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Editors: Jacco van Loon, Ambra Nanni and Albert Zijlstra

Editorial

Dear Colleagues,

It is our pleasure to present you the 214th issue of the AGB Newsletter. Resolved studies, extra-galactic studies and variability feature in this issue, as well as both the emergence and fate of AGB stars.

The Fizeau programme offers support for interferometry work, and the call in this newsletter is specifically aimed at helping people attend an interferometry school.

Another Cloudy workshop is being organised this time in India – a great way of becoming acquainted with this powerful modelling tool.

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

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

Food for Thought

This month's thought-provoking statement is:

Population III AGB stars differ from next generation AGB stars

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

Circumstellar dust around AGB stars and implications for infrared emission from galaxies

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Stellar population synthesis (SPS) models are used to infer many galactic properties including star formation histories, metallicities, and stellar and dust masses. However, most SPS models neglect the effect of circumstellar dust shells around evolved stars and it is unclear to what extent they impact the analysis of SEDs. To overcome this shortcoming we have created a new set of circumstellar dust models, using the radiative transfer code DUSTY (Ivezić et al. 1999), for asymptotic giant branch (AGB) stars and incorporated them into the Flexible Stellar Population Synthesis code. The circumstellar dust models provide a good fit to individual AGB stars as well as the IR color–magnitude diagrams of the Large and Small Magellanic Clouds. IR luminosity functions from the Large and Small Magellanic Clouds are not well-fit by the 2008 Padova isochrones when coupled to our circumstellar dust models, and so we adjusted the lifetimes of AGB stars in the models to provide a match to the data. We show, in agreement with previous work, that circumstellar dust from AGB stars can make a significant contribution to the IR ($\gtrsim$4 μm) emission from galaxies that contain relatively little diffuse dust, including low-metallicity and/or non-star forming galaxies. Our models provide a good fit to the mid-IR spectra of early-type galaxies. Circumstellar dust around AGB stars appears to have a small effect on the IR SEDs of metal-rich star-forming galaxies (i.e. when $A_V \gtrsim 0.1$). Stellar population models that include circumstellar dust will be needed to accurately interpret data from the *James Webb* Space Telescope (JWST) and other IR facilities.

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HST images reveal dramatic changes in the core of IRC +10°216

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IRC +10°216 is the nearest carbon star with a very high mass-loss rate. The existence of a binary companion has been hinted by indirect observational evidence, such as the bipolar morphology of its nebula and a spiral-like pattern in its circumstellar material; however, to date, no companion has been identified. We have examined archival *Hubble* Space Telescope images of IRC +10°216, and find that the images taken in 2011 exhibit dramatic changes in its innermost region from those taken at earlier epochs. The scattered light is more spread out in 2011. After proper motion correction, the brightest peak in 2011 is close to, but not coincident with, the dominant peak in previous epochs. A fainter point-like object was revealed at $\sim 0\farcs5$ from this brightest peak. We suggest that these changes at the core of IRC +10°216 are caused by dissipation of intervening circumstellar dust, as indicated by the brightening trend in the lightcurve extracted from the Catalina photometric survey. We tentatively identify the brightest peak in 2011 as the primary star of IRC +10°216 and the fainter point-like source as a companion. The cause of non-detections of the companion candidate in earlier epochs is uncertain. These identifications need to be verified by monitoring of the core of IRC +10°216 at high resolution in the future.

