of diffuse non-LTE matter and quantitative spectroscopy (the science of using spectra to make physical measurements). We will use Cloudy to simulate such objects as AGB stars, Active Galactic Nuclei, Starburst galaxies, and the intergalactic medium.

The sessions will consist of a mix of textbook study, using Osterbrock & Ferland, Astrophysics of Gaseous Nebulæ and Active Galactic Nuclei, application of the spectral-simulation code Cloudy to a variety of astrophysical problems, and projects organized by the participants. No prior experience with Cloudy is assumed.

See also http://cloud9.pa.uky.edu/∼gary/cloudy/CloudySummerSchool/

Fizeau exchange visitors program – call for applications

Dear colleagues!

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

The deadline for applications is September 15. Fellowships can be awarded for missions starting in November 2014.

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

The program is funded by OPTICON/FP7.

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

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

See also www.european-interferometry.eu