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Structural glitches near the cores of red giants revealed by oscillations in g-mode period spacings from stellar models

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With recent advances in asteroseismology it is now possible to peer into the cores of red giants, potentially providing a way to study processes such as nuclear burning and mixing through their imprint as sharp structural variations – glitches – in the stellar cores. Here we show how such core glitches can affect the oscillations we observe in red giants.We derive an analytical expression describing the expected frequency pattern in the presence of a glitch. This formulation also accounts for the coupling between acoustic and gravity waves. From an extensive set of canonical stellar models we find glitch-induced variation in the period spacing and inertia of non-radial modes during several phases of red-giant evolution. Significant changes are seen in the appearance of mode amplitude and frequency patterns in asteroseismic diagrams such as the power spectrum and the Échelle diagram.Interestingly, along the red-giant branch glitch-induced variation occurs only at the luminosity bump, potentially providing a direct seismic indicator of stars in that particular evolution stage. Similarly, we find the variation at only certain post-helium-ignition evolution stages, namely, in the early phases of helium-core burning and at the beginning of helium-shell burning signifying the asymptotic-giant-branch bump. Based on our results, we note that assuming stars to be glitch-free, while they are not, can result in an incorrect estimate of the period spacing. We further note that including diffusion and mixing beyond classical Schwarzschild, could affect the characteristics of the glitches, potentially providing a way to study these physical processes.

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ALMA view of the circumstellar environment of the post-common-envelope-evolution binary system HD 101584

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We study the circumstellar evolution of the binary HD 101584, consisting of a post-AGB star and a low-mass companion, which is most likely a post-common-envelope-evolution system. We used ALMA observations of the ^{12}CO, ^{13}CO, and C^{18}O J = 2–1 lines and the 1.3-mm continuum to determine the morphology, kinematics, masses, and energetics of the circumstellar environment. The circumstellar medium has a bipolar hour-glass structure, seen almost pole-on, formed by an energetic jet, $\approx$ 150 km s^{-1}. We conjecture that the circumstellar morphology is related to an event that took place $\approx$ 500 yr ago, possibly a capture event where the companion spiraled in towards the AGB star. However, the kinetic energy of the accelerated gas exceeds the released orbital energy, and, taking into account the expected energy transfer efficiency of the process, the observed phenomenon does not match current common-envelope scenarios. This suggests that another process must augment, or even dominate, the ejection process. A significant amount of material resides in an unresolved region, presumably in the equatorial plane of the binary system.

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The chemistry of planetary nebulæ in the outer regions of M 31

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We present spectroscopy of nine planetary nebulæ (PNe) in the outskirts of M 31, all but one obtained with the 10.4-m GTC telescope. These sources extend our previous study of the oxygen abundance gradient of M 31 to galactocentric radii as large as 100 kpc. None of the targets are bona fide members of a classical, metal-poor and ancient halo. Two of the outermost PNe have solar oxygen abundances, as well as radial velocities consistent with the kinematics of the extended disk of M 31. The other PNe have a slightly lower oxygen content ([O/H] ~ -0.4) and in some cases large deviations from the disk kinematics. These PNe support the current view that the external regions of M 31 are the result of a complex interaction and merger process, with evidence for a widespread population of solar-metallicity stars produced in a starburst that occurred ~ 2 Gyr ago.

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A search for water maser emission toward obscured post-AGB star and planetary nebula candidates

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Water maser emission at 22 GHz is a useful probe to study the transition between the nearly spherical mass-loss in the AGB to a collimated one in the post-AGB phase. In their turn, collimated jets in the post-AGB phase could determine the shape of planetary nebulae (PNe) once photoionization starts. We intend to find new cases of post-AGB stars and PNe with water maser emission, including water fountains or water-maser-emitting PNe. We observed water maser emission in a sample of 133 objects, with a significant fraction being post-AGB and young PN candidate sources with strong obscuration. We detected this emission in 15 of them, of which seven are reported here for the first time (IRAS 13483−5905, IRAS 14249−5310, IRAS 15408−5413, IRAS 17021−3109, IRAS 17348−2906, IRAS 17393−2727, and IRAS 18361−1203). We identified three water fountain candidates: IRAS 17291−2147, with a total velocity spread of $\simeq 96$ km s^{-1} in its water maser components and two sources (IRAS 17021−3109 and IRAS 17348−2906) that show water maser emission outside the velocity range covered by OH masers. We have also identified IRAS 17393−2727 as a possible new water-maser-emitting PN. The detection rate is higher in obscured objects (14%) than in those with optical counterparts (7%), consistent with previous results. Water maser emission seems to be common in objects that are bipolar in the near-IR (43% detection rate). The water maser spectra of water fountain candidates like IRAS 17291−2147 show significantly less maser components than others (e.g., IRAS 18113−2503). We speculate that most post-AGBs may show water maser emission with wide enough velocity spread (≥ 100 km s^{-1}) when observed with enough sensitivity and/or for long enough periods of time. Therefore, it may be necessary to single out a special group of "water fountains", probably defined by their high maser luminosities. We also suggest that the presence of both water and OH masers in a PN is a better tracer of its youth, rather than the presence of just one of these species.

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Variability in proto-planetary nebulæ: IV. Light curve analyses of four oxygen-rich, F spectral-type objects

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We present new light curves covering 14 to 19 years of observations of four bright proto-planetary nebulæ (PPNs), all O-rich and of F spectral type. They each display cyclical light curves with significant variations in amplitude. All four were previously known to vary in light. Our data were combined with published data and searched for periodicity. The results are as follows: IRAS 19475+3119 (HD 331319; 41.0 days), 17436+5003 (HD 161796; 45.2 days), 19386+0155 (101.8 days), and 18095+2704 (113.3 days). The two longer periods are in agreement with previous studies while the two shorter periods each reveal for the first time reveal a dominant period over these long observing intervals. Multiple periods were also found for each object. The secondary periods were all close to the dominant periods, with P_2/P_1 ranging from 0.86 to 1.06. The variations in color reveal maximum variations in $T_{\rm eff}$ of 400 to 770 K. These variations are due to pulsations in these post-AGB objects. Maximum seasonal light variations are all less than 0.23 mag (V), consistent for their temperatures and periods with the results of Hrivnak et al. (2010) for 12 C-rich PPNs. For all of these PPNs, there is an inverse relationship between period and temperature; however, there is a suggestion that the period-temperature relationship may be somewhat steeper for the O-rich than for the C-rich PPNs.

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Time-variable non-thermal emission in the planetary nebula IRAS 15103−5754

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The beginning of photoionization marks the transition between the post-Asymptotic Giant Branch (post-AGB) and planetary nebula (PN) phases of stars with masses < 8 M$_\odot$. This critical phase is difficult to observe, as it lasts only a few decades. The combination of jets and magnetic fields, the key agents of PNe shaping, could give rise to synchrotron emission, but this has never been observed before in any PNe, since free-free emission from the ionized gas is expected to dominate its radio spectrum. In this paper we report radio continuum observations taken with the Australia Telescope Compact Array between 1 and 46 GHz of the young PN IRAS 15103−5754. Our observations in 2010–2011 show non-thermal emission compatible with synchrotron emission from electrons accelerated at a shock with spectral index $\alpha \simeq -0.54$. However, in 2012, the spectral index $\alpha \simeq -0.28$ is no longer compatible with synchrotron emission in these types of processes. Several hypothesis are discussed to explain this change. The more plausible ones are related to the presence of the newly photoionized region in this young PN: either energy loss of electrons due to Coulomb collisions with the plasma, or selective suppression of synchrotron radiation due to the Razin effect. We postulate that the observed flattening of non-thermal radio spectra could be a hallmark identifying the beginning of the PN phase.

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Dusty wind of W Hya. Multi-wavelength modelling of the present-day and recent mass loss

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Low- and intermediate-mass stars go through a period of intense mass-loss at the end of their lives, during the asymptotic giant branch (AGB) phase. While on the AGB a significant part, or even most, of their initial mass is expelled in a stellar wind. This process controls the final stages of the evolution of these stars and contributes to the chemical evolution of galaxies. However, the wind-driving mechanism of AGB stars is not yet well understood, especially so for oxygen-rich sources. Characterizing both the present-day mass-loss rate and wind structure and the evolution of the mass-loss rate of such stars is paramount to advancing our understanding of this processes. We study the dusty wind of the oxygen-rich AGB star W Hya to understand its composition and structure and shed light on the mass-loss mechanism. We modelled the dust envelope of W Hya using an advanced radiative transfer code. We analysed our dust model in the light of a previously calculated gas-phase wind model and compared it with measurements available in the literature, such as infrared spectra, infrared images, and optical scattered light fractions. We find that the dust spectrum of W Hya can partly be explained by a gravitationally bound dust shell that probably is responsible for most of the amorphous Al_2O_3 emission. The composition of the large (~ 0.3 μm) grains needed to explain the scattered light cannot be constrained, but probably is dominated by silicates. Silicate emission in the thermal infrared was found to originate from beyond 40 au from the star. In our model, the silicates need to have substantial near-infrared opacities to be visible at such large distances. The increase in near-infrared opacity of the dust at these distances roughly coincides with a sudden increase in expansion velocity as deduced from the gas-phase CO lines. The dust envelope of W Hya probably contains an important amount of calcium but we were not able to obtain a dust model that reproduces the observed emission while respecting the limit set by the gas mass-loss rate. Finally, the recent mass loss of W Hya is confirmed to be highly variable and we identify a strong peak in the mass-loss rate that occurred about 3500 years ago and lasted for a few hundred years.

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Complex organic and inorganic molecules in Li-rich K giants

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Hydrocarbon organic material, as found in the interstellar medium, exists in complex mixtures of aromatic and aliphatic forms. It is considered to be originated from carbon enriched giant stars during their final stages of evolution, when very strong mass loss occurs in a few thousand years on their way to become planetary nebulæ. We show here that the same organic compounds appear to be formed in previous stages of the evolution of giant stars. More specifically, during the first ascending giant branch K-type stars. According to our model this happens only when these stars are being abruptly enriched with lithium together with the formation of a circumstellar shell with a strong mass loss during just a few thousand years. This sudden mass loss is, on an average, a thousand times larger than that of normal Li-poor K giant stars. This shell would later be detached, specially when the star stops its Li enrichment and a rapid photospheric Li depletion occurs. In order to gain extra carbon-based material to form the organic hydrocarbons, and also to explain the presence of complex inorganic compounds in these stars, we propose an interaction of these strong winds with remaining asteroidal/cometary disks that already existed around these stars since they were dwarf A-type stars. The mechanism of interaction presented here is successful to explain the presence of inorganic compounds, however it is unable to produce new carbon free atoms to form the organic hydrocarbon compounds. Finally, we discuss some suggestions and speculations that can eventually help solving the long-standing puzzle of Li-rich giants.

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The Large Magellanic Cloud as a laboratory for Hot Bottom Burning in massive Asymptotic Giant Branch stars

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We use *Spitzer* observations of the rich population of Asymptotic Giant Branch stars in the Large Magellanic Cloud (LMC) to test models describing the internal structure and nucleosynthesis of the most massive of these stars, i.e. those with initial mass above ~ 4 M$_\odot$. To this aim, we compare *Spitzer* observations of LMC stars with the theoretical tracks of Asymptotic Giant Branch models, calculated with two of the most popular evolution codes, that are known to differ in particular for the treatment of convection.
Although the physical evolution of the two models are significantly different, the properties of dust formed in their winds are surprisingly similar, as is their position in the colour–colour (CCD) and colour–magnitude (CMD) diagrams obtained with the *Spitzer* bands. This model independent result allows us to select a well defined region in the ([3.6]–[4.5], [5.8]–[8.0]) plane, populated by AGB stars experiencing Hot Bottom Burning, the progeny of stars with mass $M \sim 5.5$ M$_\odot$. This result opens up an important test of the strength hot bottom burning using detailed near-IR (H and K bands) spectroscopic analysis of the oxygen-rich, high luminosity candidates found in the well defined region of the colour–colour plane. This test is possible because the two stellar evolution codes we use predict very different results for the surface chemistry, and the C/O ratio in particular, owing to their treatment of convection in the envelope and of convective boundaries during third dredge-up. The differences in surface chemistry are most apparent when the model stars reach the phase with the largest infrared emission.

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The age–metalicity dependence for white dwarf stars

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We present a theoretical study on the metallicity dependence of the initial-to-final mass relation and its influence on white dwarf age determinations. We compute a grid of evolutionary sequences from the main sequence to $\sim 3\,000$ K on the white dwarf cooling curve, passing through all intermediate stages. During the thermally pulsing asymptotic giant branch no third dredge-up episodes are considered and thus the photospheric C/O ratio is below unity for sequences with metallicities larger than $Z = 0.0001$. We consider initial metallicities from $Z = 0.0001$ to $Z = 0.04$, accounting for stellar populations in the galactic disk and halo, with initial masses below ~ 3 $M_\odot$. We found a clear dependence of the shape of the initial-to-final mass relation with the progenitor metallicity, where metal rich progenitors result in less massive white dwarf remnants, due to an enhancement of the mass-loss rates associated to high metallicity values. By comparing our theoretical computations with semi empirical data from globular and old open clusters, we found that the observed intrinsic mass spread can be accounted for by a set of initial-to-final mass relations characterized by different metallicity values. Also, we confirm that the lifetime spent before the white dwarf stage increases with metallicity. Finally, we estimate the mean mass at the top of the white dwarf cooling curve for three globular clusters NGC 6397, M 4 and 47 Tuc, around 0.53 $M_\odot$, characteristic of old stellar populations. However, we found different values for the progenitor mass, lower for the metal poor cluster, NGC 6397, and larger for the younger and metal rich cluster 47 Tuc, as expected from the metallicity dependence of the initial-to-final mass relation.

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Witnessing the emergence of a carbon star

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During the late stages of their evolution, Sun-like stars bring the products of nuclear burning to the surface. Most of the carbon in the Universe is believed to originate from stars with masses up to a few solar masses. Although there is a chemical dichotomy between oxygen-rich and carbon-rich evolved stars, the dredge-up itself has never been directly observed. In the last three decades, however, a few stars have been shown to display both carbon- and oxygen-rich material in their circumstellar envelopes. Two models have been proposed to explain this dual chemistry: one postulates that a recent dredge-up of carbon produced by nucleosynthesis inside the star during the Asymptotic Giant Branch changed the surface chemistry of the star. The other model postulates that oxygen-rich material exists in stable Keplerian rotation around the central star. The two models make contradictory, testable, predictions on the location of the oxygen-rich material, either located further from the star than the carbon-rich gas, or very close to the star in a stable disk. Using the Faint Object InfraRed CAmera (FORCAST) instrument on board the Stratospheric Observatory for Infrared Astronomy (SOFIA) Telescope, we obtained images of the carbon-rich planetary nebula (PN) BD $+30^\circ 3639$ which trace both carbon-rich polycyclic aromatic hydrocarbons (PAHs) and oxygen-rich silicate dust. With the superior spectral coverage of SOFIA, and using a 3D photoionisation and dust radiative transfer model we prove that the O-rich material is distributed in a shell in the outer parts of the nebula, while the C-rich material is located in the inner parts of the nebula. These observations combined with the model, suggest a recent change in stellar surface composition for the double chemistry in this object. This is evidence for dredge-up occurring ~ 1000 yr ago.

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and from http://www.newscientist.com/article/dn27390-stars-throw-out-a-lifetimes-was

Oxygen isotopic ratios in intermediate-mass red giants

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Context: The abundances of the three main isotopes of oxygen are altered in the course of the CNO-cycle. When the first dredge-up mixes the burning products to the surface, the nucleosynthesis processes can be probed by measuring oxygen isotopic ratios.
Aims: By measuring $^{16}O/^{17}O$ and $^{16}O/^{18}O$ in red giants of known mass we compare the isotope ratios with predictions from stellar and galactic evolution modelling.
Methods: Oxygen isotopic ratios were derived from the K-band spectra of six red giants. The sample red giants are open cluster members with known masses of between 1.8 and 4.5 $M_\odot$. The abundance determination employs synthetic spectra calculated with the COMARCS code. The effect of uncertainties in the nuclear reaction rates, the mixing length, and of a change in the initial abundance of the oxygen isotopes was determined by a set of nucleosynthesis and mixing models using the FUNS code.
Results: The observed $^{16}O/^{17}O$ ratios are in good agreement with the model results, even if the measured values do not present clear evidence of a variation with the stellar mass. The observed $^{16}O/^{18}O$ ratios are clearly lower than the predictions from our reference model. Variations in nuclear reaction rates and mixing length parameter both have only a very weak effect on the predicted values. The $^{12}C/^{13}C$ ratios of the K giants studied implies the absence of extra-mixing in these objects.
Conclusions: A comparison with galactic chemical evolution models indicates that the $^{16}O/^{18}O$ abundance ratio underwent a faster decrease than predicted. To explain the observed ratios, the most likely scenario is a higher initial ^{18}O abundance combined with a lower initial ^{16}O abundance. Comparing the measured $^{18}O/^{17}O$ ratio with the corresponding value for the ISM points towards an initial enhancement of ^{17}O as well. Limitations imposed by the observations prevent this from being a conclusive result.

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Study of extremely reddened AGB stars in the Galactic Bulge

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Extremely reddened asymptotic giant branch stars (AGB) lose mass at high rates of $> 10^{-5}$ $M_\odot$ yr^{-1}. This is the very last stage of AGB evolution, in which stars in the mass range $\sim$ 2.0–4.0 $M_\odot$ (for solar metallicity) should have been converted to C stars already. The extremely reddened AGB stars in the Galactic Bulge are however predominantly O-rich, implying that they might be either low-mass stars or stars at the upper end of the AGB mass range.
Our goal is to determine the mass range of the most reddened AGB stars in the Galactic Bulge.
Using Virtual Observatory tools, we constructed spectral energy distributions of a sample of 37 evolved stars in the Galactic Bulge with extremely red IRAS colours. We fitted sc dusty models to the observational data to infer the bolometric fluxes. Applying individual corrections for interstellar extinction and adopting a common distance, we determined luminosities and mass-loss rates, and inferred the progenitor mass range from comparisons with AGB evolutionary models.
The observed spectral energy distributions are consistent with a classification as reddened AGB stars, except for two stars, which are proto-planetary nebula candidates. For the AGB stars, we found luminosities in the range $\sim$ 3 000–

30 000 $L_\odot$ and mass-loss rates $\sim 10^{-5}$–3×10^{-4} $M_\odot$ yr^{-1}. The corresponding mass range is $\sim$ 1.1–6.0 $M_\odot$ assuming solar metallicity.

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Announcements

Fizeau exchange visitors program – special 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.

IMPORTANT NOTE:
This is a special call to support attendance of the 8^{th} VLTI summer school: http://www.astro.uni-koeln.de/vltischool2015. Therefore no research plan and invitation letter from the host institution are required. The deadline for applications is May 30.

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

The program is funded by OPTICON/FP7.

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

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

See also www.european-interferometry.eu

Cloudy workshop
2015 Sept 21–26
Inter-University Centre for Astronomy and Astrophysics, Pune, India

Registration is now open for the 2015 September Cloudy workshop. It will be held Sept 21–26 at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, India.

Cloudy simulates the microphysics of matter exposed to ionizing radiation. It calculates the atomic physics, chemistry, radiation transport, and dynamics problems simultaneously and self consistently, building from a foundation of individual atomic and molecular processes. The result is a prediction of the conditions in the material and its observed spectrum.

The 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. There is no registration fee and financial support is not available.

See the website below for more information and for information on how to apply.

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